E-ISSN: 2583-1755

The Agriculture Magazine

VOLUME-3, ISSUE-6

FEBRUARY 2024



International Year of Camelids

A Monthly Peer Reviewed Magazine for Agriculture and Allied Sciences

https://theagricultureonline.com/

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Volume 3, Issue 6, February 2024

Monthly
ISSN: 2583-1755

The Agriculture Magazine

A Monthly Peer Reviewed Magazine for Agriculture and Allied Sciences

https://theagricultureonline.com/

Published by:
The Agriculture Publication



18, Keshav Nagar-1, Near Rajasthan Girls College,
Murlipura Scheme, Jaipur-302039
E-mail: info@theagricultureonline.com
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ISSN: 2583-1755
Volume : 3, Issue : 6
February, 2024
Publication Schedule : Monthly
All Correspondence Should be Address to
The Managing Editor
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The Agriculture Magazine

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Integrated Pest and Disease Management in Cucumber and Muskmelon

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Abstract

The vegetables belonging to family Cucurbitaceae are known as cucurbits. These vegetables are attacked by various insect pests right from seeding to harvest. A lot of money, time, and natural resources are invested to cultivate these vegetables. Sustainable pest management practices can save this investment by avoiding losses. Successful cultivation of cucurbits especially cucumber requires an effective and economical control of insect pests. Commercial vegetable growers must produce quality vegetables that are attractive and safe to the consumer at a minimum cost. Insect pest infestations in cucurbits cause heavy economic losses to farmers through reduction in yield, increased cost of production and lowered quality of produce. Effective and economic and sustainable pest management requires the use of cultural, mechanical, biological, and chemical methods. The integration of these different methods is necessary for achieving good management of pests. In case of cucurbits especially for cucumber pest management can be achieved only by a long-term assurance to integrated pest management practices (IPM). IPM involves the strategic use of resistant varieties, monitoring of pest incidence, cultural methods, mechanical removal of pest, biological control, and need based use of selective pesticides. Integrated pest management (IPM) is the alternative to insecticide and facilitates sustainable environment management.

Introduction

Crops belonging to the family Cucurbitaceae are commonly called cucurbits, which include more than 120 genera and 1000 species distributed in tropical and subtropical areas. Cucurbits are tropical in origin and grown mostly in Africa, tropical America, and Asia, mainly Southeast Asia. Cucurbits are a large group that include cucumber, bitter gourd, squash, bottle gourd, ridge gourd, snake gourd, watermelon, muskmelon and pumpkin. Most of the gourds and squashes are commonly used for cooking while cucumber is used for salads and pickles. Watermelon and muskmelon are taken as fruits and wax gourd is prepared as biscuits and jam. The cucurbits are beneficial for human health as their fruits help in purification of blood, boost energy level, improve digestion in the body and remove constipation. *Benincasa hispida* a member of cucurbitaceae family contains volatile oils, uronic acid, carotenes, flavonoids, ß-sitosterin and glycosides which are of pharmaceutical importance. The major phytochemical present in cucurbits is a terpenoid substance known as Cucurbitacins.

Most cucurbit species is believed to have an African origin. However, cucumber have originated from the foothills of the Himalayas. There the closely

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related wild species *C. hardwickii Royle* still exists. In India, the cucumber was already being cultivated 3000 years ago, in the 6th century, cucumber was cultivated in China and now it is cultivated worldwide. Immature fruits of cucumber are used as salad vegetable and for pickles. Cucumber and other cucurbit fruits are generally fat-free and low in sodium content. Cucumber is an annual crop and a climbing herb. Its growth development duration can last 12-13 months in favourable conditions. In present scenario, a significant constraint in the sustainable production and productivity of cucurbits is mainly due to attack of various insect-pests which are responsible for adversely affecting the qualitative and qualitative yield. A wide range of pest complex has been noticed infesting the cucurbits. This chapter joins all the information and provide overall review about the major insect pest of cucumber and other cucurbits, and different IPM measures like monitoring, cultural methods, host resistance, biological control method, use of botanicals as biopesticide and at last use of less hazardous chemical control methods recommended for management of this pest.

Melon fruit fly, *Bactrocera cucurbitae* (coquillett)

Bactrocera cucurbitae is a yellowish-brown coloured dipteran fly and commonly known as melon fruit fly. It is native to India and is wildly distributed in tropical, subtropical and temperate region of the world. Melon fruit fly attacks about 125 species of plants, mainly cucurbits, *viz*. gourds, cucumber, pumpkin, squash and other vegetables like tomato, green beans, egg plants etc. The female adult with the help of its sharp and hard ovipositor, punctures the soft and tender fruits and lays eggs just below the fruits's epidermis. After hatching, the maggots start feeding inside the pulp of fruits. A water-soaked appearance of fruits develops as a result of larval feeding, these punctures and feeding tunnels provide entry points for various bacteria and fungi and result of this, the infested fruit start rotting, distorted and malformed fruits from plants pre-maturely. About 1000 white colour eggs in the batches of 1-40 slender (2 mm long) are laid by a single female. Dirty white coloured apodous maggots are cylindrical, elongate (7-12 cm). The maggot developmental period is 3 to 21 days depending on the temperature and host. Pupation occurs in the soil at the depth of 0.5 to 15 cm, pupal period is about 7-13 days depending on host and temperature. Adults are long lived about 150 days. Melon fruit fly can cause devastating fruit damage up to 100% in all cucurbits.

Management

Cucurbits fruits are picked up at small intervals for marketing and self-consumption for that reason we cannot rely on insecticide for control of this pest but under severe infestation, it is important to use low residual toxic insecticides with short waiting periods. Therefore, in keeping view the importance of crop and this pest different strategy should be used for the management of fruit fly as follows.

Local area management: Local area management is the minimum scale of pest management over a restr-

icted area, which has no natural protection against reinvasion. Here the major objective is to suppress the pest, rather than to eradicate it. The strategies include bagging of fruits, field sanitation, protein baits and cue-lure traps, host plant resistance, biological control, and soft insecticides, can be employed to avoid environmental and health hazard. Monitoring and management with cue/pheromone lures.

For the monitoring of fruit flies, the sex attractant cue-lure traps are more effective than the food attractant tephritlure traps and cue-lure and methyl eugenol traps have been used to attract males for monitoring and mass trapping. *Ocimum sanctum* as the border crop sprayed with protein bait containing spinosad as a toxicant found effective in management of this pest. A variety of commercially produced attractants (cuelure®, Eugelure®, Flycide®) are available in the market and can be used efficiently in management of this pest. For trapping male flies, installation of old used water bottle baited with cue-lure saturated wood blocks (ethanol/ cue-lure/carbaryl in a ratio 8:1:2) at 25 traps ha^{-1} prior to flower initiation is quite effective. Use of NSKE 4% as a repellent can enhance trapping and luring in bait spots. Use of neem as a repellent enhanced the catch in parapheromone traps and increased the luring ability of para-pheromone by 52%. Although, along with repellents and bait spray, other operations like removal and destruction of maggots in early infested fruits and field sanitation must be adopted.

Cultural methods: Field sanitation is most effective method in melon fruit fly management. It should be done for minimising pest intensity and to break reproduction cycle by removal and destruction of infested fruits daily from the field and bury the damaged fruits 0.46 m deep into the soil. Akhtaruzzaman *et al*. recommended bagging of cucumber fruits after 3 days of anthesis and bag should be kept for 5 days for effective control. Bagging of 3-4 cm long fruits with two layers of paper bags reduces fruit fly infestation and enhances the net returns by 40-58%. 2-3 rows of maize as a trap crop can be grown between the cucurbits, which can be used as a resting site by the adult fruit fly. Spraying of any contact insecticides can be done on maize during the evening hours to kill adult fruit flies.

Biological control: Srinivasan reported *Opius fletcheri* Silv. to be a dominant parasitoid of *B. cucurbitae*. The parasitization of *B. cucurbitae* by *O. flatcheri* has been reported to vary from 0.2 to 1.9% in *M. charantia*. In the IPM program of *B. cucurbitae* at Hawaii, a new parasitoid, *Fopius arisanus* has been included. A nematode, *Steinernema carpocapsae* Weiser (*Neoaplectana carpocapsae*), has been found to cause 0-86% mortality to melon fruit fly after 6 days exposure. The culture filtrate of the fungus, *Rhizoctonia solani* Kuhn, act as an effective bio-agent against maggots, and the fungus, *Gliocladium virens* Origen, has been found to be an effective against adult flies. Oviposition and development of *B. cucurbitae* adversely affected by culture filtrates of the fungi *R.*

solani, *Trichoderma viridae* Pers., and *G. virens*.

Host plant resistance: Host plant resistance is an important element in IPM programs. It is an important component in IPM programs. It does not cause any negative impact to the environment. The success in developing high yielding and melon fruit fly-resistant varieties is limited. By using wide hybridization technique the resistance genes from the wild relatives can be transferred in the cultivated genotypes of cucurbits. Some resistant genotypes are IHR 89, Hisar II for bitter gourd, Arka Suryamukhi, IHR 35 for pumpkin, NB29 and Pusa smooth purple long for bottle gourd, Arka Tinda for round melon, *Cucumis callosus* for Wild melon, NS14 for sponge gourd and NR2, NR5, NR7 for ridge gourd.

Botanicals: The adult longevity reduced from 119.2 to 26.6 days by continuous feeding with extract of *Acorus calamus* (0.15%) mixed with sugar (at 1 mL g^{-1} sugar). Neem oil (1.2%) and neem cake (4%) are found to be effecting in fruit fly management.

Chemical control: The use of chemical insecticide to manage fruit fly is relatively ineffective. Application of Malathion (0.05%) as cover spray to kill the insects on contact is effective or a bait spray by adding 50 g gur + 10 mL Malathion in 10 L water that attract and kill the adults is good for its management. For good control of fruit fly spraying of Malathion + molasses + water in the ratio of 1:0.1:100 is suggested by Akhtaruzzaman *et al*. This method is economical and environmental friendly as there is very low contamination of fruits from insecticides. Gupta and Verma recommended that fenitrothion (0.025%) in combination with protein hydrolysate (0.25%) minimised melon fruit fly infestation to 8.7% compared to 43.3% damage in untreated control. Reddy reported that triazophos is the most effective insecticide to manage this pest on bitter gourd. Diflubenzuron is also found effective in controlling the melon fruit fly, and quinalphos (0.2%) successfully manage its population on different cucurbits.

Red pumpkin beetle (*Raphidopalpa foveico* llis/ *Aulacophora foveico* llis)

Red pumpkin beetle is a common and major pest of a wide range of cucurbits, especially sweet gourd, bitter gourd, watermelon, bottle gourd, and muskmelon. It is polyphagous in nature. Both larval and adult stages are voracious feeders of the cucurbit crops and cause severe damage to seedlings and young and tender leaves and flowers. The pest is widely distributed in different parts of the world, especially in Asia, Africa, Australia, and south Europe. In India, it occurs throughout the country but is more common in the north western parts.

Management

Monitoring and cultural methods: Monitoring of seedling should be done twice a week to check the infestation of red pumpkin beetle. The older plant parts should be monitored regularly and should be treated if severe defoliation is noticed. In the initial stage of infestation collection and destruction of beetles is good practice, otherwise the alternative practices can be employed for the management of

this pest. Preventive measures such as burning of old plant parts, ploughing, and harrowing of field after harvesting of the crops should be followed for the destruction of all the stages of this pest. Early planting of cucurbits than the normal planting time could also be effective in management as the plants pass the cotyledonary stage by the time the beetles become active.

Host plant resistance: Khan reported the preferred cucurbit host plants for this beetles and categorised bitter gourd, ribbed gourd, sponge gourd, and snake gourd as non-preferred hosts (resistant), while cucumber, muskmelon, and sweet gourd were the most preferred hosts (susceptible) and bottle gourd and ash gourd were moderately preferred hosts (moderately susceptible).

Botanicals and biopesticides: Application of neem oil cake in the soil is effective in killing grubs. Treatment of bottle gourd plants with entomo-pathogenic fungi *B. bassiana* resulted in maximum reduction of beetle infestation along with the highest fruit yield. Khan and Wasim reported maximum repellence against pumpkin beetles in treatment comprising of neem extracts mixed with benzene. *Parthenium spp*. extract was found to be effective in management of the red pumpkin beetle.

Chemical control: Generally, this pest attacks the crop at the cotyledonary stage when adults skeletonize the young leaves. At the time of initial infestation, applications of Malathion (0.5%) or carbaryl (0.1%) minimise the damage successfully. Dusting with permethrin (0.5%) alone and ash + permethrin dust (2000:1 *a.i.* w/w) provide good control against this beetle on the cucumber crop, with no phytotoxicity symptoms on the plant. Synthetic pyrethroids (cypermethrin 0.012%, deltamethrin 0.004%, and fenvalerate 0.01%) were effective in suppressing the beetle population for about a week.

Hadda beetle (*Epilachna implicate, E. viginitioctopunctata and E. borealis*)

This is an occasional pest on cucurbit. It is a serious pest of squash, bitter gourd, and pumpkin. Grub only feed on the underside of the leaf, whereas adults may be found to feed on both the leaf surfaces or even on the fruit rind, leaving spiral-shaped scars and deteriorating fruit quality. Both grub and adult feed voraciously by scrapping the chlorophyll of the leaves which cause characteristic skeletonization of leaf lamina and leaving a fine net of veins on leaves. The affected leaves gradually dry and fallen down. The young plants are killed overnight in case of severe infestation. The yellowish-brown coloured adult beetles are globular in shaped and 6-8 mm long, bearing 12-28 black spots on the elytra. The female lays about 300-400 eggs in clusters on the under surface of the leaves. Eggs on hatching turns into yellowish larvae (grub) with branched black spines covering the body. Full-grown larvae about 7-9 cm long pupate below the leaf or at the base of the stems. The pupa is yellow in colour, and lacks spines and hangs from the leaf. The development period comprises of 4-6 weeks under optimal conditions. Adults make semicircular cuts in rows, while Scrapping of the epidermis indicates the feeding ma-

nner of the grubs. Young plants can be totally destroyed, but older plants can tolerate considerable leaf damage. Overwintering sites for adults are under loose tree bark or under leaf litter near the edge of fields.

Management

Cultural methods: The best time of day for the inspection of hadda beetles on cucurbits is around noon. As they are not strong fliers, so crop rotation to distant fields tends to limit population and colonisation. On the small scale like kitchen garden handpicking is recommended for the management of this pest because both the larvae and adults are not very aggressive defoliators. Harrowing and destroying vines and larvae after harvesting early cucurbits is recommended to suppress pest population. Row covers can be used to protect cucurbit from the beetles.

Botanicals: The application of seed extracts of *Annona squamosa* (3 mL L^{-1} of water) helps in minimising population build up to the extent of 76% which is followed by 64% and 57% through NeemAzal (5 mL L^{-1} of water) and petroleum ether rhizome extracts of *A. calamus* (2 mL L^{-1} of water), respectively. Aqueous neem kernel extracts foliar spray at concentrations of 25, 50, and 100 g L^{-1} once in a week and neem oil spray with an ultralow-volume sprayer at 10 and 20 L ha^{-1} significantly was found effective in reducing feeding by *Epilacna* beetles in cucumber and squash. Tephrosia leaf extract (20 g/100 mL water) provide highest yield and good control of *Epilachna* beetle by killing adults and inhibition of pupae formation and this is an environment friendly pest control method. Swaminathan *et al*. have observed the antifeedant and lethal effects of *Azadirachta indica*, *Madhuca latifolia* and *P. glabra*, on this pest. Islam *et al*. performed larvicidal bioassays with crude aqueous leaf extracts of *plants viz., Ricinus communis, Datura metel* and *Calotropis procera* and these extracts showed considerable toxicity against the Hadda beetles by adversely affecting both oviposition and egg hatching besides prolonged larval duration, pupae formation, and adult emergence.

Chemical control: Foliar applications of some synthetic pesticides like parathion, malathion, lambda-cyhalothrin, pyrethrin and spinosad are found to be effective in control of severe infestation of this pest.

Aphid (*Myzus persicae and Aphis gossypii*)

Many aphid species including melon aphid (*Aphis gossypii*) and green peach aphid found to feed on cucurbits and cause similar devastating damage. They pierce the tender plant part with their slender mouthpart and suck plant fluids from it. Aphids are small about 3 mm long, pear-shaped soft bodied insects with long legs and antennae. They are yellow, pale green, red, brown or black in colour. Some aphid secretes a waxy grey or white material that covers their body and it gives them a waxy or woolly appearance. The adults are usually wingless but when populations are high especially during spring and autumn season winged forms can also be seen. A

pair of tube-like structures known as cornicles projecting rearwards from their abdomen is present in most of the aphid species. Aphids can disperse long distances with the help of wind flow. Asexual reproduction is a common phenomenon in majority of aphid species. Adult females give birth to wingless nymphs which become adults after moulting and shedding the skin multiple times within a week. Each adult reproduces numerous nymphs in a short span of time therefore, aphid population increase rapidly. The green peach aphid (*Myzus persicae*) is slender, dark green to yellow in colour, and it has no waxy bloom. They tend to cluster on succulent plant parts and within 10-12 days one generation completes and there are about over 20 generations annually under mild climates. This aphid (both nymph and adult) is known as the most important vector for the transmission of viruses throughout the world. Aphids' infestation causes a variety of symptoms, including reduced plant growth and vigour, yellowing, mottling, browning, curling and wilting of leaves, ultimately result in low economic yields and sometimes death of plant. The downward curling and crinkling of the leaves are the first sign of aphid infestation. Malformed flowers or fruits are developed due to feeding of aphid on flower buds and fruits. Honeydew excreted by aphids also act as a growth substrate for sooty moulds (fungi) on leaves and other plant parts, which ultimately hinders photosynthesis by blocking light. Aphids also transmit several viruses that affect all cucurbits causing a high rate of crop failure and great economic losses. These viruses are cucumber mosaic virus, zucchini yellow mosaic virus, watermelon mosaic virus and papaya ring spot virus. Mottling, yellowing, or curling of leaves and stunted plant growth are some usual symptoms of viral infection.

Management

Monitoring: Aphids multiply at a very fast rate, and this must be considered while monitoring this pest. Plants should be inspected at least two times a week especially at the under surface of the leaves. Severe infestation is noticed during end of growing season. Yellow sticky traps should be used for detecting aphids 2-3 weeks prior to planting.

Cultural method: Floating row covers or reflective mulches may be effective to exclude or repel this pest. On early crop stage, aluminium foil mulches can be used to repel the invading aphid and check transmission of viruses. Reflective mulches can increase temperature beyond optimum for cucurbits in very hot and arid regions therefore, not recommended for these areas. Reflective mulches repel aphids from plants and consistently suppress aphid population and also help in delaying symptoms of watermelon mosaic and cucumber mosaic cucumo virus and zucchini yellow mosaic potyviruses by 3-6 weeks. Biodegradable synthetic latex spray mulches and reflective polyethylene and provide good control of aphids and aphid-borne virus diseases on late-season melons. Living mulches minimise the contrast between the plant foliage and bare land, subsequently, the aphids do not detect their host and these mulches around main crop provide

additional feeding sites for viruliferous aphids (aphids carrying virus) and hence minimise aphid-borne non -persistently transmitted viruses incidence and spread.

Biological control: Beneficial insects like predators, parasitoids, and pathogens are attracted to plants with moderate to heavy aphid infestations. These natural enemies may attack large numbers of aphids but as the reproductive potential of aphids is very high hence, the impact of these natural enemies may not be enough to keep the aphids population below economic threshold levels. Lady bird beetles and their larvae (*Hippodamia convergens, Harmonia axyridis, Coleomegilla maculata*), larvae of the syrphid fly, minute pirate bug (*Orius tristicolor* and *O. insidiosus*) and green lacewing larvae (*Chrysoperla carnea, Chrysopa spp*.) and brown lacewing larvae *(Hemerobius spp.)* and larvae of the aphid midge *(Aphidoletes aphidimyza*) are common predators of aphid and help in natural control of this pest. Parasitoids comprises important place among natural enemies of aphid. Some commonly found aphid parasitoids are *Aphidius matricariae, Aphidius colemani, Binodoxys angelicae and Lysiphlebus fabarum*. Under humid conditions. Some fungi infect and provide biological control of aphid population, the most common entomopathogenic fungi are *B. bassiana, M. anisopliae, Verticillium lecanii*, and *B. bassiana* must be applied three times at an interval of 5-7 days for good control. Entomopathogenic fungus could be more effective than insecticides for controlling large populations of aphids if utilised properly.

Chemical control: Potassium soap and petroleum oil or Actara are recommended for the management of this pest. Killing of aphid population should be done before destroying old crops to avoid winged virus-infected aphids from getting to nearby crops by using a detergent and vegetable oil solution. Acetamiprid (0.01%) or Cypermethrin (0.01%) or malathion (0.05%) can be used to control aphids.

Whitefly (*Bemisia tabaci, B. argentifolii and Trialeurodes vapararіorus*)

Cucurbits are attacked by several species of whiteflies. Of these, silverleaf whitefly (*Bemisia argentifolii*), tobacco whitefly (*Bemisia tabaci*), and greenhouse whitefly (*Trialeurodes vaporariorum*) are the most devastating. Whiteflies are small in size about 1-1.5 mm long and the body and wings of adult are covered with fine whitish powdery wax. Adults and eggs are commonly found on younger leaves while nymphs are present on older leaves. A female lays around 300 eggs; eggs are oval in shape and are laid by making a slit in the leaf. Initially the eggs are white, changing to brown colour, and are hatched within 8-10 days. The first instar is known as called crawler is the only mobile instar that moves to look for feeding sites, while the other instars are sessile and complete its life cycle on the same feeding site. One generation of whitefly completes in about 3-4 weeks. The silverleaf whitefly gets injects a toxin into the plant that causes whitening of the under surface of newly emerging leaves. Severe damage may be occurred on younger plants compared to

older plants. Whitefly directly affects the cucurbits by its feeding and by acting as a vector of viruses. Cucurbit yellow stunting disorder virus, Cucurbit chlorotic yellow virus, beet pseudo yellow virus, and lettuce infectious yellows virus, are exclusively transmitted by whiteflies in both field and greenhouse-grown cucurbits. Whiteflies also excrete honeydew which promotes the growth of sooty mould on leaves and economic plant parts.

Management

Monitoring: For early detection and monitoring the activity of whiteflies in the field, yellow sticky traps can be used. These traps are very important step for their management of whitefly. Traps should be placed just above the canopy at every 100 m^2 distance of the crop as whiteflies are most attracted toward young foliage.

Cultural methods: Crop rotation, mulching, floating row covers, non-infested transplants, cover crops, and good field sanitation are some common cultural practises to prevent the build-up of whiteflies. Delayed planting or host-free periods may reduce severity of infestation as temperature and rainfall influence whitefly population dynamics. Soil ground covers such as living or synthetic mulches have been found to suppress whitefly infestation. UV-reflective plastic mulch provides good management of silverleaf whitefly by repelling the adults' flies, which minimize their colonisation and nymph population on zucchini squash and pumpkin. Field sanitations an important practice to control whiteflies infestation, whitefly-transmitted virus incidence, and insecticide resistance. Crop residues that shelter whiteflies should be destroyed immediately after final harvesting to reduce their population and sources of plant viruses. Weeds should be eradicated regularly from the crop as they can support large populations of whiteflies.

Biological control: Natural enemies of whitefly such as *Encarsia Formosa, E. luteola* and *Eretmocerus californicus* have been found quite effective in the greenhouse conditions. Entomo-pathogenic fungi-based products namely, *V. lecanii, B. bassiana* and *Paecilomyces fumosoroseus* are very useful to suppress whiteflies in both field and greenhouse crops. The important predators affecting whiteflies are true bugs (Miridae, Anthocoridae), beetles (Coccinellidae), lacewings (Chrysopidae, Coniopterygidae), spiders (Araneae) and mites (Phytoseiidae), *Conwentzia africana* (dusky lace-wing) has been considered one of the most important predators of *B. tabaci*.

Botanicals: Azadirachtin containing neem-based pesticide formulations like NeemAzal and Azatin have been found to control young nymphs and inhibit growth and development of older nymphs, and suppress egg laying by adult flies. Soap and certain oil sprays can be used in an organically certified crop. The efficacy of neem-based pesticides can be increased by adding 0.1%-0.5% soft soap in it.

Chemical control: The adults at immature stage reside on the underside of leaves, therefore whiteflies are usually difficult to control by using chemicals. Neonicotinoid insecticide like imidacloprid or thia-

methoxam applied in soil at the time of planting effectively controls whiteflies. Foliar spray with neonicotinoid insecticide such as acetamiprid can be done at early stages of growth before flower initiation. Spiromesifen is effective against immature stages of the whitefly. Consecutive applications of the same insecticide should be avoided. Soil application of any neonicotinoid with a foliar application of another neonicotinoid never be followed.

Squash bug (*Anasa tristis*)

The pest has been reported to attack nearly all cucurbits but most preferred cucurbits for oviposition and high rates of reproduction and survival are squash and pumpkin. It damages the crop severely by secreting highly toxic saliva into the cucurbit. Foliage is the primary site of that wilts, becomes blackened, and dies upon feeding. The fruits are also infested. The intensity of damage is directly proportional to the population density of pest. The adults emit a strong odour when crushed.

Management

Cultural methods: Plastic and spun bounded material can be used a row cover at the time of planting. Straw mulch is found effective in controlling squash bugs by providing cover. As this pest prefers squash over other cucurbits, squash planting can be used as a trap crop around other cucurbit. Trap crop squash can be treated with insecticide to control the infestation.

Biological control: Several natural enemies are known to parasitize squash bug, especially Hymenoptera parasitoids belonging to family Encyrtidae and Scelionidae. A important tachinid fly parasitoid *T. pennipes*, attacks nymphs and adults of this pest and 100% parasitisation in certain fields in particular years was observed.

Botanicals: Certain plant derived oils such as neem oil are helpful in the management of squash bug.

Chemical control: For the successful squash bug control timing of application is the key. Systemic insecticides are effective in suppression of these bugs up to 3 weeks. Foliar sprays targeting newly hatched nymphs are more effective than sprays used against older stages. Multiple foliar sprays are often needed for long periods of control. Soil application of dinotefuran and pyrethrin in foliar application are recommended for management of this pest.

Conclusion

The attacks made by the insect pests in cucurbits cause severe yield and quality losses in cucurbits. Cucurbitaceous crop is an important part of the fresh market vegetable crops. The current pest management still relies mainly on chemical pesticides and excessive dependence on chemicals leads to environmental pollution, pest resurgence, pest resistance and disturbance in balance between pest and their natural enemies. There are also the real and important risks to human health and environment as insecticide residue persist in these vegetables for longer times. Therefore, an integrated approach including monitoring of pests; cultural methods, like field rotation, use of mulches and trap crops and shifting planting dates; resistant cultivars; biological

control; botanicals and biopesticides; and judicious use of chemicals can minimise this associated risk with chemical pesticides. An effective integrated programme for pest management is necessary for the management of these pest problems in cucurbits. By giving focused attention through adopting IPM techniques, sustainable production of cucurbits can be achieved.

Integrated Insect-Pest and Disease Management in Brinjal and Tomato

Manish Kumar, Devi Singh and Anita Kerketta

Introduction

IPM & IDM simply means that growers use a combination of biological, cultural, and chemical methods to suppress pest & disease populations, rather than relying only on one method, such as repeated pesticides use. This integrated approach uses preventive measures to avoid likely insects and diseases, crop monitoring to allow early detection, biological control when possible, and pesticides when needed. A sound IPM & IDM program reduces pesticide use, allows more timely application of needed pesticide treatments, and improves pest & disease control.

Major pest of brinjal

Shoot and Fruit Borer

- ✓ Withering of terminal shoots/dead hearts.
- ✓ Bore holes on shoots and fruits plugged with excreta.
- ✓ Shedding of flower buds.
- ✓ Withering and drying of leaves.

Spotted beetle

- ✓ Scrapping of chlorophyll.
- ✓ Skeletonization and drying of leaves.

Brown leaf hopper

- ✓ Reduction in size of leaves.
- ✓ Shortened petioles.
- ✓ Excessive growth of branches general stunting of plants.
- ✓ Conversion of floral parts into leafy structures.
- ✓ Plants become bushy
- ✓ Fruiting is rare
- ✓ Vector of little leaf of brinjal

Major Diseae of Brinjal

Damping off

- ✓ Sudden collapsing of the seed lings occur in the seed bed.
- ✓ The seedlings are attacked at the collar region and the attacked seedlings are toppled down.
- ✓ The disease spreads through fungi present in the soil. The disease spreads through fungi present in the soil.

Alternaria leaf spot

- ✓ Cracks appearing in leaf spot.
- ✓ The two species of *Alternaria* occur commonly, causing the characteristic leaf spots with concentric rings.
- ✓ The spots are mostly irregular, 4-8 mm in diameter and may coalesce to cover large areas of the leaf blade.
- ✓ Severely affected leaves may drop off.
- ✓ *A. melongenae* also infects the fruits causing large deep-seated spots.
- ✓ The infected fruits turn yellow and drop off prematurely.

Major pest of tomato

Fruit borer

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- ✓ Young larvae feed on tender foliage.
- ✓ Mature larvae bore circular holes.
- ✓ Thrust only a part of its body into fruit and eat the inner content.

White fly

- ✓ Chlorotic spots
- ✓ Yellowing
- ✓ Downward curling and drying of leaves.
- ✓ Vector of tomato leaf curl disease.

Thrips

- ✓ Silvery streaks on leaf surface.
- ✓ Pre-mature dropping of flowers.
- ✓ Bud necrosis.
- ✓ Vector of tomato spotted wilt virus.

Major Disease of Tomato

Damping off

- ✓ **Pre-emergence phase:** Complete rotting of seedlings.
- ✓ **Post-emergence phase:** Infected tissues become soft and water soaked.
- ✓ Seedlings topple over or collapse.

Early blight

- ✓ Brown spots with concentric rings in a bull's eye pattern with yellow margin.
- ✓ Fruit gets infected through calyx or stem attachment.
- ✓ Brown concentric rings on fruits.

Late blight

- ✓ Water-soaked black lesions on leaves and stems
- ✓ Lesions expand rapidly and the entire leaf becomes necrotic.
- ✓ White sporulation (sporangia and sporangiophores) on leaves.

Principles of Integrated Pest Management (IPM)

Integrated Pest Management (IPM) offers a holistic and sustainable approach to pest and disease control. By combining various strategies, it aims to minimize the use of chemical interventions while maintaining crop health.

Cultural Practices

Implementing cultural techniques such as crop rotation, proper spacing, and sanitation helps prevent the buildup of pests and diseases, reducing reliance on external interventions. Avoid ratoon cropping, avoid continuous cropping of brinjal, and avoid crops which may act as alterner host.

Biological Control

Utilizing natural predators like beneficial insects or nematodes serves as an eco-friendly method to control pest populations in brinjal fields. Predators such as *campyloneura sp.*, *Cheilomenes sexmaculata* have been identified. Parasite such as *Pseudoperichaeta* sp, *Phanerotom*a sp. can be used. Egg parasitoids trichogramma chilonis @ 1.0 lakh ha^{-1}. Entomopathogens *Bipolaris tetramera* (fungus) baculovirus, nuclear polyhedeosis virus.

Mechanical and Physical Control Measures

Implementing physical barriers, traps, and other mechanical methods provides additional layers of defense against pests, complementing other management strategies. Hand picking of larvae and adults. Erecting mechanical barriers. Cleaning of planted areas prior to, during or after the cropping season. Destruction of the EFSB infested shoot and

fruits. Use of light traps @ 1 ha^{-1}. Use of sex pheromone. Delta and funnel traps are used @ 100 ha^{-1}. Traps placed at 0.5 m above crop canopy.

Integrated Disease Management (IDM)

Incorporating specific strategies for managing cucumber diseases within the integrated framework enhances overall disease control and prevention.

Biological control

In this method the pathogen actively is reduced through the use of other living organisms e.g., hyper-parasites, resulting in a reduction of disease incidence and severity. Eg. *Trichoderma spp., trichograma spp*. and *psedomonas spp*.

Physical method

- ✓ Hot water treatment
- ✓ Hot air treatment
- ✓ Remove infected seed
- ✓ Removal and destruction of affected plant parts

Chemical method

- ✓ Spraying the affected plants with Bavistin (0.1%)
- ✓ Chlorothalonil (2 g $liter^{-1}$ of water).

Cultural control

- ✓ Intercropping
- ✓ Crop rotation
- ✓ Field as sanitation
- ✓ Manipulation of sowing dates.

Conclusion

Now a day's increasing use of chemicals for the management of disease & pest of tomato and brinjal has resulted in growing concern of both in public health and environment hazards. Thus, emphasis is now on the use of IDM & IPM sources for the management of the plant disease and pest which is less costly and doesn't affect public health and environment.

Paruthi Paal: Triple Nutrient Healthy Drink from Cotton Seed

Darshana Patra, Tanmaya Kumar and Janhvi Makwana

Introduction

The primary purpose of cotton cultivation is to produce fiber, which is regarded as the primary economic component. The most significant by-product of cottonseed was left over after the fiber was removed during ginning. Cottonseed oil (20-22%) is regarded as a healthy oil because it includes unsaturated fatty acids. It can be used for salad dressing, frying, and combining with other oils to enhance their flavor stability, such as soybean, groundnut, and sunflower oil. In addition to being a nutritious oil, cottonseed also has a significant amount of protein (20-25%) and some phenolic chemicals that give the protein component anti-oxidant properties. These essential components of cottonseed can be utilised as a source of nutrition in cotton-growing countries. Tanzania, Uganda, Zimbabwe, Burkina Faso, Zambia, and other ten countries of African subcontinent depend on cotton earnings and its crucial source of income for farmers and their families. These countries also face menace of malnutrition and energy malnutrition. Hence, cottonseed, if utilised as a food supplement, can play a crucial role to overcome these problems in a cost-effective manner (Paal signifies milk and Paruthi means cottonseed). Paruthi Paal, a traditional delicacy of the Indian state of "Tamil Nadu," is known as a "triple-nutrient" food because of its abundance in protein, vital fatty acids, and carbohydrates. It can also be referred to as an "energy drink." The history of consumption cottonseed as a source of energy or Paruthi Paal is not so rich. However, at the time of World War II due to the unavailability of most of the other edible sources, various products made from the cottonseed were served to the soldiers

Protocol for preparation Paruthi Paal

Ingredients: cottonseeds (Paruthi) (one tumbler (glass)), rice/kudu millet (one fourth tumbler (glass)), jaggery (one tumbler (glass)), cardamom powder (onefourth tsp), coconut milk (one tumbler (glass)), grated coconut (one-half tsp)/coconut milk and dry ginger powder (one-fourth tsp).

Procedure: Pick out any cotton or mud that has adhered to the cottonseeds and soak them in water overnight before washing them under running water. Repeat the cleaning process 3-4 times under running water. Add a little water to the cottonseeds and proc-

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ess in the blender for a minute to extract the milk from them. Utilizing a sieve or muslin cloth, remove the milk from it. Then, add another cup of water, blend it once more, and separate the milk from the cottonseed mash. Make jaggary syrup by extracting milk from coconut milk in a similar manner. One method to produce syrup is to crush the jaggery, add it to a pan with water (to dissolve the jaggery), and cook the mixture over medium heat until it achieves the consistency of syrup. After filtering it, set it apart. Place the filtered cottonseed milk in a pot and heat it until it starts to boil, stirring from time to time. After it starts to boil, stir and maintain a low heat for five minutes. Almond flour can be used to make a paste, or you can mix rice flour and kodu millet flour with a cup of water and stir thoroughly to avoid lumps. To avoid lumps developing, add this to the cottonseed milk that is now heating while whisking continuously. The cardamom pods should be crushed and set aside. Cardamom powder, cardamom pods, and ginger powder can be added; stir continuously until the mixture thickens. Pour the jaggery syrup in and cook for 5 minutes on medium heat, stirring occasionally, until it thickens. Pour the coconut milk into the pan while maintaining a low flame, stirring continuously until the raw scent disappears. In the morning, remove from the fire and serve hot. This can also be made into an herbal beverage that is beneficial for digestion, colds, and coughs by adding a few herbal spices.

Benefits of paruthi paal

Heals stomach ulcer: A number of factors, including dietary behaviors that modify the stomach's ecology, can lead to stomach ulcers. The most common cause of stomach ulcers is the bacterium *Helicobacter pylori*. Eating Paruthi Paal has long been recognized as a treatment for stomach ulcers. Suppression of Helicobacter pylori activity could be the cause.



Prevents polycystic ovary syndrome: Polycystic ovary syndrome (PCOS) can also lead to other serious health challenges, such as diabetes, cardiovascular problems, depression and increased risk of endometrial cancer. Controlling the diabetic condition by consuming low-calorie or low-glycaemic index foods such as legumes, seeds, nuts and fruits. Cottonseed is also considered as a low-glycaemic index and have beneficial effects in preventing PCOS. Secondly, cottonseed is also a very good source of magnesium and shown good results in the prevention of PCOS.

Remedy for cold and cough: Paruthi Paal, a blend of almonds, cardamom, ginger, and cottonseed milk, is a popular cold and cough cure in Tamil Nadu.

Ease in labour pains: The combination of cottonseed and root of cotton stimulates uterine contraction and leads in preventing the labour pains.

Cholesterol benefits: Cottonseed consumption has been demonstrated to increase the body's levels of HDL, or good cholesterol, and help lower levels of LDL, or bad cholesterol. This is because cottonseed oils have a high oleic acid concentration, which raises HDL activity over time.

Improves neurological health and memory: Another crucial source of vitamin E, an antioxidant, is cottonseed. Thus, Paruthi Paal contributes positively to the nervous system's operation, thereby enhancing memory abilities.

Conclusion

The main component of Paruthi Paal is cottonseed milk, an excellent source of protein, fiber, and good fat. The research also produced a technique for producing milk from cottonseed. The produced ready-to-serve product “Paruthi Paal” can also be taken as a protein supplement to fight malnutrition. In actuality, India is capable of producing and marketing cottonseed milk, which is a ground-breaking commodity. Apart from being a dietary supplement, Paruthi Paal also functions as an antioxidant, guards against heart-related problems, lessens stomach ulcers, and has numerous other advantageous properties.

Role of Biochar in Insect Pest Management

Ajay Baldaniya, Pawan Saini and Shruti Biradar

Introduction

Excessive use of chemical fertilizers, damaging the environment and interfering with the absorption of other nutrients. Pesticides applied to agricultural systems can be detected in air, surface and ground water, sediment, soil, vegetables, and to some extent in food. Pesticides applied in soil for soil-borne pest control and pathogens will also produce accumulated residues and metabolites in soil at very high levels. Utilization of microorganisms (bacteria and fungi) is known to be a detoxifying agent of pesticides. Treatment of microbial and compost addition on pesticide contaminated soil resulted in decreasing percentage of chlorpyrifos, ethoprophos and carbofuran residues after 6 weeks of treatment were 86.35%; 83.91% and 82.32% (Shalaby *et al*., 2010). Composting is a good way to solve environmental issues, such contaminated soil, through bioremediation. Microorganisms play a crucial role in the process. Biochar is a carbon-rich solid material produced via pyrolysis conducted under specific conditions of low oxygen and high temperatures ranging from 250 to >800 °C (Lehmann *et al*., 2006). It is also called the black gold of agriculture. Biochar from paper mill waste has proved beneficial to ferrous soil at a dose of 10 ton ha^{-1} which provides improvements to soil quality and affects plant growth. Utilizing agricultural waste, bioremediation technique with biochar has also been widely developed for the restoration of contaminated soil caused by microbial activity and the enzymes it produces to convert toxic substances into non-hazardous components. Furthermore, biochar has been shown to improve habitat for many beneficial soil microbes, making it an efficient soil additive for promoting soil and plant health (Abit *et al.*, 2012).

Benefits of Biochar

- ✓ Applying biochar to soils has been proposed as a possible strategy for reducing greenhouse gas emissions.
- ✓ It improves the soil properties.
- ✓ It is regarded as one among the nutrients required for plant growth and the production of biochemical components.
- ✓ Both the yield and health of the plants are enhanced by it.
- ✓ It plays an important part in suppressing the plant diseases.
- ✓ Biochar amendment to soils can have a negative effect on herbivory by sap-feeding insects.

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Mode of action of biochar

Increased silica uptake: Silicon (Si) availability in soil and uptake by rice plants increases. Primed by Si transporter genes influx and efflux (LSi_1 and LSi_2, respectively) (Ma *et al*., 2007). Because of silica deposition, primarily in the form of opaline phytoliths, in a variety of tissues, including epidermal silica cells, plant tissues may exhibit physical resistance as well as decreased digestibility and/or increased hardness and abrasiveness. Numerous insect herbivores have now shown to be susceptible to this impact (Teixeira *et al*., 2017).

Decrease nitrogen uptake: For example, though biochar itself is not a N fertilizer in the usual sense, it generally has a larger potential in decreasing soil N losses. This is suggestive of biochar capable of N-retention. So, if biochar is applied to N-deficient soils, the soils common in paddy field, the uptake of N by plants can be reduced. Biochar amendment can decrease nitrogen contents in rice (Liu *et al*., 2014). Therefore, we presume that the rice plant's decreased nitrogen and maybe other nutritional contents as a result of the biochar amendment may lower the rice leaves' suitability as food for *C. medinalis* larvae.

Induced chemical defenses: Increased Si contents in the host plant can enhance not only physical resistance also herbivory-induced chemical defenses. Through the enhanced production of defensive enzymes or possibly the enhanced release of plant volatiles. Si can prime jasmonic acid (JA) mediated anti-herbivore defense responses in rice to herbivores. And biochar amendment leads to an upregulation of four defense-related genes over the period of feeding. One of the main phytohormones involved in biotic stress resistance is jasmonic acid (JA). It works by releasing volatiles that either directly repel invaders by drawing in their natural enemies or indirectly kill herbivores by luring them. Viger *et al*. (2014) offered an alternate theory for the defense responses of plants to biochar application: higher plant growth at the price of downregulating defense-related genes (in Arabidopsis and Lettuce).

Biochar effect on insects

Certain sap-sucking herbivorous insects may have difficulties developing and reproducing when exposed to biochar. For instance, following a brief observation that the wide mite *Polyphagotarsonemus latus* Banks caused less harm to peppers *Capsicum annum* treated with charcoal (Elad *et al*., 2010). A few explanations have been proposed for the negative biochar effect. The first suggests that biochar applications enhance herbivory-induced plant resistance to herbivores. For example, biochar amendment increases jasmonic acid level in two rice varieties on being damaged by the white-backed planthopper. Defense-related genes are upregulated in biochar-treated wheat plants that are being damaged by *S. avenae*. It is generally known that nutritious elements in plants are relevant to feeding performances of herbivorous insects. While some elements (e.g., nitrogen) stimulate probing and feeding, others (e.g., silicon) impair them.

Conclusion

There is increasing interest in using biochar

to reduce insect pests. Given that the application of biochar has demonstrated a detrimental effect on pathogens, it is possible that biochar will have biological features. However, the impact of biochar varies depending on the kind of feedstock we employ as well as the soil conditions we employ. The main mechanisms through which biochar effects insects are altering nutrient uptake by the plant and inducing chemical defenses in the plant. These herbivory-induced defense responses in plants often varies with the herbivore species, the plant species and genotype within species, the environmental conditions under which plants are grown, the number of herbivore species attacking the plant, and feeding habits of the herbivorous species.

References

Abit, S. M., Bolster, C. H., Cai, P. and Walker, S. L. (2012). Influence of feedstock and pyrolysis temperature of biochar amendments on transport of *Escherichia coli* in saturated and unsaturated soil. *Environmental Science & Technology*, 46(15): 8097-8105.

Elad, Y., Cytryn, E., Harel, Y. M., Lew, B. and Graber, E. R. (2011). The biochar effect: plant resistance to biotic stresses. *Phyto-pathologia Mediterranea*, 50(3): 335-349.

Lehmann, J., Gaunt, J. and Rondon, M. (2006). Bio-char sequestration in terrestrial ecosystems-a review. *Mitigation and Adaptation Strategies for Global Change*, 11: 403-427.

Liu, X., Li, L., Bian, R., Chen, D., Qu, J., Wanjiru Kibue, G., ... and Zheng, J. (2014). Effect of biochar amendment on soil-silicon avail-ability and rice uptake. *Journal of Plant Nutrition and Soil Science*, 177(1): 91-96.

Ma, J. F., Yamaji, N., Mitani, N., Tamai, K., Konishi, S., Fujiwara, T. and Yano, M. (2007). An efflux transporter of silicon in rice. *Nature*, 448(7150): 209-212.

Shalaby, S. and Abdou, G. (2010). The influence of soil microorganisms and bio-or-organic fertilizers on dissipation of some pesticides in soil and potato tubers. *Journal of Plant Protection Research*.

Teixeira, P. C., Donagemma, G. K., Fontana, A. and Teixeira, W. G. (2017). Manual de métodos de análise de solo.

Viger, M., Hancock, R. D., Miglietta, F. and Taylor, G. (2015). More plant growth but less plant defence? First global gene expression data for plants grown in soil amended with biochar. *Gcb Bioenergy*, 7(4): 658-672.

Integrated Pest Management in Fruit Crops

Suresh Kumar Jat, Anchal Sharma and Ashok Choudhary

Global transformation in the food system, change in the consumption pattern away from the rice, wheat and pulses and health consciousness are causing major shift in the focus towards the horticultural crops. This increasing recognition of the horticultural produce for nutritional values in human diet has resulted greater demand for fruits in the market. Innovations in production technology of horticultural crops and acceptance of these as a mean of diversification have contributed significantly in meeting the increased demand of these crops. Mango, grapes and pomegranate are the three important fruit crops exported to many countries which follows very stringent quality measures. Having recognized the importance of cultivation of fruits in the state for greater role in providing the livelihood security to the local farmers and nutritional security at the national level, the state department of Horticulture started paying greater attention toward quality standard as well as in preventing losses due to the pests of fruits. To keep a constant watch on the pests and diseases activities and issuance of timely ecofriendly integrated pest management advisories to prevent losses due to the pests so as to minimize the contamination of the produce by pesticides residues and looking after important environment and quarantine issues. It was made possible through the constant efforts of the state department of Horticulture, scientists of state agricultural university and ICAR institutes and through establishment of strong linkage among themselves, the stake holders and the end uses of the technologies and by reducing pest damage and other constraints of increasing the production and productivity.

Principles of IPM

- ✓ Identification of key pests and beneficial organisms.
- ✓ Defining management unit, the Agro-ecosystem.
- ✓ Establishment of Economic thresholds (loss & risks).
- ✓ Development of assessment techniques.
- ✓ Evolving description of predictive pest models.

Concepts of IPM

- ✓ Avoidance of economic damage with minimum affects on the environment.
- ✓ IPM (Term coined by Geir and Clark, 1961): IPM is a system that in the context of the associated environment and the population dynamics of the pest species utilizes all suitable techniques and methods in as compatible manner as possible and maintains the pest populations at

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level below those causing economic injury (FAO, 1972).

- ✓ Economic Injury Level [Term coined by Stern *et al.*, 1959 (EIL)]: It is the minimum pest population which causes the economic damage.
- ✓ Economic damage (ED): The damage caused by the pest to a crop which justifies the cost of control or in other words it is the damage equal to the cost of control.
- ✓ Economic Threshold Level [Term coined by Stern *et al*, 1959 (ETL)]: It is the pest population where control measures should be initiated to prevent the pest population in reaching the EIL.

Basic necessities in IPM

- ✓ Measurement of pest population intensity.
- ✓ Determining the influence of natural enemies on the pest population.
- ✓ Crop loss assessment by the pest.
- ✓ Monitoring of pest population for decision making.

Components of IPM:

Monitoring: Use of different techniques for monitoring of insects.

- ✓ Keeping a track of phytophagous insects and their natural enemies is basic requirement of IPM for taking management decisions.
- ✓ This provides knowledge about the current pests and crop situation and is helpful in selecting the best possible combinations of pest management methods.

Resistant varieties: Use of Malling Merton series rootstocks in apple can prevent/or reduce the attack of woolly apple aphid (*Eriosoma lanigerum*).

Cultural control

- ✓ Tillage
- ✓ Planting and harvesting time
- ✓ Sanitation and Plant diversity
- ✓ Trap cropping
- ✓ Crop rotation
- ✓ Nutrient and water management
- ✓ Spacing may influence the population and damage many insect pests by modifying the micro-environment of the fruit crop or affecting health, vigour and strength of the crop plants.
- ✓ The type and time of tillage can markedly influence the soil environment and affect the survival of insect pests or their natural enemies.
- ✓ Intercropping with suitable crop can either divert the population of insects from the main fruit crop or inhibit the incidence of insect attack.
- ✓ Use of organic manure release nitrogen in small quantities over a longer period and hence their application does not generally leads to pest outbreak in comparison to the use of inorganic fertilizers. Integrated nutrient management (INM) must, therefore, form an integral part of IPM programme.

Physical control

- ✓ Hot and cold treatment for fruit fly.
- ✓ Light trapping for nocturnal insects.

Mechanical control

- ✓ Hand picking: Large size insects or their stages.
- ✓ Exclusion by screens and barriers eg. Against fruit sucking moth and Anar butterfly.

- ✓ Clipping and pruning: for bark eating caterpillar.
- ✓ Trapping.
  - Bait trap for household, fruit sucking moth, fruit fly etc.
  - Pheromone trap for same sex.
  - Malaise trap for beetles, moth etc.
  - Suction trap for sucking pest.
  - Window trap for flying insect.
  - Water trap for BPH.
  - Sticky trap for sucking pest.
  - Blue sticky trap for thrips
  - Yellow sticky trap for aphid.
  - Pitfall trap for soil dwelling insect.

Legal control

- ✓ Legislation for foreign quarantine to prevent the introduction of new pests from abroad.
- ✓ Legislation for domestic quarantine to prevent the spread of established pests within country or a particular state.
- ✓ Legislation for notified campaigns of control against pests.
- ✓ Legislation to prevent the adulteration and mishandling of insecticides or other devices used for the control of pests.

Biological control

- ✓ **Predators:** Lady bird beetles, syrphid flies, lace wings, etc. against sucking pests.
- ✓ **Parasitoids:** *Trichogramma spp* (Egg Parasitoid), *Apanteles spp, Bracon sp*, etc.
- ✓ **Bacteria:** *Bacillus thuringiensis* against caterpillars, grubs.
- ✓ **Viruses:** NPVs and GVs have been successfully used against caterpillars.
- ✓ **Fungi**
  - ***Beauveria bassiana*:** Against beetles and caterpillars
  - ***Metarrhizium anisopliae*:** Against beetles and caterpillars.
  - ***Nomuraea rileyi*:** Against caterpillars
  - ***Verticillium lecanii*:** Against sucking pests
  - ***Paecelomyces sp*:** Against sucking pests

Botanical control

- ✓ A pesticide produced by and extracted from plants and use against pest management called Botanical control.
- ✓ Neem oil at 2% and neem seed kernel extract (NSKE) at 5% with liquid soap 0.05% have been proven effective against pests.
- ✓ Neem cake applied at 250 kg ha^{-1} at last ploughing before sowing has been found effective against cotton stem weevil and soil insects of many other crops.
- ✓ Nicotine, Pyrethrum, etc.

Chemical control: The new generation insecticides are grouped into:

- ✓ **Neonicotinoids/Nitroquanidines:** Imidacloprid, Acetamiprid, Thiamethoxam.
- ✓ **Synthetic pyrethroids:** Lamda cyhalothrin, Beta cyfluthrin.
- ✓ **Insect growth regulators:** Diflubenzuron, Teflubenzuron, Fluenoxuron, Nuvaluron. These insecticides are effective chewing insects and defoliators.
- ✓ **Organic insecticides:** Spinosad, Abamectin,

Cartap hydrochloride. Spinosad is extracted from actinomycetes *Saccharopolyspora spinomosa*. The insecticide formulation contains two components as spinosyn A+D. It is a contact and stomach poison targeted against Defoliators and Chewing insects. Abamectin is extracted from bacteria, Streptomyces avermectilis. This insecticide having contact and translaminar action and it is used as an Acaricide in ornamentals.

- ✓ **Organophosphates:** Malathion, Profenofos, Quinalphos, Dimethoate.
- ✓ **Carbamates:** Thiocarb, Carbosulfan.
- ✓ **Insecticide combinations**

Semiochemicals

- ✓ **Allelochemical:** Allomone, Kairomone, Synomone.
- ✓ **Pheromone:** Sex, Aggregation, Trail, Alarm pheromone

Other components

- ✓ **Genetic control:** Male sterile techniques.

Advantages of IPM

- ✓ It provides sustainable control of the pest and also adds to sustainable crop productivity.
- ✓ It is economically viable and is affordable by marginal farmers.
- ✓ It is environmentally safe.
- ✓ Less health hazards.
- ✓ Social and political stability.
- ✓ Quality produce with minimum pesticide residues and hence will enhance the export of agricultural commodities.
- ✓ Delay the development of resistance.

Food Safety Issues in Modern Agriculture

Yash Pateriya, N. R. Meena, Aman Verma and Anurag Dixit

Abstract

Modern agriculture has undergone significant transformations to meet the growing global demand for food. However, along with increased productivity and efficiency, there has been a rise in food safety concerns associated with various stages of the agricultural process. This abstract provides an overview of key food safety issues in modern agriculture, highlighting the challenges and potential solutions. The first section explores contamination risks at the farm level, examining the use of pesticides, herbicides, and fertilizers. While these inputs contribute to higher crop yields, improper application and residue levels can pose risks to human health. The abstract discusses the need for sustainable farming practices and the adoption of integrated pest management strategies to minimize chemical residues. The second section focuses on post-harvest handling and storage, addressing issues related to inadequate hygiene practices, temperature control, and transportation. Improper handling and storage conditions can lead to the growth of pathogens, mycotoxins, and spoilage microorganisms, impacting the safety of the final food products. The abstract emphasizes the importance of implementing Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) to mitigate these risks. The third section delves into the role of technology in enhancing food safety throughout the supply chain. From blockchain to sensor technologies, advancements offer new opportunities for traceability, monitoring, and quality assurance. The abstract explores the integration of these technologies and their potential to improve transparency and accountability in the food system.

Introduction

Modern agriculture plays a crucial role in sustaining the world's growing population by providing a steady supply of food. However, along with its benefits, contemporary farming practices also give rise to various food safety issues. Ensuring the safety of the food supply is paramount for the well-being of consumers and the overall public health. This introduction will shed light on some key food safety concerns in modern agriculture, examining the challenges and potential conseq-uences associated with these issues.

Pesticide Residues: Pesticides are widely used in modern agriculture to protect crops from pests and diseases. However, the residues of these chemicals can persist on fruits, vegetables, and grains, posing potential health risks to consumers. The overuse or improper application of pesticides can lead to contamination and compromise food safety.

Antibiotic Use in Livestock: In livestock farming,

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antibiotics are commonly administered to promote growth and prevent disease. The overuse and misuse of antibiotics in animals can contribute to the development of antibiotic-resistant bacteria, posing a significant threat to human health. Resistant bacteria can enter the food chain through contaminated meat and pose challenges for effective medical treatment.

Contamination from Environmental Factors: Modern agriculture is susceptible to various environmental contaminants, such as heavy metals, pollutants, and industrial runoff. These contaminants can find their way into the soil and water used for cultivation, leading to the accumulation of harmful substances in crops. Consuming food grown in contaminated environments can have adverse effects on human health.

Genetically Modified Organisms (GMOs): While genetically modified crops aim to enhance productivity and resistance to pests, concerns about the potential long-term health effects and environmental impact persist. The introduction of genetically modified organisms into the food supply raises questions about allergenicity, unintended consequences, and the need for stringent regulatory measures.

Foodborne Illness Outbreaks: The globalization of the food supply chain has increased the risk of foodborne illness outbreaks. Contamination during various stages of production, processing, and distribution can lead to the spread of pathogens, such as Salmonella, *E. coli*, and Listeria, causing widespread illness and necessitating large-scale food recalls.

Water Scarcity and Quality: Agriculture heavily relies on water resources, and scarcity or compromised water quality can impact both crop production and food safety. Inadequate water management practices may lead to the irrigation of crops with contaminated water, increasing the likelihood of microbial contamination in fresh produce.

Conclusion

In conclusion, the abstract summarizes the multifaceted nature of food safety issues in modern agriculture and emphasizes the need for a holistic approach. Balancing the demands for increased production with the imperative to ensure food safety requires collaborative efforts from farmers, policy-makers, and industry stakeholders. The abstract suggests that a combination of sustainable farming practices, improved post-harvest handling, and the strategic implementation of technology can contribute to a safer and more secure global food supply.

Honey Bee Species and Colony Organisation

Suresh Kumar Jat, Ashok Choudhary and Anchal Sharma

The genus *Apis* includes seven recognized species of honey bees of which four are major species and the other three are presently considered as minor. The major species include two domesticated/hive bees, *Apis mellifera* Linn. and *Apis cerana* F. and two well known wild species, *Apis dorsata* F. and *Apis florea* F. The other honey bee species are *A. koschevnikovi*, *A. andreniformis*, *A. laboriosa*. India is a country where all the four major species are present. Three major species were present in India and the fourth *A. mellifera* was introduced from European countries.

***Apis dorsata* F.:** Among the four major honey bee species, Apis dorsata is the largest and is known as "Giant or Rock honey bee". *A dorsata* is most spectacular due to its bigger size, larger nest, greater honey and wax production, and above all, the unique open nesting behavior. *A. dorsata* builds single comb nest attached to a branch of tree, rocks and ceilings of neglected and uninhabitated houses protecting it from direct sun rays and rain. Average crop colony^{-1} is 30 to 40 kg year^{-1}.

***Apis florea* F.:** It is the smallest of all honey bees species and is popularly known as little bee. Like *A. dorsata* it also builds single vertical comb in the open but at a relatively lower height. Comb is fixed to branches of bushes, hedges, trees etc. in the shaded places. The worker bees are temperamentally very gentle; however they do sting when irritated. The bees are very prone to swarming. *Apis florea* is a poor honey yielder and a comb yields 200 to 1200 g of honey. The honey produced by this species is believed to have special medicinal qualities but there are no scientific studies to support this belief.

***Apis cerana* Fab.:** This honey bee is commonly known as Indian honey bee. The species had been the base of Indian apiculture and is found throughout India. This bee lives in the cavities of tree trunks, hollows of rocks, poles and other covered places. It can be domesticated in all kinds of hollows and recesses. On an average a colony yields 5-10 kg of honey year^{-1} in plains but the yields are as high as 20-25 kg of Kashmir race.

***Apis mellifera* L.:** This species is a remarkable honey bee and is found all over Europe and has spread to other continents also during the last six centuries. Now it is found almost in every country. The bee is similar in habits to the Indian honey bee in that it builds parallel combs in hollow of trees, walls or in the shady places. On an average a colony yields 60-180 kg of honey year^{-1}.

Apis koschenikovi: This honey bee species is very

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Honey Bee species and features

Common name	Rock bee	Indian bee	European or Italian bee	Little bee	Dammer bee/ stingless bee/ mosquito bee/ Biting bee
Scientific name	*Apis dorsata*	*Apis cerana*	*Apis mellifera*	*Apis florea*	*Melipona irridipennis* or *Trigona irridipennis*
Size of bee	Largest	Larger than *Apis florea* but smaller than *Apis mellifera.*	Medium	Small	Smaller than *Apis florae* 4 mm length
Tongue length of worker	6.68 mm	4.39-5.53 mm	5.5-7.2 mm	3.44 mm	Very small
Comb type	Single, large, semicircular, open comb	Multiple, medium, semicircular, parallel combs	Multiple, large, semicircular, parallel combs	Single small open comb	Combs made up of mixture of wax, resin/propolis and earth called as Cerumen
Nest location	Branches of tall trees, steep rocks, rafters of tall buildings, water tanks and towers	In hollow cavities of trees, cracks in rocks and old walls, in termite mounds	Hollow trees and caves	Twigs and branches in bushes, hedges, piles of dried sticks and house chimneys.	In cracks of walls, ground, hollow trees and rocks
Distribution (altitude)	Upto 1600 m above MSL	Upto 2500 m above MSL	Variable	Upto 300 m above MSL	Variable
Domestication	Non Domesticated	Domesticated	Domesticated	Non Domesticated	Non Domesticated
Behaviour	High temperament and highly ferocious. Frequent swarming. Highly migratory.	Mild temperament and less ferocious. More prone to swarming and absconding	Less tempera-ment and less ferocious than *Apis cerana*. Less prone to swarming and absconding	Mild temperament and less ferocious. Highly migratory even with slight disturbance and absconding	Less temperament and less ferocious. Less prone to swarming and absconding
Honey yield colony^{-1} year^{-1}	30-40 kg	5-10 kg in plains and 20-25 kg in hilly areas	60-180 kg	200-1200 g	60-180 ml

similar to *A. cerana*. It also nests in natural cavities and builds multiple parallel combs. It has been reported from only some parts of Indonesia.

Apis andreniformis: Small honey bee specis is similar to *A. florea* in many ways. It also builds a single comb in open like the little bee. It has been reported from Thailand, China and Malaysia.

Apis laboriosa: This species is similar to giant honey bee in many ways. It also builds single comb in the open. Its presence has been reported from western China, parts of Himalayas, Nepal, Bhutan, Tibet and India.

Colony Organization

Honey bees are highly social insect which live in a well organized colony. They are capable of multiplying their colonies and establishing new nests; providing a high degree of brood care, communicating among themselves about the distance, direction and potential of a flora and presence of queen bee etc; producing different castes which perform different duties on the basis of division of labour. Different castes are dependent upon each other and bees work for the benefit of the colony as a whole. The worker bees, in the act of

Tablet 1: Morphological Differentiation in Different Castes of *A. mellifera*

Character	Queen	Worker	Drone
Body	Largest and broader than worker	Smallest of three castes	Longer than workers but shorter than queen bee. Stoutly built and broadest of all castes.
Wings	Do not cover the abdomen fully.	Cover the abdomen fully.	Cover the abdomen fully.
Head	Small in proportion to the body size.	Large in proportion to the body size	Largest in proportion to body size.
Abdomen	Shining brown in colour and gradually tapering.	Abdomen with slight golden and black stripes. Tip of the abdomen conical	Tip of the abdomen blunt/ round and hairy.
Compound eyes	Medium sized and well apart	Medium sized and well apart	Large, black, kidney shaped meeting with each other at the top of the head.
Proboscis	Not well developed	well developed	Not well developed
Pollen collecting legs	Absent	Present	Absent
Sting	Curved with very small barbs used for stinging only the rival queen. Sting can be retracted after use.	Well developed sting with barbs, used for colony defence. Sting cannot be retracted after use.	Absent

stinging even die, sacrifices for the defence of the colony. A colony of honey bees is composed of three castes. The queen, a few hundred drones and thousands of worker bees, which may be recognized by their morphological differences (Table 1).

Division of Labour: Age dependent duties of worker bees.

Indoor duties (first 3 weeks of the life)

- ✓ Cell cleaning: Upto 3rd day.
- ✓ Nurse bee: 4th to 13th.
- ✓ Feed the older larvae: 4th to 6th day.
- ✓ Feed the young larvae: 7th to 13th day.
- ✓ Orientation play flights: 13th day.
- ✓ Helper and Comb builder: 14th to 17th day (clean the hive, pack pollen, ripen the honey, produce bees wax, build combs and use propolis inside the hive to plug cracks and crevices).
- ✓ Guard bee: 18-20th day.

Outdoor duties (Remaining 3 weeks of life)

- ✓ Foragers: Bees older than 21 days are responsible for collection of nectar, pollen, water and propolis etc. from the field.

However there is flexibility in the working of worker bees. If due to some reason a specific working class declines or dwindles, bees of other age group can take up their work.

Secretory Proteins in Virulence and Pathogenicity of Plant Pathogens

Vineeth M. and MD Thabrez

Abstract

The fungal plant pathogen secretes a whole suite of proteins, collectively known as secretome, during its interaction with the host. The secretome comprises effector proteins and specific enzymes crucial for host colonization, and the composition of each of these secreted proteins may vary between pathogen types based on the pathogen's mode of nutrition and lifestyle. Firstly, plant pathogens must overcome the physical barrier of host cell walls, composed mainly of polysaccharides such as cellulose, hemicellulose and pectin. To penetrate this barrier most phytopathogenic fungi have evolved an arsenal of secreting cell wall degrading enzymes (CWDEs) to breakdown the components of the plant cell wall. Enzymes involved in the breakdown and assembly of complex carbohydrates are collectively designated as carbohydrate-active enzymes (CAZymes).

Introduction

Peptidases, also known as proteases, are also important during plant pathogen interaction. Serine peptidase and metallopeptidases cleave plant chitinases essential for host defense response. In addition, some peptidases cause cell death. Moreover, fungal and bacterial pathogens secrete effector proteins to manipulate plant cellular response and colonize host tissue efficiently. Although many fungal effectors are small in size and cysteine-rich, they do not share sequence similarities or conserved sequence motifs.

These effector proteins play a major role in inducing plant cell death, suppression of host immune response and manipulating plant cell physiology, thereby increasing the susceptibility to pathogen attack (Zhang *et al.*, 2022).

Effector proteins predicted from secretomes

The set of secreted proteins contains many effector proteins. For most species of fungi, 5-10% of the total proteome are predicted to be secreted proteins. Therefore, predicting secreted proteins is the first step for identifying effector proteins. Normally, secreted proteins have the N-signal peptide and lack a transmembrane structure. Signal P and Target P are the two most frequently used.

Pineda-Fretez *et al.* (2023) studied the proteomic analysis of proteins secreted by *Macrophomina phaseolina* in culture media supplemented with soybean leaf infusion. A total of 250 proteins were identified with a predominance of hydrolytic enzymes. Plant cell wall degrading enzymes and peptidases were found, probably involved in the infe-

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ction process. Predicted effector proteins were also found that could induce plant cell death or suppress plant immune response. Some of the putative effectors presented similarities to known fungal virulence factors. Expression analysis of ten selected protein-coding genes showed that these genes are induced during host tissue infection and suggested their participation in the infection process.

Qian *et al.* (2022) identified an RNase, FoRnt2, from the *Fusarium oxysporum* secretome that belongs to the ribonuclease T_2 family. FoRnt2 is an important contributor to the virulence of *F. oxysporum*, possibly through the degradation of plant RNA. FoRnt2 possesses an N-terminal signal peptide and can be secreted from *F. oxysporum.* FoRnt2 exhibited ribonuclease activity and was able to degrade the host plant total RNA in vitro dependent on the active site residues H80 and H142. Deletion of the FoRnt2 gene reduced fungal virulence but had no obvious effect on mycelial growth and conidial production. The expression of FoRnt2 in tomato significantly enhanced plant susceptibility to pathogens.

Functional annotation of SPs

To obtain the GO annotation and Pfam domain annotation of the SP, the InterProScan-5.47-82.0 was used to annotate the predicted secretome. HMMER 3.1B2 was used to identify carbohydrate enzymes in the secretion group (E-value < 1e-5 and selection of the best hit; The sources of the carbohydrate enzyme datasets were from dbCAN2. BlastP 2.7.1 was used to identify proteases and peroxidases in the secretome (p-value <1E-05 and selection of the best hit; The protease and peroxidase datasets were downloaded from MEROPS and fPoxDB, respectively.

Orthologous clustering of SPs

Chen *et al*. (2023) functionally characterized a non classically secreted nuclear targeting effector in Magnaporthe oryzae (MoNte1). MoNte1 has no signal peptide, but can be secreted and translocated into plant nuclei driven by a nuclear targeting peptide. It could also induce hypersensitive cell death when transiently expressed in Nicotiana benthamiana. Deletion of the MoNTE1 gene caused a significant reduction of fungal growth and conidiogenesis, partially impaired appressorium formation and host colonization and also dramatically attenuated the pathogenicity. Upon pathogen attack, pathogen-associated molecular patterns (PAMPs) activate pattern-recognition receptors (PRRs) in the host, resulting in a downstream signaling cascade that leads to PAMP-triggered immunity (PTI).

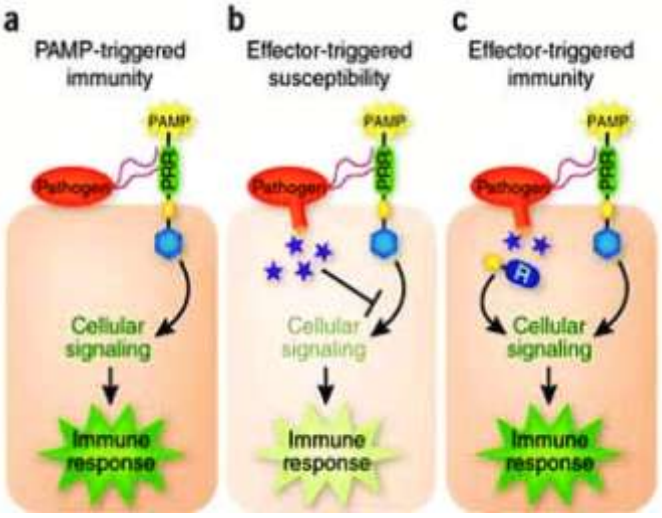


Fig. 1: Simplified schematic representation of the plant immune system

(b) Virulent pathogens have acquired effectors (purple stars) that suppress PTI, resulting in effector-triggered (Fig 1) susceptibility (ETS). (c) In turn, plants have acquired resistance (R) proteins that recognize these attacker-specific effectors, resulting in a secondary immune response called effector-triggered immunity (ETI).

Conclusion

The relationship between host-pathogen recognition and the evolution of pathogenicity, including analyses of the costs of resistance and pathogenicity and whether host-parasite interactions correspond to a GFG or an MA model, are other research areas that would benefit from future interactions between molecular and populational plant pathologists. The evidence available now points to certain patterns, but it comes from a small number of pathosystems, which restricts the validity of theories. In the near future, testing theories and predictions regarding the development of virulence and pathogenicity through the application of current information on the mechanisms of plant-parasite interactions should prove to be a fruitful field of study.

References

Qian, H., Wang, L., Wang, B. and Liang, W. (2022). The secreted ribonuclease T2 protein FoRnt2 contributes to *Fusarium oxysporum* virulence. *Molecular Plant Pathology*, 23 (9): 1346- 1360.

Chen, X., Pan, S., Bai, H., Fan, J., Batool, W., Shabbir, A., Han, Y., Zheng, H., Lu, G., Lin, L. and Tang, W. (2023). A nonclassically secreted effector of Magnaporthe oryzae targets host nuclei and plays important roles in fungal growth and plant infection. *Molecular Plant Pathology*, 24(5):1093-1106.

Pineda-Fretez, A., Orrego, A., Iehisa, J. C. M., Flores-Giubi, M. E., Barúa, J. E., Sánchez-Lucas, R., Jorrín-Novo, J. and Romero-Rodríguez, M. C. (2023). Secretome analysis of the phytopathogen *Macrophomina phaseolina* cultivated in liquid medium supplemented with and without soybean leaf infusion. *Fungal Biology*, 127(5): 1043-1052.

Zhang, S., Li, C., Si, J., Han, Z. and Chen, D. (2022). Action mechanisms of effectors in plant-pathogen interaction. *International Journal of Molecular Science*, 23(12): 6758.

Nature's Underground Allies: The Hidden Heroes of Soil Health

K. V. Deshmukh and A. V. Deshmukh

Abstract

The present article explores the vital roles played by beneficial soil-dwelling insects and microorganisms in fostering a resilient and sustainable soil ecosystem. Unveiling their functions in soil aeration, nutrient cycling and organic matter decomposition, the article sheds light on the indispensable contributions of earthworms, ants, beetles and other insects. These hidden heroes not only enhance soil structure and fertility but also contribute to sustainable agriculture by reducing reliance on chemical inputs.

Introduction

Soil, often overlooked, is vital for life on our planet. Serving as the bedrock of terrestrial ecosystems, it nurtures plant growth by storing essential nutrients such as nitrogen, phosphorus and potassium, ensuring robust development and resilience against environmental stress. The dynamic process of nutrient cycling, facilitated by soil microorganisms breaking down organic matter, sustains plant life and maintains soil fertility. Beyond individual plant health soil stability is crucial for entire ecosystems, with a network of microorganisms regulating water flow, preventing erosion and purifying water. This intricate balance underscores the importance of soil health in fostering biodiversity, supporting agriculture and preserving environmental equilibrium. As we explore the symbiotic relationship between soil health and beneficial soil-dwelling insects, we uncover the mechanisms vital for sustaining life and resilience in the face of environmental challenges.

Role of beneficial organisms in maintaining a balanced and healthy soil ecosystem

The role of beneficial organisms in maintaining a balanced and healthy soil ecosystem is indispensable, contributing to critical processes such as soil aeration, nutrient cycling and organic matter decomposition (Culliney, 2013). Soil-dwelling organisms like earthworms, ants and beetles are key players in these ecological functions.

Soil Aeration: Invertebrates such as earthworms, though not insects but rather annelids are integral to soil health by serving as "ecosystem engineers." As they burrow through the soil, these earthworms create channels that enhance air circulation and water infiltration (Huang, 2023). This process improves soil structure, facilitates root growth and enhances nutrient absorption by plants.

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Nutrient Cycling: Certain insects, like dung beetles, contribute significantly to nutrient cycling within the soil. Dung beetles play a crucial role in recycling organic matter by breaking down dung and incorporating it into the soil. This decomposition process releases essential nutrients, including nitrogen and phosphorus, making them available for plants. Additionally, ants participate in nutrient cycling by transporting and distributing organic materials throughout the soil.

Organic Matter Decomposition: Insects such as beetles and certain species of ants are efficient decomposers of organic matter. They break down dead plant material, contributing to the formation of humus a crucial component of fertile soil. This decomposition process not only recycles nutrients but also enhances soil structure, water retention and overall soil health (Neher and Barbercheck, 2019).



Fig. 1: Soil Heroes

Examples of Beneficial Insects

Earthworms

Role: Earthworms are essential soil-dwelling organisms that enhance soil structure and fertility.

Contribution: They burrow through the soil, creating channels that improve aeration and water infiltration. Earthworms also facilitate nutrient cycling by breaking down organic matter, releasing nutrients for plant uptake.

Ants

Role: Ants play a vital role in soil ecosystems through their nesting and foraging behaviours.

Contribution: Ants contribute to soil aeration by building and maintaining tunnels. They aid in nutrient cycling by incorporating organic matter into their nests, promoting decomposition. Additionally, ants disperse seeds and interact with other soil organisms, fostering biodiversity.

Beetles

Role: Beetles, particularly dung beetles, contribute to nutrient cycling and organic matter decomposition.

Contribution: Dung beetles break down and bury animal dung, recycling nutrients into the soil. This activity improves soil structure and nutrient availability for plants. Ground beetles are also predators of various soil-dwelling pests, contributing to natural pest control.

Nematodes (Certain Species)

Role: Beneficial nematodes are microscopic roundworms that play a crucial role in pest control and nutrient cycling.

Contribution: Some nematode species are predators of harmful soil-dwelling insects and pests, helping to regulate their population. Others contribute to nutrient cycling by feeding on bacteria and fungi, releasing nutrients into the soil.

Springtails

Role: Springtails are small, wingless insects found in soil and leaf litter.

Contribution: Springtails are decomposers, breaki-

ng down organic matter and contributing to nutrient cycling. They also help in soil aeration by moving through the soil and creating channels.

These beneficial insects collectively contribute to maintaining a healthy and balanced soil ecosystem, promoting nutrient cycling, improving soil structure, and aiding in natural pest control. Recognizing and preserving their role is crucial for sustainable and resilient soil management.

Soil Microorganisms and Insect Interactions: The intricate interplay between beneficial insects and soil microorganisms forms a symbiotic relationship that significantly boosts nutrient availability for plants and enhances overall soil fertility.

Decomposition and Nutrient Cycling

Insects Contribution: Beneficial insects, like beetles and ants, actively engage in breaking down organic matter on the soil surface.

Microorganisms Role: Soil microorganisms, including bacteria and fungi, collaborate with insects to break down complex organic compounds into simpler forms.

Enhanced Nutrient Cycling: This joint effort accelerates nutrient cycling as insects consume and break down organic matter, providing a substrate for microorganisms to release essential nutrients like nitrogen, phosphorus and potassium. The byproducts become readily available for plant uptake.

Nitrogen Fixation and Soil Aeration:

Insects Contribution: Certain soil-dwelling insects, such as burrowing beetles, contribute to soil aeration through their tunnelling activities.

Microorganisms Role: Nitrogen-fixing bacteria, often associated with leguminous plant roots, collaborate with insects to enhance soil structure and nutrient availability.

Enhanced Nitrogen Availability: Insects create passageways for air and water movement, fostering the colonization of nitrogen-fixing bacteria. This enriches the soil with nitrogen, a vital plant nutrient.

Organic Matter Breakdown and Humus Formation

Insects Contribution: Soil-dwelling insects, including detritivores like beetles and ants, actively participate in breaking down dead plant material.

Microorganisms Role: Microorganisms, particularly fungi, further decompose the organic matter processed by insects.

Enhanced Humus Formation: The combined efforts result in humus formation- an organic component enhancing soil structure, water retention, and nutrient-holding capacity. Humus acts as a nutrient reservoir, gradually releasing nutrients for plant uptake.

The collaborative interactions between beneficial insects and soil microorganisms create a dynamic and synergistic environment. This not only accelerates organic matter breakdown but also improves nutrient availability, contributing to overall soil fertility.

Challenges and Conservation

It is vital to tackle potential risks facing beneficial insect populations, where habitat loss and the use of pesticides present substantial challenges.

The destruction of habitats deprives insects of the environments they need to thrive, while pesticides can negatively impact their populations. To address these issues, it is imperative to explore conservation measures and sustainable practices. Essential steps involve the adoption of agroecological approaches, preservation of natural habitats and the implementation of integrated pest management strategies. These efforts are crucial for safeguarding and fostering the well-being of these invaluable insects.

Conclusion

Understanding and safeguarding the relationship between soil health and beneficial soil-dwelling insects play a fundamental role in nurturing resilient and sustainable ecosystems. Confronting challenges like habitat loss and pesticide use calls for proactive conservation measures. By embracing agro-ecological practices and drawing insights from successful case studies, we can establish a delicate equilibrium that ensures the protection of these invaluable insects. The vitality of our soils and the richness of biodiversity within our ecosystems hinge on our steadfast commitment to comprehending, appreciating and nurturing the complex life that thrives beneath the ground.

References

Huang, Z. (2023). The hidden world of soil microbes: Guardians of ecosystem health. *Ukrainian Journal of Ecology*, 13(7): 28-30.

Neher, D. A. and Barber check, M. E. (2019). Soil microarthropods and soil health: intersection of decomposition and pest suppression in agroecosystems. *Insects*, 10: 2-13.

Culliney, T. (2013). Role of arthropods in maintaining soil fertility. *Agriculture*, 3: 629-659.

Organic Certification

P. Lakshmanakumar, V. Vasudevan and E. Sree Gayathri

Introduction

The important aspect in modern era of organic farming is certification programme which consists of standards (rule), inspection (checking whether the rules are implemented) and certification (judgment).

Organic farming can be distinguished from other methods of sustainable agriculture by this certification programme. The standards define what can be labeled "certified organic" and sold comercially as such. Certification in organic agriculture generally refers to independent third-party certification.

Certification

A third part implies it is not done by either the producer (first party) or the buyer (second party) the system includes farm inspector and audit trails (checking of records).

Certificate is valid only if it is done by accredited certifying agency. Certification by an agency includes:

- ✓ Certification attested by the certification manager.
- ✓ Inspection done by an inspector.
- ✓ Adopting standards attested by the quality control manager.

From a commercial perspective it is not enough that product is produced organically, what is equally important is that it should be certified as such.

In India, APEDA, an apex organization under Ministry of Commerce, Govt. of India has formulated a National Programme for Organic Production (NPOP). APEDA has developed National Standards for organic export. The scopes of these standards are:

- ✓ Lay down policies for development and certification of organic products.
- ✓ To facilitate certification of organic products confirming to the National Programme containing the standards for organic production.
- ✓ Institute a logo and prescribe its award by accrediting bodies on products qualifying for bearing India organic label.

Certification being expensive, technical and time-consuming other schemes such as Internal Control Systems (ICS), Participatory Guarantee Systems (PGS) and Producer Companies (PC) are being viewed as better options to be promoted in the country.

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Global Certification Bodies

- ✓ 468 organizations offer organic certification services throughout the world.
- ✓ Most certification bodies are in Europe (37%), followed by Asia (31%) and North America (18%). The countries with the most certification bodies are the Japan, USA, Germany and China.
- ✓ Forty per cent of these certification bodies are approved by the EU; 32 per cent have International Organization for Standardization 65 (ISO65) accreditation and 28 per cent are accredited under NOP (National Organic Programme, United States).

Purpose of Certification

It is a marketing tool for exports. The entire production chain from the producer up to the importer has to be inspected by independent and neutral bodies Coertification bodies) that are operating according to specific guidelines. Exporter and the advantages of certification agency are that it acts as a trust building system between farmers and customers, helps in authentication of the product, enables transparency and strengthens the position of the primary producer and helps in market promotion of product.

Certification-Tasks of the Growers -Producers

In order to certify a farm, the producer is typically required to start number of new activities in addition to normal farming operations. is and what is Study the organic standards which cover in specific detail what not allowed for every stage of farming, including storage, transport and sale.

- ✓ Farm facilities and production methods must comply with the standards. This may involve modifying facilities, sourcing and changing suppliers, etc. Records like detailed farm history and current set-up, day to day farming, soil, plant tissue and water analysis etc. should be kept and available for reference.
- ✓ An annual production plan detailing everything from seed to sale, seed sources, field and crop locations, manuring and pest control activities, harvest methods, storage locations etc. will have to be submitted.
- ✓ The field must meet basic requirements of being free from use of prohibited substances (synthetic chemicals, etc.). Annual on-farm inspections are required, with a physical tour, examination of records, and face to face interview. A conventional farm must adhere to organic standards during transition, often, three years.
- ✓ Transitional crops are not considered fully organic. The transition period could be minimized if a farm already growing without any chemicals and followed other procedures of organic farming.

Accreditation Agencies

- ✓ Under NPOP, the mandate of the accreditation agencies includes, among others, the prescription of a package of practices for organic products within their jurisdiction and accreditation of certification agencies.
- ✓ The inspection and certification charges to be levied by the certification agencies are to be fixed

by the accreditation agencies.

- ✓ On the basis of the mandate given by the NPOP, the accreditation agencies have issued detailed regulations covering, among others, standards, packages of practices and procedures for accreditation of certification agencies for their mandated products.

Symbol for Organic Certification



Guidelines for Organic Certification

- ✓ General Requirement for Certification
- ✓ Application for Certification
- ✓ Review of Application
- ✓ Scheduling of Inspection
- ✓ Verification during Inspection
- ✓ Group Certification Standard
- ✓ Continuation of Certification
- ✓ Tamil Nadu Organic Certification Department (TNOCD) Standards for Organic Certification

General Requirement for Certification

- ✓ A registered operator shall Comply with National Programme for Organic Production (NPOP) norms and shall adhere to the National Standards for Organic Production (NSOP) and TNOCD general standards for organic agricultural production, animal husbandry production, honey, wild collection, processing, packaging, storage, labelling and transport standards.
- ✓ Prepare, implement, and update annually an organic production plan and submit to Tamil Nadu Organic Certification Department (TNOCD) every year.
- ✓ Permit on-site inspections with complete access to the production and handling operation, including non-certified production and handling operation, areas, structures, offices by the Organic Certification Inspectors and other higher officials of TNOCD and also officials of APEDA whenever required.
- ✓ Maintain all records applicable to the organic operation for not less than 5 years after creation of such records and allow authorized representatives of TNOCD, State or Central Government officials of accrediting agency access to such records during normal working hours for review and copying to determine compliance with NPOP norms and TNOCD Standards.
- ✓ Pay the prescribed fees charged by TNOCD within stipulated time.
- ✓ Operator shall inform the TNOCD in case of any
  - Application, including drift, of a prohibited substance to any, production unit, site, facility, livestock, or product that is part of an operation and
  - Changes in certified operations or any portion of a certified operation that may affect the organic integrity in compliance with standards of NPOP and TNOCD.

Application for Certification

A person seeking organic certification of production or handling operation shall submit appli-

cation for registration in the prescribed format in triplicate. The application shall include the following information.

- ✓ An organic production or handling system plan,
- ✓ All information requested in the application shall be completed in full i.e. name, addresses, details of contact person, telephone number of the authorized person etc.
- ✓ The names of organic certification body to which application is previously made and outcome, non-compliance noted if any, copy of such records and reason for applying shall be given.
- ✓ Any other information necessary to determine the compliance with the standards specified.
- ✓ The prescribed registration fee, one-time inspection fee, one-time travel cost shall be paid by the operator along with the application form. The other prescribed fees shall be paid by the operator as notified by TNOCD during the course of certification process.

Review of Application

- ✓ Application shall be scrutinized.
- ✓ Any information required shall be communicated to the operator and operator shall submit the requested information immediately.
- ✓ Application without prescribed fee shall not be reviewed.
- ✓ After review of application decision shall be made by TNOCD on acceptance/ rejection of the application.
- ✓ The rejected application shall be returned to the applicant citing reasons for rejection along with the fees enclosed.
- ✓ Fee paid for the applications accepted by TNOCD shall not be refunded at any circumstances.
- ✓ An initial onsite inspection shall be fixed and communicated to the operator after registration or shall be noted in the registered copy of application itself.
- ✓ An applicant can withdraw the application at any time but the fees paid shall not be refunded.

Scheduling of Inspection

- ✓ Initial field inspection shall be fixed at a reasonable time so that the operator can demonstrate compliance or capacity to comply with the standards while conducting inspection of land, facilities and activities. Such initial onsite inspection shall be delayed up to six months from the date of registration so as to give time for the operator to comply with required standards including record keeping.
- ✓ All onsite inspection shall be conducted only in the presence of operator or an authorized representative of the operator who is knowledgeable about the operation. However, this requirement does not arise in the case of unannounced / surprise inspections.
- ✓ There shall be one annual inspection and additional inspection shall be fixed based on the risk assessment carried out during initial inspection.

Verification during Inspection

- ✓ During the field inspection, the OCI shall verify

the compliance or the capacity to comply with the NPOP standards and TNOCD standards.

- ✓ Verification of information on organic production plan submitted by the operator and practical implementation of the standards.
- ✓ OCI shall ensure that the prohibited substances/ materials are not used and in case of suspicion the OCI, shall draw samples of soil, water, wastes, seeds, plant tissues, plant, animal and processed products.
- ✓ The samples shall be tested in NABL accredited ISO 17025 laboratories. The operator shall bear the cost of samples sent for analysis.
- ✓ During onsite inspection the OCI shall conduct interview with the person responsible for the organic production system to confirm accuracy of information gathered during inspection and completeness of inspection, observation gathered during the onsite inspection. The inspector shall also collect other required information as well as issues of concern.
- ✓ After inspection the OCI shall prepare checklist and inspection report and obtain signature of the operator or his representative.
- ✓ A copy of the check list and inspection report shall be sent to the concerned operator and Evaluator.
- ✓ Inspection reports shall be evaluated by the evaluator within reasonable time and any additional information required shall be addressed to the operator.
- ✓ In case of any non-compliance to the prescribed standards an explanation shall be called from the operator and sanctions shall be imposed if required.

Group Certification Standards

General Requirement: This system applies to farmer groups, co-operatives, producer groups, contract production and small-scale processing unit.

- ✓ The producer group shall have similar production system and within the same geographical proximity.
- ✓ Farmers holding four hectares and above can be part of group but has to be inspected individually. The total area of such farm shall be less than 50% of total area of group.
- ✓ Processor an exporter may be a part of the same group but they shall be inspected annually by TNOCD.

Constitution of Group

- ✓ Group shall have a legal status or structured organization.
- ✓ The group shall maintain a documented Internal Control System (ICS).
- ✓ The responsibilities of the group shall be delegated to individual members/committee for carrying out specific activities.
- ✓ The group shall develop an internal quality system manual comprising of implementation of internal control system and assessment of risk.

Internal standards for group certification

- ✓ Internal standards shall be prepared in local language under the framework of NPOP standards.

- ✓ The internal standards shall include definition of production unit, method of dealing with part conversion, parallel production, period of conversion, production norms for entire production unit, harvest and post-harvest procedures.
- ✓ The IQS shall include buying procedure, trading procedure and processing procedure for the group.

Granting of Certification

- ✓ TNOCD shall issue Scope Certificate or Certificate of Registration, Transaction Certificate and Product Certificate to the eligible operators.
- ✓ The issue of certificate shall be based on the decision taken by the certification committee.
- ✓ Scope Certificate.

Denial of Certification

- ✓ If the Organic System of operation does not comply with the Standards, the operator shall be intimated about denial of certification stating the reasons for such action with non-conformities noticed and time limit for submission of correction.
- ✓ Upon receipt of such reports the operator shall correct the noncompliance and submit the action taken report to the TNOCD.
- ✓ TNOCD shall ensure the correction carried out by the operator before issuing certificate.
- ✓ Operator with another certification body willing to come under TNOCD certification shall submit a new application form to TNOCD along with the notification of issue of non-conformities issued by the previous certifier.
- ✓ TNOCD upon receipt of such application shall verify the correction carried out onsite and supporting documents. Any records required shall be received from the, CB previously registered or from APEDA.
- ✓ TNOCD shall issue written notice to the operator for denial of certificates in case of operator failing to respond to the notification of non-compliance.
- ✓ A notice of denial of certification shall inform the operator about the reasons and applicants right to reapply for certification or file an Appeal to the Appeal Committee.

Continuation of Certification

- ✓ To continue certification the operator shall renew registration by paying fees for renewal.
- ✓ An updated annual report for production or handling operation shall be submitted by the operator.
- ✓ An updated corrective action for minor non-conformities previously identified shall be submitted by the operator.
- ✓ TNOCD after receipt of renewal application for continuation of certification shall scrutinize the application and verify the facts.

Fair trade

All the operators shall perform their operation with social justice, they shall not employ child labour, and shall protect rights of women, smallholder, traditional agriculture and indigenous people's rights.

Appeal

- ✓ Registered operator may appeal against the notice of denial of certification, proposed suspension or revocation to the appellate authority (Director, TNOCD).
- ✓ An appeal shall be made within the time period mentioned in the notification or within 30 days from the date of receipt of the notification, whichever occurs later. The appeal shall be considered filed on the date of receipt in the office of Director, TNOCD. The decision of the appellate authority shall be final.

Conclusion

The organic certification system through assures the quality of the produce for the consumer is very cumbersome and expensive for the poor farmers. Organic agriculture provides a sequel of environmental services in addition to producing safe food.

References

https://apeda.gov.in/apedawebsite/organic/organic_products.htm

https://jaivikbharat.fssai.gov.in/

Constraints for Crop Production in Rainfed Agriculture under Climate Change

P. H. Rathod, P. V. Mahatale and M. D. Yenpreddiwar

Introduction

The climate changes of geological proportions are occurring over time spans as short as a single human life time. They are happening at a time when many of the world's life support systems are already stressed by the growth of population, economy, industry and agriculture which has led to unsustainable exploitation of natural resources. The climate change-led global warming mainly occurs due to increasing concentration of atmosphere emissions resulting from various human activities. They include primarily carbon dioxide, the necessary product of combustion of fossil fuels, CFCs (Chloro Flouro Carbons) from refrigeration and helons from firefighting systems, methane from the anaerobic digestion of organic matter, and the nitrous oxide from increased use of chemical fertilisers. These gases absorb and partially trap the heat radiated by the earth, reradiate some of it back to the surface, and this leads to the warming of the earth's atmosphere.

Rainfed agriculture refers to the crop cultivation wherein majority of the water requirement of the plant is met by rainfall with minimum irrigation interventions. It has been theorized that even if the full irrigation potential of the country is used up, 50 % of the net sown area will still depend on the rainfall for fulfilling the water requirement of the crop. This shows the importance of rainfed agriculture in the Indian scenario. Increasing/decreasing trend in area, production as well as productivity of the major rainfed crops over the years have also been concluded. Besides environmental factors, as rainfall, the changes in crop production may also be attributed to other aspects as increase/decrease in area, changing cropping patterns, improved agricultural practices and use of high yielding climatic resilient varieties (Kumar *et al.*, 2004).

Change in rainfall amount and pattern is particularly deleterious to rainfed agriculture (Venkateswarlu and Shankar, 2012) affecting crops either directly or indirectly. Direct effect is mainly in form of change in duration of crop and deleterious impact on pollination and fertilisation, an important determinant of crop yield in seed crops. While indirect effect is mainly attributed to reduction in crop production as a result of change in availability of water, exposure to abiotic stress as drought and flood and altered dynamics of weeds, pest and diseases (Maheswari *et al.*, 2019). For the development of stress tolerant varieties, the identification of traits responsible for maintaining and promoting the

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growth as well as development of crops during the stress period is important (Shanker *et al.*, 2014; Maheswari, 2017). The tolerance to stress conditions depends primarily on the ability of plant to withstand the adverse conditions as well as reproduce successfully. Generally multiple loci distributed throughout the crop's genome are responsible for genetically controlling stress tolerance as well as resource-use efficiency.

India is the seventh-largest country in the world with an area of 3,287,263 square kilometres (India at a Glance: Area, 2020). The country receives maximum of its annual rainfall from the southwest summer monsoons which provides 80% of the total annual rainfall and is one of the most productive seasons (Collier and Webb, 2002; Bagla, 2006). The country has predominance of agriculture and its allied sectors and is one of the largest sources of livelihood for the people. Agriculture sector is predominated by rainfed agriculture which occupies almost 50.9 % of the countries' net sown area and contributes 40 % of the total food grain production. Rainfed agriculture in India constitutes a wide variety of crop species, prominent among them being sorghum, maize, millets, chickpea, pigeon pea, groundnut, rapeseed, soybean and sunflower (Kumar and Abbo, 2001; Agarwal *et al.*, 2013; Nayak *et al.*, 2013; Singh *et al.*, 2014; Kumar *et al.*, 2016).

Rainfed agriculture is subjected to a number of productivity constraints including low and aberrant rainfall, degradation of land, poor land productivity, low input levels, lower technology use, inadequate availability of fodder, low livestock productivity and inadequate availability of credit. It is predominated by crops including coarse cereals, pulses and oilseeds and their production is largely dependent on the amount of rainfall received during the crop season.

Impact of Climate Change on Agriculture

Given that rain-dependent agricultural area constitutes about 60 per cent of the net sown area of 142 mha (TERI, 2003), Indian agriculture continues to be fundamentally dependent on the weather, with much of the recent high growth rates being the result of a number of successive good monsoons. Indian climate is dominated by the southwest monsoon, which brings most of the region'sprecipitation. It is critical for the availability of drinking water and irrigation for agriculture. Agricultural productivity is sensitive to the following classes of climate induced effects:

* Effect of increasing temperature on crops.
* Direct effect of increasing levels of CO_2 on crops.

Effect of Temperature: The change of weather with respect to temperature in different seasons is very characteristic in India. One of the major greenhouse effects would be an increase in global mean temperature ranging from 1.5 to 4.5 ^{o}C. At present it is not clear as to how this global mean temperature would be distributed in different regions of the world. However, it is predicted that there could be serious effects on the productivity of many crops. Cereals are the major foodgrains for consumption in our country. Since Independence the proportion of

wheat and rice in total cereal production has shown a remarkable change. In 1951-52 the proportion of wheat and rice was 55 per cent and coarse grains accounted for 45 per cent. The proportion has changed to 85 and 15 per cent in 2009-10. An important implication of this change is that our dependence on rice and wheat has increased considerably. Any factor which would influence the productivity of these crops would affect our food security. Both these crops are sensitive to higher temperature as discussed by Sinha *et al.* (1989) and Sinha and Swaminathan (1990).

Rainfed Farming: Some Issues

A large part of the India's sub-continent is prone to droughts which is evident from frequent recurrence of severe droughts in one-third of India's geographical area. The fragile ecosystems of the drylands with their delicate ecological equilibrium and reduced water supply are very vulnerable to the stresses of climatic fluctuations. There are large variations in the total rainfall from place to place in the country and from year to year. These variations are particularly large in drought-prone areas where the rainfall is 20-40 cm or less. And this precipitation occurs in mere 20-30 hrs at any place. Moreover, an overwhelmingly large part (>85 per cent) of this water goes waste as floods and less than 15 per cent infiltrates underground to recharge the groundwater (Valdiya, 1987). Even if there is a normal rainfall in any region as a whole, there is always a considerable uneven distribution and erratic precipitation.

Policies and Practices for Rainfed Farming in the Light of Climate Change

The area under rainfed agriculture is going to expand because of the impact of climate change. Agriculture in rainfed areas differs from that of irrigated systems in capital base to crop productivity. It is the dominant source of employment, income and sustenance for the bulk of the population in the country. Its contribution to national income and employment is around 70 to 80 per cent supporting 44 per cent of our total foodgrain requirement in terms of cereals (50 per cent), pulses (86 per cent), oilseeds (80 per cent) etc. (Singh, 2002). Hence, any climatic change which adversely affects the resource base and production environment of rainfed agriculture would severely affect the economic and social impacts. In the context of nation's food security, the focus should be to enhance the productivity of rainfed agriculture by restructuring the agricultural policy that is appropriate and exclusive to rainfed farming and also differs with that of irrigated farming systems. Through a variety of practices aimed at diversification and sustainability, the farmers in the rainfed regions have developed adjustment mechanisms against climatic risks (Jodha *et al.*, 1987).

The following are the major areas that need policy advocacy

Land Development: The present concept of land development in all the rural development programmes orbits around soil and moisture conservation practices. Simple soil conservation practices/ structures may protect the land from further degrada-

tion but do not address the productivity of lands that were already degraded. The concept of productivity should be seen in the broader context of land rather than crops which includes management of crop, water and soil fertility. It is also revealed in many studies that continuous application of chemical fertilisers over long period results in soil degradation. Moreover, subsidy to selected nutrients resulted in imbalance of nutrients in soil thus impairing the complete nutrient availability to plants which results in deficiency of several micronutrients.

Groundwater Management: Rainfed agriculture has become more vulnerable because of rainfall variances recurring as a result of climate change. The irony is that, many a time the *kharif* crop which is the only crop on which rainfed farmers can be dependable is in jeopardy due to rainfall fluctuations. A minimum of 1-2 irrigations should be provided during critical stages of crop growth to sustain the crop as well as to increase the yield substantially. The implied value of capital cost of surface irrigation was worked out to be Rs. 70,000 ha^{-1} (Dhawan, 1997). Whereas, there is no policy to support investments on critical or protective irrigations in rainfed areas.

Support Systems for Rainfed Farming: Another major concern is the timely availability of seeds including contingency seeds, seedlings for planting bunds etc. as timely sowing reduces the risk of pest incidence by 30 per cent. However, the present policy does not recognise the seed banks and hence, most of the subsidy given for the seeds by the government is being appropriated in other routes. Seed systems within the village under the control of community in the form of community managed seed banks could solve the problems of timely availability of seed. Contingency crop seeds and seeds of intercrops should also be made available at seed banks. The seed banks run by many voluntary organisations are already in place. The experiences of these organisations could be considered for institutionalisation of the seed bank programme through farmers' groups or through SHGs. This system can result in crop diversification through inter-cropping with food and fodder crops and also in promoting green manuring.

Cultivation Practices: The System of Rice Intensification (SRI) is being promoted to improve water use efficiency in paddy. This method also reduces methane gas emissions which is a major culprit being highlighted in case of water-logged paddy cultivation. The SRI advocates drainage of soil which not only aerates the soil but also the drying stimulates rice root development and also accelerates decomposition of organic manure in the soil organically which reduces methane emission. The concern of the farmers with this system is it promotes weeding. Therefore, popularising the SRI with incentivising the weeding machinery may be promoted.

Extension System: Studies reveal that extension system under public-private partnership involving NGOs gives good results in dissemination of technology. Extension and technology support by the government was more towards large and medium

farmers whereas, the NGO's support was more for small and marginal farmers (Radhika *et al.,* 2006). Therefore, the involvement of CBOs, SHGs, farmer groups, CIGs, paravets, village activists etc. should be institutionalised in extension system to act as a window for alternate delivery system for technology transfer, supply of inputs, awareness programmes and communication campaigning etc.

Conserving the Genetic Material: Rainfed region is endowed with wide biodiversity that withstands harsh climate. However, proper policy is not in place to conserve it. The biodiversity management committees as visioned in the National Bio Diversity Act were not in place in many panchayats. Many livestock breeds and crops native to rainfed regions are replaced by the new breeds which failed to adjust to the harsh climate. For example, drought resistant Deccani sheep breed in Deccani track and local poultry breed are replaced by the improved breeds. Similarly, millets of rainfed crops are replaced by irrigated dry crops and irrigated crops. Developing drought-resistant varieties by using the local strains of rainfed crops need to be promoted.

Conclusion: The climate resilient varieties of major rainfed crops, one of the most effective options to mitigate the effect of climate change on productivity of rainfed lands, have been documented. This assessment would be helpful in devising strategies for maintaining as well as enhancing production of crop in future and hence sustain one of the most important aspects of Indian economy: the rainfed agriculture.

References

Agarwal, D. K., Billore, S. D., Sharma, A. N. *et al*. (2013). Soybean: Introduction, improvement, and utilization in India-Problems and prospects. *Agriculture Research*, 2: 293-300.

Bagla P. (2006). Controversial rivers project aims to turn India's fierce monsoon into a friend. *Science*, 313(5790): 1036-1037.

Collier, W. and Webb, R. H. (2002). Floods, Droughts, and Climate Change, University of Arizona Press (published 1 November 2002), ISBN 978-0-8165-2250-7

Compendium of Lectures in Summer School on Land Use Diversification in Rainfed Agro Eco System,April 15- May 5, 2002, CRIDA, P: 1-10.

Dhawan, B. D. (1997). Large Scale Canal Irrigation How Cost Effective? *Economic and Political Weekly*, 32: 26.

Jodha, N. S., Virmani, S. M., Huda, A. K. S., Gadgil, S. and Singh, R. P. (1987). The Effects of Climatic Variations on Agriculture in Dry Tropical Region of India, in the Impact of Climate Variations on Agriculture. Vol. 2. Assessment in Semi-arid Regions, M. L. Parry, T. R.Carter, N. T. Konijn, eds., Reidel, Dordrecht. The Netherlands.

Shanker, A. K., Maheswari, M., Yadav, S. K., Bhanu, D., Attal, N. B. and Venkateswarlu, B. (2014). Drought stress responses in crops. *Functional Integration of Genetics*, 14: 11-22.

Kumar, C. V. S., Singh, I. P., Vijaykumar, R., Patil, S. B., Tathineni, R., Mula, M. G., Saxena, R. K., Hingane, A. J., Rathore, A., Reddy, C. R., Kumar, M. N., Sudhakar, C. and Varshney, R. K. (2016). Pigeonpea - A unique jewel in rainfed cropping systems. *Legume Perspectives*, 11: 8-10.

Singh, H. P. (2002). Land Use Diversification for Sustainable Rainfed Agriculture in the 21st Century.

Maheswari, M., Sarkar, B., Vanaja, M., Srinivasa, Rao, M., Prasad, J. V. N. S., Prabhakar, M., Ravindra Chary, G., Venkateswarlu, B., Choudhury, P. R., Yadava, D. K., Bhaskar, S. and Alagusundaram, K. (Eds.). (2019). Climate resilient crop varieties for sustainable food production under aberrant weather conditions. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. P64.

Maheswari, M. (2017). Enhancing tolerance to climatic stresses in rainfed crops: The road ahead. p. 105-111. In: Agriculture under Climate Change: Threats, Strategies and Policies. Eds. Belavadi VV, Nataraja KN, Gangadharappa NR. Allied Publishers.

Radhika Rani, Ch., Srivastava, S. C. and Suresh Babu, V. (2006). Risk Vulnerability and Coping Mechanisms in Rainfed Agriculture - A Study in Three States', Research Report, Published by National Institute of Rural Development, Hyderabad.

Kumar, K. K., Rupa, K. K., Ashrit, R., Deshpande, N. R. and Hansen, J. W. (2004). Climate impacts on Indian agriculture. *International Journal of Climatology*, 24: 1375-1393.

Singh, P., Nedumaran, S., Ntare, B. R., Boote, K. J., Singh, N. P., Srinivas, K. and Bantilan, M. C S. (2014). Potential benefits of drought and heat tolerance in groundnut for adaptation to climate change in India and West Africa. Mitigation Adaptation Strategy for Global Chang, 19: 509-529.

Sinha, S. K. and Swaminathan, M. S. (1990). Deforestation, Climate Change and Sustainable Nutrition Security: A Case Study of India, Climatic Change.

Sinha, S. K., Rao, N. H. and Swaminathan, M. S. (1989). Food Security in the Change Global Climate, In Proc. of the Conference - The Changing Atmosphere: Implications for Global Society, World Meteorological Organisation, 165-190.

Valdiya, K. S. and Bartarya, S. K. (1989). Diminishing Discharges of Mountain Springs in a Part of Kumaun Himalaya. *Current Science.*

Venkateswarlu, B. and Shanker, A. K. (2012). Dryland agriculture: bringing resilience to crop production under changing climate. In: Crop Stress and its Management: Perspectives and Strategies (pp. 19-44). Springer Netherlands.

Ornamental Crops: A Source for Essential Oil Extraction Industry

M. Kumaresan

Introduction

Flower-patterned essential oils are basically produced or extracted from the flowering part of the plants. Flowers acquire naturally sweet and floral scent that is conscientious for the type of aroma produced from its natural essential oil. Essential oils are present in different parts of plants viz. leaves, bark, wood, roots, gum, seeds, fruits, rhizomes and flowers etc., Essential oils are most famous for used in perfumes and other type of fragrances. Essential oils are indispensable in various human activities. They are adjuncts of cosmetics, soaps, pharma-ceutical preparations, perfumery, confectionery, ice-cream, aerated waters, disinfectants etc.

Components responsible for fragrance in ornamental crops

Flowers	Chemical constituents
Rose	1- citronellol, nerol, gereniol, linalool, eugenol etc.
Jasmine	Benzyl acetate, benzyl benzoate geraniol, eugenol, benzaldehyde, indole, nerol, methyl jasmonate etc.
Tuberose	Geraniol, nerol, benzyl alcohol, methyl benzoate, methyl salicylate, eugenol and methyl anthranilate
Marigold	Dihydrotagetone , β-ocimene, tagetone, limonene etc.,
Murraya paniculata	Phenyl ethyl alcohol, indole, (*E*)-nerolidol, benzyl benzoate, phenyl ethyl benzoate and manool
Champaca	Linalool, methyl benzoate, benzyl acetate, phenyl, α-ionone, β-ionone, ionone oximes and methyl linoleate
Carnation	Phenyl ethyl alcohol, eugenol, hexyl benzoate, benzyl benzoate, benzoin, nootkatone, benzyl salyicylate, m-cresyl phenyl acetate, hexadecanoic acid and eicosene.

Essential oil yield of major flowers

Flower crops	Concrete recovery (%)
R. damascena	0.14
R. centifolia	0.11
R. borboniana	0.09
J. auriculatum	0.28-0.36
J. grandiflorum	0.25-0.32
J. sambac	0.14-0.19
Tuberose (Single flowered cultivars)	0.08-0.11
Marigold (*Tagetes* sp.)	1.25
Champaca *(Michelia champaca)*	0.16-0.20
Magnolia *(Magnolia biondi)*	0.03-0.16
Ylang-ylang *(Cananga odorata)*	0.8-0.95
Nerium *(Nerium indicum)* cv. Double pink	0.32-0.33

Flowers crops used for extraction of essential oil

Rosa sp.



R. damascena

- ✓ One of the world's most fragrant flowers is the rose.
- ✓ *R. damascena* and *R. bourboniana* are grown for rose oil in India.
- ✓ The world produces 10 t of rose oil, of which Bulgaria produces more than 5 t.
- ✓ India produces very little rose oil, not more than 10 kg.
- ✓ *Rosa damascena* yielded 1 kg of oil per 4000 kg of flowers in Bulgaria.
- ✓ Rosa damascene yields 0.05% oil.
- ✓ Bulgaria and Turkey are the world's leading producers of rose essential oil

Jasminum spp.

- ✓ India, Egypt, China, and Morocco are the countr-

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ies that produce jasmine essential oil.



Jasminum grandiflorum

- ✓ Jasmine is the most important raw material used in perfumery.
- ✓ The top producer of concrete is Egypt (10-15 t yr^{-1}), followed by Morocco, France, Algeria, Italy, and India.
- ✓ The oil recovery of *Jasminum auriculatum* is the highest at 0.29%.
- ✓ The finest oil (0.25-0.30%) comes from *Jasminum grandiflorum*, most commonly used species for essential oil extraction.

Polianthes tuberosa

- ✓ Tuberose flowers emit a powerful and delightful fragrance.
- ✓ The concrete concentration in single flowered cultivars ranges from 0.08 to 0.11 percent.



Polianthes tuberosa

- ✓ From 30,000 kg of loose flowers, 27.5 kg of concrete and 5.5 kg of absolute can be obtained.
- ✓ Generally speaking, 1150 kg of flowers yield 1 kilogram of concrete.
- ✓ Oil is used to create stronger fragrances and is also utilized in non-alcoholic drinks, baked foods, ice cream, and candies.

Tagetes sp

- ✓ One of the most popular types of essential oils used in a baby product is marigold.



Tagetes minuta

- ✓ Commercial production of *T. minuta* and *T. erecta* essential oils for use in perfumes occurs in France and Africa.
- ✓ About 1.25 percent of freshly ripened flowers yield essential oil content

Champaca

- ✓ *Michelia champaca* is also known as Magnolia Champaca.



Michelia champaca

- ✓ Compounds such methyl eugenol, 62% linalool, beta-elemene, and beta-caryophyllene are found in champaca oil.
- ✓ It emits a powerful, lingering, and very nice scent.
- ✓ Ylang Ylang oil and champaca oil can be combined.

Murraya paniculata

- ✓ Orange jessamine, or *Murraya paniculata*, is an ornamental plant with white blooms that have a pleasant scent.



Murraya paniculata

- ✓ *M. paniculata* are very scented and contain a significant amount of essential oil, they are also employed as a source of tastes in addition to perfumery.

Ylang-ylang (*Cananga odorata*)

- ✓ Flowers from *Cananga odorata* (*C. odorata*) or ylang-ylang which is native to the islands of



Cananga odorata

Indian Ocean and tropical Asia.

- ✓ It is among the most often used essential oils.
- ✓ Widely used due to their sweetly fragrant flowers.
- ✓ The oil comprised of p-methyl anisole, linalool, methyl benzoate, benzyl acetate, geranyl acetate etc.

Carnation

- ✓ Carnation fragrances have been included into soaps, talcum powder, hair oils, and brilliantines.



Carnation

- ✓ Carnation is mostly utilized as a fragrance modifier in contemporary cosmetic perfumes to provide a warm, spicy floral scent.
- ✓ A key ingredient in scents for both men and women is the smell of carnations.

The Vital Role of Biochar in Agriculture and the Environment

Kasthuri Kajeevan

In recent years, the farming sector has seen a growing interest in sustainable practices aimed at improving soil health, increasing crop yields, and reducing environmental damage. Among sustainable agricultural practices, the utilization of biochar has emerged as a prominent solution garnering significant attention. Crafted through the pyrolysis of organic materials such as wood chips, residual crop components, or even animal by-products, biochar stands as a versatile remedy for addressing multi-faceted challenges within modern agriculture while concurrently delivering environmental advantages. Its importance in farming comes from its multiple roles as a soil enhancer. When added to soil, biochar improves its structure and fertility of the soil through several mechanisms. Beyond its agricultural benefits, biochar also plays a crucial role in reducing environmental degradation. Integrating biochar into farming systems offers a promising path for sustainable farming, providing numerous benefits such as improved soil health, higher crop yields, climate change mitigation, and environmental protection. As the farming industry continues to address the challenges of feeding a growing global population while protecting natural resources, biochar emerges as a practical and environmentally friendly solution poised to shape the future of agriculture.

Improving Soil Health, Fertility and Crop Yields

Biochar offers significant benefits in agriculture by enhancing soil health and fertility. When added to soil, biochar increases the amount of organic matter, which is essential for healthy soil. This improvement in organic matter helps to create better soil structure, retain water more effectively, and make nutrients more available to plants. Biochar has a large surface area and plenty of tiny holes, allowing it to hold onto nutrients like nitrogen, phosphorus, potassium, and micronutrients. This means that these nutrients are less likely to be washed away with water and can be used by plants over a longer period.

Biochar also provides a habitat for helpful soil microorganisms that play key roles in breaking down nutrients for plants to use. Its neutral to slightly alkaline pH can help balance out acidic soils, creating a better environment for plants to grow. By improving soil structure through better aggregation, water retention, and air circulation, biochar encourages roots to grow deeper, take up more nutrients, and absorb water more efficiently, ultimately leading to healthier plants and higher crop yields.

Using biochar in compacted soils can improve their structure by creating more space for roots to grow and allowing better nutrient uptake. It also supports beneficial microorganisms in the soil,

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like bacteria and fungi, which contribute to nutrient cycling, disease control, and overall soil health. By promoting microbial activity, biochar helps maintain soil health, supporting optimal plant growth and increasing crop productivity. Biochar-treated soils are more resistant to erosion because they have better structure and stability, reducing soil loss and nutrient runoff. Additionally, biochar can help suppress soil-borne diseases by improving soil conditions and fostering the growth of beneficial microorganisms. This contributes to healthier crops and higher yields over time.

Carbon Sequestration and Climate Change Mitigation

Biochar plays a crucial role in carbon sequestration and climate change mitigation by locking carbon in the soil for long periods, thus reducing atmospheric CO_2 levels. Unlike traditional biomass burning, which releases carbon into the atmosphere, the pyrolysis process used to produce biochar stabilizes carbon, preventing it from being readily decomposed and released back into the atmosphere. As a result, biochar helps to offset carbon emissions and contribute to efforts aimed at mitigating global warming and climate change.

Reduction of Greenhouse Gas Emissions

In addition to sequestering carbon, biochar can also help reduce greenhouse gas emissions from agricultural activities. When used as a soil amendment, biochar enhances soil microbial activity, leading to a decrease in the emissions of nitrous oxide (N_2O), a potent greenhouse gas associated with synthetic fertilizer application. Furthermore, biochar-amended soils have been shown to emit lower levels of methane (CH_4), another significant greenhouse gas produced in anaerobic conditions, such as flooded rice paddies.

Livestock Feed Additive

In agriculture, biochar can be incorporated into livestock feed as an additive. Studies suggest that biochar in animal feed can improve digestion, reduce methane emissions from livestock, and enhance overall animal health.

Water Quality Improvement and Nutrient Management

Biochar application in agriculture can also contribute to water quality improvement and nutrient management. By enhancing soil structure and reducing nutrient leaching, biochar helps to minimize nutrient runoff into water bodies, thereby reducing the risk of eutrophication and algal blooms. Biochar has been utilized in water filtration systems to remove contaminants and impurities. Its porous structure and high surface area make it effective in adsorbing pollutants, heavy metals, and organic compounds from water.

Remediation of Contaminated Soils

Biochar has shown promise in the remediation of contaminated soils. Biochar's porous structure and high surface area make it effective for remediation of contaminated soils. It can adsorb heavy metals, organic pollutants, and other contaminants, reducing their bioavailability and preventing their uptake by plants.

Renewable Energy Production

The process of producing biochar through pyrolysis generates bioenergy in the form of heat and syngas. This bioenergy can be utilized for heating, electricity generation, or as a substitute for fossil fuels.

Promotion of Sustainable Land Use Practices

The use of biochar promotes sustainable land use practices by providing a means to utilize organic waste materials effectively. By converting biomass residues into biochar, agricultural by-products that would otherwise contribute to waste accumulation and environmental pollution can be repurposed as valuable soil amendments, closing the nutrient loop and reducing the reliance on synthetic fertilizers. Furthermore, biochar production can generate additional revenue streams for farmers and rural communities, thereby fostering economic development and livelihood improvement.

Biochar holds immense potential as a sustainable solution for addressing various challenges faced by modern agriculture while also providing significant environmental benefits. From enhancing soil health and fertility to mitigating climate change and improving water quality, the importance of biochar in agriculture and the environment cannot be overstated. As we continue to explore innovative approaches to meet the growing demand for food production while minimizing environmental impacts, biochar stands out as a promising tool for building resilient and sustainable agricultural systems for the future.

Residual Effect of Plastic on Soil Health

Ajay Kumar Baheliya, Krishna Kumar Patel, Neeraj Kumar and Dharmendra Kumar

Plastic has emerged as a critical environmental challenge in contemporary times, exerting significant impacts on ecosystems, marine life, and human health. While the immediate repercussions of plastic waste are readily apparent, the enduring effects on soil health often go unnoticed. This article aims to delve into the persistent impact of plastic on soil, unravelling the mechanisms through which it compromises soil health and examining the broader implications for the environment. The global crisis of plastic pollution is undeniable, with far-reaching consequences for ecosystems and human well-being. Despite its ubiquity in daily life, the profound and often underestimated impact of plastic on soil and environmental pollution necessitates closer examination. This article seeks to explore how plastic interacts with soil, elucidating its role in contributing to broader environmental contamination.

Plastic items and bags have become pervasive components of everyday life, contributing to a global environmental concern. While the visible consequences of plastic pollution are widely acknowledged, the insidious effects on soil health and microbial communities are frequently overlooked. This article delves into the specific impacts of plastic items and bags on soil, shedding light on the intricate relationship between these materials and the delicate balance of soil ecosystems. Plastic pollution poses an undeniable environmental challenge, with consequences extending to the most fundamental component of ecosystems: soil. This article endeavours to explore the detrimental effects of plastic items and bags on soil health, with a particular focus on their impact on the delicate microbial communities crucial for sustaining soil fertility and ecosystem balance. By unravelling these complexities, we can gain a deeper understanding of the intricate interplay between plastic and soil, fostering awareness and driving informed efforts toward mitigating this global environmental crisis.

There are some points that explain the harmful effects of plastic on soil health and the environment, besides human life, both directly and indirectly, which are given below.

Persistence of Plastic in Soil

Plastic items, designed for durability, persist in the environment long after their intended use. When discarded or improperly managed, these items find their way into the soil, where they resist natural degradation processes. The longevity of plastic items in soil sets the stage for a cascade of consequences that extend beyond the visible surface.

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Microplastics: The Unseen Threat

Microplastics, tiny bits of plastic smaller than 5 mm, are a big problem for soil and nature. They're made when larger plastic items break down into smaller pieces over time. Once they get into the soil, they mess with its makeup and can harm the tiny living things there. These microplastics come from different places, like old plastic breaking down, farming activities, and even synthetic clothes breaking apart. They mess up the soil's texture, how much water it can hold, and how plants get their food. This makes it harder for plants to grow well and for the soil to stay healthy. They also bring in harmful chemicals that hurt the tiny organisms in the soil. Overall, these plastic bits make it tough for soil to do its job properly, which affects how well plants can grow and how healthy the environment is. So, we need to do something about it quickly to protect our soil and nature.

Long-Term Consequences: The impact of plastic items and bags on soil health goes beyond immediate concerns. The persistence of microplastics in the soil can lead to chronic contamination, affecting agricultural productivity and posing risks to human health through the food chain. The degradation of soil microbial communities can result in a cascading effect on higher trophic levels, disrupting entire ecosystems.

Persistence and Breakdown: Plastic's persistence in the environment is a testament to its durability. When plastic waste infiltrates soil, it undergoes a slow process of breakdown, giving rise to smaller particles known as microplastics. This breakdown is primarily a result of exposure to sunlight, wind, and microbial activity. While it may take years, if not centuries, for larger plastic items to degrade, the resulting microplastics pose a unique threat due to their minuscule size.

Ecological Consequences: The residual effects of plastic on soil health have far-reaching ecological consequences. Impaired soil fertility can lead to reduced agricultural yields, threatening food security. Moreover, contaminated soil poses a risk to the health of plants, animals, and humans alike. As plastic particles persist in the environment, they may eventually find their way into water bodies, exacerbating the broader issue of plastic pollution.

Water and air pollution: The consequences of plastic in soil extend beyond terrestrial boundaries. Microplastics can migrate through the soil profile, reaching groundwater and surface water bodies. This not only contaminates drinking water supplies but also contributes to the broader issue of water pollution. Additionally, the wind can transport microplastics from soil surfaces into the air, potentially leading to respiratory issues and further contaminating the atmosphere.

Mitigation and Sustainable Practices

Addressing the response of plastic in soil and its role in environmental pollution requires a comprehensive and coordinated effort. Mitigation strategies include reducing plastic use, improving waste management systems and promoting recycling initiatives. Sustainable alternatives to plastic, coupl-

ed with public awareness and education, play a crucial role in preventing further contamination of soil and the environment.

Conclusion

The impact of plastic on soil health is a complex issue that requires a multifaceted approach. It involves reducing plastic use, improving waste management, and promoting sustainable alternatives. Research into innovative plastic remediation solutions is also crucial to mitigate long-term consequences. Understanding the interconnectedness of environmental systems is essential for developing strategies that safeguard soil health and ensure a sustainable future. Mitigating plastic pollution involves adopting responsible waste management practices, reducing single-use plastic consumption, and promoting the development of biodegradable alternatives. By safeguarding soil health, we protect ecosystems and ensure a healthier, more sustainable future for our planet. The response of plastic in soil triggers a chain reaction with profound environmental implications. Urgent action is needed to curb plastic's impact on soil and environmental pollution. By embracing sustainable practices, innovating alternative materials, and fostering a global commitment to responsible consumption, we can work towards preserving soil resilience and fostering a healthier, more sustainable environment for future generations.

References

Horton, A. A., Walton, A., Spurgeon, D. J., Lahive, E. and Svendsen, C. (2017). Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. *Science of The Total Environment*, 586: 127-141.

Barnes, D. K. A., Galgani, F., Thompson, R. C. and Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1526): 1985-1998.

Horton, A. A., Walton, A. and Spurgeon, D. J. (2017). Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. *Science of the Total Environment*, 586: 127-141.

Nizzetto, L., Futter, M. and Langaas, S. (2016). Are agricultural soils dumps for microplastics of urban origin? *Environmental Science & Technology*, 50(20): 10777-10779.

Rillig, M. C. and Bonkowski, M. (2018). Microplastic transport in soil by earthworms. *Science Advances*, 4(5): eaau1761.

Wagner, M., Scherer, C., Alvarez-Muñoz, D., Brennholt, N., Bourrain, X., Buchinger, S. and Reifferscheid, G. (2014). Microplastics in freshwater ecosystems: What we know and what we need to know. *Environmental Sciences Europe*, 26(1): 12.

Cyber Extension: Important Cyber Extension Initiatives in India

Antima Meghwal and Sanju Meena

The extension methods such as newspapers, leaflets, radio and television that were conducted indirectly through conventional mass media had faced various challenges. Submission of extension materials through conventional media in the process of delivering agricultural information is sometimes still not on time, right place, target and not necessarily accepted by farmers. Today, the agricultural knowledge to overcome the problems faced by farmers are more varied, so that agricultural extension workers are required to be ready at any situation. The appropriate strategy of information dissemination can improve farmers' ability to find information and change information dissemination. Agricultural information needs is still dominated by the conventional information sources, communication technology-based information sources or ICTs. Based on these conditions, Agency for Agricultural Extension and Human Resources Development (BPPSDMP) as the representative of the Ministry of Agriculture modified the formulation and dissemination of agricultural extension through internet-based network called cyber extension. The existence of cyber extension can support the performance of agricultural extension both in enriching extension content and introducing it to farmers. In addition, cyber extension in Indonesia is extension information system through internet, to support provision extension material and agricultural information of extension workers in facilitating agribusiness learning process for main and business actors. The cyber extension is one of the effective mechanisms for developing communication networks among farmers by implementing ICTs in the agricultural extension system. The effectivity of agricultural information is one of the indicators in achieving the success of agricultural extension. The performance of extension workers are also reflected by the level of farmers' satisfaction who receive agricultural extension services.

Important tools of cyber extension

E-Mail

- ✓ E-mail (electronic mail) - is the most frequently used application in the cyber extension.
- ✓ Currently is being used by over 50 million people for business and personal use.
- ✓ E-mail allows us to send & received text messages to other users of the internet.
- ✓ Some of well-known tools are- web browsers like Netscape, Internet explorer etc.
- ✓ To send an e-mail you have to know the receiver's e- mail address.

Telnet: Telnet is an application that allows one to log on to a remote computer. It is like a terminal emulation programme. Telnet sessions present text based data as a terminal would. However now GUI

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(Graphic User Interface) clients are now available which offer better service. Before the advent of World Wide Web (WWW) the telnet sessions were very common, but now most of the organizations use web sites for applications such as this.

FTP

- ✓ FTP (File Transfer Protocol)
- ✓ FTP use to send copies of files from one computer to another computer and is responsible for highest percentage of data transfer on internet.
- ✓ FTP transfers can either through "anonymous" connection or by password protected ID.
- ✓ Command line and graphic user interfaces.

Gopher

- ✓ Gopher was the first attempt of making it easy to access resources on the internet.
- ✓ As recently as in 1994 gopher was considered the most useful internet tool.
- ✓ Gopher uses text based nested menus to access FTP sites, directories, files & documents.
- ✓ It was designed by computer scientists at the University of Minnesota.

Archie: It is a service run on only a handful of hosts which allows you to search a list of all the files and directories on all the FTP sites in the world.

World Wide Web: The World Wide Web has become so popular that it has almost replaced all the above Internet tools and is slowly becoming synonymous Internet. WWW is an organization of hypertext documents containing text, images, animation, sound, video and increasingly interactive programmes. WWW is an easy to use interface. The web is truly worldwide. The World Wide Web is called because sites around the world can be accessed, and because documents seem to stretch web like through endless hyperlinks (Allan Leek Jensen). The WWW is thus the most important tool of cyber extension. The web sites hosting a particular institution or organizations are searched and browsed through search engines. The web can turn to be a better medium for transfer of knowledge and technology to the farmers by placing the up-to date and dynamic information. Then Institute Launched Web site at the Institute Server. To consolidate and disseminate information related to fruit crops to farmers an attempt has been made to develop Software entitled Information System for Arid Fruit Crops. In this paper we describe about the development of website and utilization website. In addition to that we present the preliminary information about the development of project "Information System for Arid Fruit crops" which can be used for Cyber Extension.

Application of cyber extension

- ✓ Village information shops Dr. M. S. Swaminathan Research Foundation, Chennai.
- ✓ Information villagers MANAGE in Ranga Reddy District in Andhra Pradesh.
- ✓ Gyandoot net initiative of District Dhar, Madhya Pradesh.
- ✓ Warna wired village of National Informatics Center (NIC) in Kolhapur- Sangli Districts of Maharashtra.

Advantages of Cyber Extension

- ✓ Cyber extension will save money, time and effort.
- ✓ Cyber extension will save time, cut steps from extension process.
- ✓ Cyber extension will be information rich and interactive.
- ✓ Cyber extension will offer instant international reach.
- ✓ Cyber extension will be continuously available.

Important Cyber Extension Initiatives in India

Agricultural Technology Information Centre (ATIC)

- ✓ ATIC is a "Single window delivery system" for different innovative and farm worthy technologies.
- ✓ Established during the NATP (1998).
- ✓ The participating institutions/ SAUS are expected to provide support in terms of technological as well as methodological backstopping for implementation of the Project.

Karshaka Information Systems Services and Networking (KISSAN)

- ✓ Integrated, multi-modal delivery of agricultural information system.
- ✓ Citizen centric e-governance projects of the Department of Agriculture, Govt. of Kerala.
- ✓ Officially launched on 1st November 2003.
- ✓ Project was conceived, developed and managed by the Indian Institute of Information Technology and Management- Kerala

Raita Samparka Kendras (RSK)

- ✓ RSKS are the Agricultural Extension Centres opened under Raitha Mitra Yojane.
- ✓ Implemented in the State since 2000-01.
- ✓ Established one at each hobli (sub-blocks) levels.
- ✓ Headed by an Agricultural Officer duly supported by Assistant Agricultural.
- ✓ Officers and Agricultural Assistant.
- ✓ Farmers can visit these RSK's personally or they can contact the RSK's over phone to obtain the information.
- ✓ The scheme is implemented in all 27 Districts, 176 Talukas and 745 Hoblis of the State.
- ✓ Out of 745 RSKs established 251 RSK's are provided with Computers and 523 Kendras are provided with Telephone connections.

Bhoomi (Computerization of land records)

- ✓ Bhoomi is centrally sponsored scheme impleme-nted by the government of Karnataka.
- ✓ The project was implemented in the year 2001 Bhoomi covers more than 20 million land records and more than 6.7 million land owners in the Karnataka state.
- ✓ Farmers today can obtain a print RTC copy for a fee of Rs.15 from a computerized land record kiosks (Bhoomi centers) located in 177 taluka offices.
- ✓ National Informatics Centre (NIC, Bangalore) developed the Bhoomi land records management software Farmers can obtain copies of land records whit at the Bhoomi Land Records Kiosk.

Evaluation of E-Government Systems: Project Assessment of Bhoomi

- ✓ By Rahul De
- ✓ Of the users who had used the earlier manual system and also the Bhoomi system, 78% found Bhoomi to be simpler to use.
- ✓ In the manual system about 60% of the respondents had to meet 2-4 officials for their work, whereas with the Bhoomi system 79% could complete their work by interacting with kiosk staff itself.
- ✓ 74% of users of Bhoomi stated that their documents.
- ✓ 28% respondents had to make more than one trip to the kiosk.
- ✓ 3% of users had to pay a bribe with the new system, as opposed to 66% in the manual system.

India Agriline

- ✓ Launched by EID Parry in early 2001
- ✓ Internet kiosks in 16 villages
- ✓ These kiosks were called Parry's Corners
- ✓ Parry's corners - a one-stop shop
- ✓ www.Indiagriline.com portal was developed to meet the demand for information and connectivity.

Jan-Mitra Project (Rajasthan)

- ✓ A UNDP-Rajasthan government ICT partner-ship.
- ✓ The main objective of the Jan Mitra project is to provide a single- window facility to citizens.
- ✓ Each service comes with a price.

Rural e-seva

- ✓ Web enabled rural kiosks termed e-Seva centres at the mandal level working since Objectives.
- ✓ Helping the rural women as information leaders to bridge the gender divide.
- ✓ Providing people of the district various services.
- ✓ 200 kiosks in West Godavari district.
- ✓ One-stop-shop' for over 66 services.

Akshaya Project

- ✓ Primary contact point for residents.
- ✓ First district wide e-literacy project in India.
- ✓ 600 Akshaya centres have been set up covering 600 villages.
- ✓ Working since 2002

Major services

- ✓ Agriculture Information System
- ✓ Implementation of Health Data Acquisition System
- ✓ Government Services
- ✓ e-Education

e-Choupal

- ✓ ITC-IBD initiative
- ✓ Launched in June 2000
- ✓ ‘e-Choupal’ services today reach out to over 4 million farmers growing a range of crops in over 40,000 villages through 6500 kiosks across ten states.
- ✓ Farmers can access Offers the information, products and services needed by the farmers.

Chiraag Kendras

- ✓ n-Logue has been set up to provide Voice and Internet services in every underserved village and small towns in India.
- ✓ Dedicated to evolving technically superior and cost-effective connectivity solutions for Indian

rural population.

- ✓ Established by Telecommunications and Computer 57 Networks

Tara Kendras

- ✓ TARA haat was launched as a pilot in late 2000 in Madhya Pradesh and Uttar Pradesh.
- ✓ Today, TARA haat has 41 centres.
- ✓ It's an initiative promoted by Development Alternatives (DA), an NGO.
- ✓ TARA haat delivers their service through a network of franchised community and business centres owned by individual entrepreneurs.

Digital Marketing: A Sustainable Way to Thrive in Competition of Agriculture Marketing

Antima Meghwal and Sanju Meena

Introduction

The agriculture and food sector is a vital element of any economy as it determines the existential potentiality of any community by taking care of the primary need of human being and its livestock. The share of agriculture in the total GDP of any economy is quite significant and even surpasses the half way mark in the case of developing nations. Its employment providing capability is well appreciated in economic literature as the percentage of population employed in this sector is highest in countries like India. As economy develops, there is a decline in the share of agriculture in GDP and employment generation capability, making it less attractive as an economic sector. Agriculture as an economic sector is also facing new challenges, such as biodiversity protection, broad-based cultural landscape preservation, rural development including the creation and safeguarding of jobs, and the notion of regional products as cultural assets, the impact of climate change, etc. To remain significant, agriculture sector has undergone changes which facilitated the adoption of new business strategies which can lead to the expansion of the international market of agricultural products. The contribution of agriculture can be improved by strengthening relations in the industry, through agro processing, value additions and improving post-harvest operation, storages, distribution and logistics that are essential elements of agribusiness value chains. In an economy like USA, with highly productive agriculture sector, the agribusiness sector is large consisting of different layers of activity in marketing, storage and processing. Productivity is the key factor affecting growth in agribusiness. The growth and productivity of agribusiness are vital for economic development of any country and the new forces for economic growth worldwide are technological innovation in every aspect of the business processes.

Agriculture Marketing

Marketing activities deal with the identification of customer's need, creation of products to satisfy such needs and exchanging such products with potential buyers at a price thereby establishing profitable relationships between seller and buyer. This helps in promoting and enabling the process of trading goods or service. As marketing is involved in every economic sector, its presence in agriculture sector is very prominent and responsible for the changes which have taken place in this area. A sound marketing strategy ensures reasonable benefits to the producers and consumers. Agriculture marketing deals with the application of marketing tools and techniques in the area of agriculture with

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the main objective of increasing the value of the agricultural output and thereby maximizing profit. Marketing has helped in increasing the satisfaction level of agriculture customers through proper identification of their need and delivering such benefits as desired by them. The most laudable contribution of agriculture marketing is timely decimation of accurate information to potential customers. This has facilitated both the buyer and seller to plan their action for better outcome. So agricultural marketing covers the amenities involved in transferring agricultural outputs from the farm to the ultimate users. Several interrelated actions are involved in undertaking this, such as planning, production, grading, packing, transport, storage, agro-and food processing, distribution, advertising and sale.

Digitalization of Agriculture Marketing

Digital marketing is a non-conventional virtual platform basically on Internet for identifying and accepting consumer's requirements, promoting goods and services, associating customers through usage of digital technologies and devices. Nowadays running a business without any online presence is not possible as because figures show that the trend from consuming in shops goes in the direction of online consuming. The agriculture sector being so vital for the economy cannot be devoid of the digitalization process.

In simple term, digital agriculture marketing is the application of digital technologies in agriculture marketing and involves promotion of agricultural products or brands via one or more forms of electronic media. The main objective of digital marketing is to promote brands, build preference and increase sales through various digital marketing techniques. There is a massive increase in the number of agribusinesses which are looking for the Internet as a marketing, management, service and coordination tool. For anyone who wants to go for digital marketing should have individual website or App through which different promotion and tools are linked and used. Digital marketing can help an organization to reach its target customer easily and at lowest possible cost. Usually, above-the-line promotion, refers to traditional methods of advertising, such as, print advertisements in magazines and newspapers, billboards and TV advertisements is very expensive and increases the cost of marketing. In contrast, below-the-line promotion aims to reach more targeted groups of consumers that too at very low cost. Use of digital technology helps in below-the-line promotion.

E-marketing is also known as Internet Marketing, Web Marketing, Digital Marketing, or Online Marketing and referred to those marketing strategies and techniques which use online ways to reach target customers, gather relevant information and provide the required offerings. In the whole process, digital technologies are used. E-marketing of agricultural products means marketing of agricultural products through online ways from agricultural producer to any business organizations or final users. E-marketing or digital marketing of

agricultural products is gaining acceptance world-wide due to its ability to overcome some of the major problems associated with agriculture, right from production till final consumption.

Enablers of Digital Marketing of Agricultural Products

FAO (2018) report on digital marketing of agricultural products has identified three key factors (enablers) which are responsible for the growth of digital marketing of agriculture and will influence the future growth. They are:

- ✓ The increase use of Internet and mobile and social networks among farmers and agricultural extension officers.
- ✓ Digital skills among the rural population and
- ✓ A culture which encourages digital agri-preneurship and innovation.

High speed Internet connections, i.e. 4G connection, smartphones, mobile apps, social media and digital engagement platforms have significantly improved access to information and services for those who are involved in agriculture production and distribution. With newly acquired skill in digital technology, people find it convenient to use it. Secondly, the reach and 24x7 availability have contributed positively. Education and income are two important determinants as educated people tend to adopt new technologies faster and better. Digitalization increases the demand for digital skill development. So with the rise in literacy rate, the demand for digital skill increases which leads to faster adoption. With the rise in competence level of the potential users, the process of digitalization will accelerate.

Advantages of Digitalization

Digitalization is capable of improving the performance of these stages and upon its application can benefit the agriculture Digital Marketing: A Sustainable Way to Thrive in Competition of Agriculture sector by creating huge opportunities for farmers and other people involved in this sector. The advantages can be broadly grouped under the following:

Market Expansion: Digitalization of agriculture marketing will help in widening the market. With the application of Internet, farmers can approach worldwide market with increased number of potential customers. With easy and free flow of information, awareness level is bound to increase, which will facilitate the smooth and hassle free transaction of agricultural output. With the spread of Internet in the rural areas, the availability of information regarding different aspect of agriculture and its marketing is assisting in developing this market. Internet has made this market operational 24x7, which enables the farmers, the most important stakeholders, access the market as per their convenience, which in turn increasing the size of the market. In fact, the digitalization process is creating an environment of freedom to do business and people can participate in the transaction process as per their convenient time as every time is the real time. It is much easier for customers to find substitutes from competitors on the Internet because of the minimal

effort a person has to make to get to another website. So it can be said that digitalization allows people to participate not only as per their suitable time, it also provides huge amount of information which makes the whole process more effective and efficient.

Cost Reduction: The main objective of marketing is not only to facilitate transaction of goods and services but also to carry out these activities at minimum cost. Use of Internet has increased the reach of this market in the one hand and has also reduced the transaction cost. Schwarz *et al.* (2015) found that average return on online marketing investment is very high making the whole process quite profitable which has attracted many agribusiness owners to adopt Internet marketing. Easy access to information reduces the risks of overproduction of agricultural crops, provides access to real prices for agricultural products, and reduces the cost of intermediary services, simplifies the construction of transport chains. Shortening the chain of agricultural product marketing through digital marketing helps in saving time and avoiding unwanted expenses.

Reduction in Agriculture Waste: With the application of digital technologies, the transaction process has not only become smooth but less time taking. The volume of agricultural products is huge and is easily perishable. Time lost due to complicated transaction process actually contributes in enhancing the chances of wastage and degradation of output. Application of digital technology makes the transaction process smooth, fast and accurate, which actually reduces the wastage of agricultural products. The net income of the farmers and other people involved in agriculture marketing increases due to decrease in wastage. Establishment of online agriculture market facilitates people to sell or buy agricultural product and provides platform to advertise their outputs.

Encourages Healthy Competition: Digitalization has provided an efficient platform for gathering information about different product availability, their features, sources and price. It acts as a repository for the buyers and seller which can easily access and used. It is much easier for customers to find substitutes from competitors on the Internet because of the minimal effort a person has to make to get to another website. Every Internet page is full of different kinds of touch points as advertisements and offers which makes it hard for companies to guide potential buyers to a certain website without "losing" them through their way of the Internet. Online platform encourages customers to share their experience of product utilization against the experience of using competitors' products and then to publish these blocks of information online. So it encourages consumers to get involved in the marketing process and thereby increases the credibility of the message delivered. Digitalization encourages higher involvement of customers and producers in the marketing process of agricultural output which give rise to healthy competition. With reasonable chance for comparison, the customer can make their purchase without any bias and the produ-

cer can identify the scope for improving the quality of their output. Many small producers can join the transaction process more easily which was otherwise not possible in the traditional method. Producers can comprehend the need for improving the packaging of their product and can avail the advantage of branding their output.

Easy Availability of Rare Products: Digital technology can be used in every aspect of agriculture right from plantation to final consumption by users. It is being used by agriculturist to predict the expected pests attach in the area of cultivation and the potential need of pest control agents. The cultivators can analyse the expected yield from the standing crops and can plan mode of action for increasing the return by proper utilization of this technology. This technology can assist the marketers of agricultural products to deliver the right kind of product to the appropriate customer at the right place with minimum effort and cost. If properly applied digital technology can bring paradigm shift in the area of agriculture and food sector. Though the potential role of digital technology in the area of agriculture and its marketing seems impressive but a lot has to be done to make it more effective. FAO (2019) report on digitalization of agriculture and its marketing reflects the positive aspect on the basis of falling handset prices (smart phones), increasing Internet coverage and the growing youth population. This indicates the significant opportunities for the use of mobile phones in agricultural areas and the huge opportunity for performance improvement.

Evaluation of Different Genotypes on Growth, Yield and Quality of Cowpea (*Vigna unguiculata* L.)

Satyam Pandey and Vijay Bahadur

Abstract

This comprehensive review explores the multifaceted aspects of cowpea (*Vigna unguiculata*), shedding light on its unique position in global agriculture. Recognized for its adaptability to diverse agroecological conditions, resilience to environmental stress, and nutritional richness, cowpea emerges as a versatile leguminous crop with substantial potential for enhancing agricultural sustainability. The article covers key facets of cowpea cultivation, including genetic diversity, breeding strategies, and sustainable agricultural practices. Emphasizing the economic and nutritional significance, it underscores cowpea's pivotal role in addressing food security challenges, especially in regions with adverse climatic conditions. The exploration of its potential in improving soil fertility and reducing pest pressure through rotational and intercropping practices adds to its agricultural value. The integration of modern biotechnological tools for cowpea improvement, coupled with its nutritional composition, positions cowpea as a crucial asset in combating malnutrition and contributing to a balanced diet. The article concludes by outlining future research directions and policy considerations, envisioning the continued growth and adoption of cowpea in diverse farming systems globally, thus contributing to sustainable agriculture and food security efforts.

Introduction



Cowpea, scientifically known as *Vigna unguiculata*, is an annual plant belonging to the pea family (Fabaceae). It is primarily cultivated for its edible legumes, and its origins are believed to be in West Africa. Cowpeas are grown in warm regions worldwide and serve various purposes beyond being a food crop.

Key Characteristics

Plant Type: Cowpeas are typically climbing or trailing vines, and they may exhibit a variety of growth habits.

Leaves: The plants have compound leaves with three leaflets.

Flowers: Cowpea plants produce white, purple, or pale-yellow flowers, often in pairs or groups of threes. These flowers typically appear at the ends of long stalks.

Pods: The pods of cowpeas are long and cylindrical, reaching lengths of 20-30 cm (8-12 inches), though this can vary among different cultivars.

Adaptation: Cowpeas are well-adapted to hot climates and are known for their heat tolerance. They are also drought-tolerant, making them suitable for cultivation in arid regions.

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Uses

- ✓ **Edible Legumes:** The primary purpose of cultivating cowpeas is for their edible legumes. These legumes are a good source of protein and are commonly used in various cuisines around the world.
- ✓ **Hay Crop:** Cowpeas are grown as a hay crop, providing fodder for livestock.
- ✓ **Green Manure/Cover Crop:** In agriculture, cowpeas are utilized as a green manure or cover crop. When plowed back into the soil, they contribute organic matter and nutrients, enhancing soil fertility.

Cultivation

- ✓ Cowpeas are cultivated in warm regions where they can thrive in the heat. They are adaptable to various soil types.
- ✓ The plants are known for their ability to withstand drought conditions, making them suitable for cultivation in areas with limited water availability.
- ✓ Cultivars of cowpeas may vary in terms of pod size, color, and other characteristics, allowing for diverse agricultural applications.

Overall, cowpeas play a significant role in agriculture, providing a valuable source of nutrition, fodder for livestock, and contributing to sustainable farming practices through their use as cover crops. Cowpea is a versatile plant known for its drought-hardy nature. Belonging to the Leguminaceae family, it goes by various common names such as Cowpea, Lobia, Barbati, and Black-eyed pea. The plant's distinctive wide and droopy leaves contribute to its ability to conserve soil and moisture through a shading effect. This leguminous plant serves multiple purposes, including being used for food, feed, forage, fodder, green manuring, and as a vegetable. The seeds of cowpea are nutritious and are a valuable component in human diets. Additionally, they are employed as affordable livestock feed. Both green and dried cowpea seeds are suitable for canning and boiling.

In the Indian context, cowpea is considered a minor pulse crop primarily cultivated in arid and semi-arid regions. It is grown in pockets of states such as Punjab, Haryana, Delhi, West Uttar Pradesh, Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra, and Gujarat. The cultivation of cowpea in these areas helps in addressing food and fodder requirements, especially in regions with challenging climatic conditions.

Varieties: Cowpea also known as black-eyed pea or southern pea, has diverse varieties with varying sizes, colors, and growth traits. Popular types include Black-Eyed Pea, California Blackeye, Mississippi Silver, California #5, Iron and Clay (grown for forage and cover crop), Purple Hull, Cream Pea, Pinkeye Purple Hull, IT89KD-288 (resistant to diseases and pests), and TVu 946 (drought-tolerant, used in water-scarce areas). These varieties cater to different climates and agricultural needs, showcasing regional adaptations worldwide. Farmers select varieties based on factors like climate, soil type, and specific agricultural requirements.

- ✓ **Black-Eyed Pea (*Vigna unguiculata* subsp. unguiculata):** This is one of the most common and widely recognized varieties, known for its distinctive black eye on the seed.
- ✓ **California Blackeye (*Vigna unguiculata* subsp. unguiculata var. unguiculata):** A variety with a medium to large seed size, popular in the southern United States.
- ✓ **Mississippi Silver (*Vigna unguiculata* subsp. unguiculata var. unguiculata):** This variety is known for its silver-colored seeds.
- ✓ **California #5 (*Vigna unguiculata* subsp. unguiculata var. unguiculata):** Another California variety, known for its large seeds and good yield.
- ✓ **Iron and Clay (*Vigna unguiculata* subsp. sesquipedalis):** This variety is often grown for forage and as a cover crop. It has long, slender pods.
- ✓ **Purple Hull (*Vigna unguiculata* subsp. unguiculata var. unguiculata):** Characterized by purple-colored pods and seeds, this variety is popular in the southern United States.

Different stages of cow pea cultivation

Cowpea is a legume that is widely cultivated for its edible seeds and leaves. Here is an overview of the different stages of cowpea cultivation:

Site Selection

- ✓ Choose a well-drained field with good sunlight exposure.
- ✓ Cowpea can tolerate a wide range of soil types but prefers well-drained, sandy loam soil.

Land Preparation



- ✓ Prepare the land by plowing and harrowing to create a fine seedbed.
- ✓ Incorporate organic matter into the soil for better fertility.

Sowing

- ✓ Cowpea can be sown directly in the field.
- ✓ The optimal sowing time depends on the region, but it is generally during the warm season.
- ✓ Sow seeds at a depth of about 2-5 cm, with rows spaced 60-90 cm apart.

Germination and Seedling Stage

- ✓ Germination usually occurs within 5-7 days after sowing.
- ✓ Thin the seedlings to achieve the desired plant density.
- ✓ Provide adequate irrigation during the seedling stage.

Vegetative Growth

- ✓ Cowpea plants have a bushy growth habit.
- ✓ Regularly monitor for pests and diseases, and apply appropriate measures if necessary.
- ✓ Provide sufficient water, especially during dry periods.

Flowering Stage

- ✓ Cowpea plants typically start flowering about 30-40 days after sowing.
- ✓ Flowers are usually white, and pods develop after successful pollination.

Pod Formation and Development

- ✓ Pods develop after successful pollination, and they contain the cowpea seeds.
- ✓ Harvesting can begin once the pods have reached the desired size and the seeds are mature.

Harvesting

- ✓ Harvest when the pods are mature but before they become too dry and lose quality.
- ✓ Hand harvesting is common, and the entire plant can be uprooted or just the pods can be collected.

Post-Harvest

- ✓ After harvesting, the cowpea pods can be shelled to extract the seeds.
- ✓ The seeds can be used for consumption or for sowing in the next season.

Crop Rotation

- ✓ Consider crop rotation to prevent soil-borne diseases and improve overall soil health.

Cover Cropping

- ✓ Cowpea can also be used as a cover crop, helping to fix nitrogen in the soil and improving soil structure.
- ✓ Remember that specific practices may vary depending on the variety of cowpea, local climate conditions, and agricultural practices. It's essential to adapt cultivation techniques to the specific requirements of the region where cowpeas are being grown.

Conclusion

The cowpea, with its adaptability, nutritional richness, and resilience, emerges as a critical player in addressing global challenges related to agriculture and food security. Its ability to thrive in diverse environments, coupled with a nutrient-dense profile, positions the cowpea as a sustainable solution for enhancing both agricultural productivity and human nutrition. As we navigate the complexities of a changing climate and increasing demand for food resources, harnessing the potential of the cowpea through continued research, cultivation innovation, and widespread adoption can significantly contribute to a more resilient and sustainable future for agriculture and global food systems.



References

https://www.britannica.com/plant/cowpea

http://www.iita.org/cropsnew/cowpea/

https://agritech.tnau.ac.in/agriculture/CropProduction/Pulses/pulses_cowpea.html

Effect of Organic Manures and Inorganic Fertilizers on Growth, Yield and Quality of Cucumber (*Cucumis sativus* L.)

Suresh Kumar Choudhary and Vijay Bahadur

Abstract

This study underscores the pivotal role of integrating organic and inorganic manure in cucumber cultivation, emphasizing their collective significance in enhancing crop yield and quality. Organic manure, derived from natural sources, enriches soil fertility and structure, fostering sustainable nutrient release throughout the crop's growth cycle. Simultaneously, inorganic manure, with its controlled nutrient composition, facilitates rapid plant growth and resource utilization. The synergy between these two manure types contributes to optimal nutrient management, improving cucumber plant health, yield, and fruit quality. This research provides valuable insights for farmers and agricultural stakeholders, offering a balanced approach to maximize productivity while promoting sustainable and environmentally conscious practices in cucumber cultivation.

Introduction

The cultivation of cucumber (*Cucumis sativus*) represents a cornerstone in global agriculture, driven by the vegetable's widespread consumption and economic importance. Achieving optimal yield and quality in cucumber crops requires a nuanced understanding of soil fertility and nutrient management. In this context, the use of fertilizers, specifically organic and inorganic manure, plays a critical role in influencing plant growth, development, and overall productivity. Organic manure, derived from natural sources, contributes to soil health and sustainability, fostering a holistic approach to nutrient release. In contrast, inorganic manure, with its controlled nutrient composition, offers precision in meeting the specific needs of cucumber plants for optimal growth.

This study delves into the crucial interplay between organic and inorganic manure in cucumber cultivation, aiming to elucidate their combined impact on crop performance, yield, and nutritional quality. By exploring the intricate relationship between these two types of manure, we seek to provide insights that can guide sustainable practices and contribute to the advancement of cucumber farming in a balanced and environmentally conscious manner.

Cucumber

The cucumber (*Cucumis sativus*) is a warm-season, vining crop belonging to the gourd family, Cucurbitaceae. Widely cultivated across the globe, cucumbers are renowned for their versatility, nutritional value, and culinary applications. Originating from South Asia, cucumbers have been

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cultivated for thousands of years, with various cultivars adapted to different climates and growing conditions. The plant typically features trailing vines, palmate leaves, and tendrils that aid in climbing or spreading. Cucumbers can be classified into two main types: slicing cucumbers, which are consumed fresh, and pickling cucumbers, primarily used for processing into pickles. Cucumber cultivation has evolved significantly over time, from traditional open-field farming to modern greenhouse and hydroponic systems. These variations in cultivation methods are driven by the need to optimize yield, quality, and resource use efficiency. Cucumbers are valued for their high water content, low-calorie profile, and rich vitamin and mineral content, making them a popular choice in salads, snacks, and various culinary dishes.



Successful cucumber cultivation requires careful attention to environmental factors, soil quality, and nutrient management. The choice and application of fertilizers, particularly organic and inorganic manure, are critical considerations in promoting healthy plant growth and achieving desirable yields. This integration of manures becomes crucial in sustaining soil fertility and mitigating environmental impacts associated with intensive agricultural practices. In this context, understanding the intricate relationship between organic and inorganic manures plays a pivotal role in optimizing cucumber cultivation practices, ensuring not only productivity but also the long-term sustainability of this globally significant crop.

Organic manure

Organic manure, often referred to as organic fertilizer, is a key component in sustainable and environmentally conscious agriculture. It encompasses a diverse range of natural materials, including compost, animal dung, green manure, and crop residues, which are utilized to enhance soil fertility and improve overall soil health. The use of organic manure is rooted in traditional farming practices and has experienced a resurgence in modern agriculture due to its numerous ecological and agronomic benefits. Unlike synthetic or inorganic fertilizers, organic manure releases nutrients slowly, providing a steady and sustained supply to plants. This gradual nutrient release not only promotes robust plant growth but also helps in building soil structure, increasing water retention, and fostering beneficial microbial activity. As agriculture increasingly shifts towards more sustainable practices, the importance of organic manure becomes evident, contributing to the overall goal of maintaining a balanced ecosystem while ensuring productive and resilient crop cultivation.

Inorganic manure

Inorganic manure, commonly known as synthetic or chemical fertilizers, plays a crucial role in modern agriculture by providing a concentrated and precise source of essential nutrients for plant growth. Unlike organic manure derived from natural materials, inorganic manure is manufactured through

industrial processes to create specific formulations of nitrogen, phosphorus, and potassium, along with other micronutrients. The controlled composition of inorganic manure allows for accurate nutrient management, addressing specific deficiencies in the soil and promoting targeted plant development. The widespread adoption of inorganic manure has contributed significantly to increasing agricultural productivity, particularly in areas where nutrient levels are limiting. However, the use of inorganic manure raises concerns about environmental sustainability, as excessive application may lead to nutrient runoff and soil degradation. Striking a balance between the advantages of enhanced nutrient availability and the potential environmental impact remains a critical consideration in modern farming practices. This introduction highlights the complex and dynamic role of inorganic manure in contemporary agriculture, emphasizing the need for responsible nutrient management practices to ensure both productivity and environmental stewardship.

Different Stages of cultivation of cucumber crop

The cultivation of cucumber involves several distinct stages, each critical for the successful growth, development, and eventual harvest of the crop. Here are the key stages in the cultivation of a cucumber crop:

Selection of Site: Choose a well-drained site with good sunlight exposure. Cucumbers thrive in warm conditions, so a location with adequate sunlight is essential.

Soil Preparation: Prepare the soil by incorporating organic matter, such as compost or well-rotted manure, to improve fertility and structure. Cucumbers prefer slightly acidic to neutral soil with a pH range of 6.0 to 7.0.

Variety Selection: Choose cucumber varieties based on your specific needs, whether for slicing, pickling, or greenhouse cultivation.

Seed Germination: Start cucumber seeds indoors in seed trays or directly sow them in the prepared soil after the last frost. Maintain optimal germination conditions, including warmth and moisture.



Transplanting

Seedling Development: Once seedlings have developed several true leaves and the threat of frost has passed, transplant them into the prepared garden beds or containers.

Spacing: Plant cucumber seedlings at appropriate spacing to allow for proper growth and air circulation.

Cultivation and Growth

Watering: Ensure consistent and adequate watering, particularly during dry periods. Cucumbers require regular moisture for optimal growth.

Nutrient Management: Apply organic and inorganic manure or fertilizers as needed to provide essential nutrients for healthy plant development.

Support Structures: For vining varieties, provide trellises or supports to encourage upward growth and save space.

Flowering and Pollination

Flower Development: Cucumber plants produce both male and female flowers. Female flowers, identified by the small fruit at their base, are the ones that develop into cucumbers.

Pollination: Cucumbers require pollination for fruit set. Bees and other pollinators play a crucial role in this process.

Fruit Development

Fruit Formation: As pollinated female flowers develop into fruit, monitor for proper growth and shape.

Thinning: Consider thinning excess fruit to promote larger and higher-quality cucumbers.

Harvesting



Timing: Harvest cucumbers at the appropriate stage, depending on the intended use and variety. Generally, pick them when they are firm, green, and before they become overripe.

Regular Harvesting: Regular harvesting encourages continuous fruit production and prevents overripening.

Post-Harvest Care

Storage: Store harvested cucumbers in a cool and humid environment to maintain freshness.

Processing: If growing pickling cucumbers, follow appropriate processing methods for pickling.

By understanding and managing each of these stages, growers can optimize cucumber production, ensuring a bountiful and healthy harvest.

Conclusion

In conclusion, the synergistic utilization of organic and inorganic manure emerges as a pivotal strategy in enhancing the cultivation of cucumber crops. The organic manure, derived from natural sources, contributes to sustained soil health, microbial activity and long-term nutrient availability. Simultaneously, the precision and immediacy offered by inorganic manure play a crucial role in addressing specific nutrient requirements during critical growth stages. The harmonious integration of these two manure types not only optimizes cucumber yield but also promotes sustainable agricultural practices by fostering a balance between productivity and environmental stewardship. Recognizing the nuanced benefits each type of manure brings to the cultivation process allows farmers to make informed decisions, ensuring not only the economic viability of cucumber farming but also the resilience and health of the broader agricultural ecosystem.

References

https://www.istockphoto.com/photos/cucumber-plant

https://www.shutterstock.com/search/cucumber-plant

https://www.istockphoto.com/photos/cucumber-growing

Wildlife Forensic as Futuristic Approach in Biodiversity Conservation

Vishal Bhojyawal, Sweety Gupta, Shubhangi Sahu, Amit Agrahari and Mansi Kesarwani

Introduction

Biodiversity is the multifariousness of Life on Earth, which includes a diversity of genes, populations, species, communities, ecosystems and ecological processes. From genes level to micro-organisms level to top predator of the ecosystem and even whole humanity rely on biodiversity for every single thing. The Earth comprises complex collections of countless organisms which constitute the vital life support for survival of humans. Biodiversity is of Brobdingnag cultural and socio-economic value, but is being widely lost at record rates as a result of human activities. Various conservation initiatives have been established to reduce these impacts but with limited success. The future of Biodiversity Conservation holds significant promises with the integration of advanced Wildlife Forensic approaches.

Wildlife Forensics is the use of scientific methods to investigate crimes cases against wildlife, like poaching and illegal trade, by investigating physical and chemical evidence to identify species, individuals, and origins, helping in law enforcement and finally leads to Biodiversity Conservation.

Wildlife Forensics plays a key role in Biodiversity Conservation by utilising scientific techniques to investigate crimes involving wildlife, such as poaching, illegal trafficking, and habitat destruction. By analyzing evidence like DNA, hair, feathers, and even pollen, forensic researchers and scientists can identify species, individuals, and geographic origins, aiding law enforcement in prosecuting offenders and deterring future crimes. This scientific approach helps to protect endangered species, preserve ecosystems, and combat illegal wildlife trade, ultimately contributing to the conservation of biodiversity.

Advantage of Wildlife Forensic investigation: Wildlife Forensic investigation provide several advantages, including:

Crime Prevention

- ✓ Acts as a deterrent against wildlife crimes like poaching and illegal trade.
- ✓ Helps in preventing further illegal activities by identifying and prosecuting offenders.

Species Identification

- ✓ Accurately identifies species from trace evidence like feathers, fur, or bones.
- ✓ Aids in combating wildlife trafficking and enforcing conservation laws effectively.

Individual Identification

- ✓ Utilizes DNA profiling and other forensic metho-

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ds to identify individual animals.

- ✓ Enables tracking of individuals in populations, monitoring of endangered species, and gathering data for conservation efforts.

Legal Evidence

- ✓ Provides robust scientific support in legal proceedings related to wildlife crimes.
- ✓ Helps secure convictions and uphold justice for offences against wildlife.

Support for Wildlife Rehabilitation

- ✓ Assists in identifying injured or confiscated wildlife for rehabilitation and release back into the wild.
- ✓ Ensures appropriate care and management based on the species' specific needs and genetic considerations.

International Collaboration

- ✓ Facilitates collaboration between law enforcement agencies and scientific experts across borders.
- ✓ Improves the effectiveness of conservation efforts by addressing transnational wildlife crime networks.

Technique for Wildlife Forensic investigation: Several techniques are employed in wildlife forensics to analyze physical evidence and provide valuable information for investigations. Some common techniques include:

DNA analysis: Identifying species, individuals, and genetic relationships by DNA extracted from samples like hair, blood, or saliva.

Stable isotope analysis: Determining the geographic origins and movements of animals by analyzing stable isotopes in tissues like feathers, bones, or teeth.

Microscopic analysis: Examining structures and characteristics of evidence like feathers, hairs, or plant material under a microscope for species identification.

Chemical analysis: Analyzing chemical compounds in samples like bones, tusks, or feathers to determine their origin, age, or exposure to toxins.

Radiographic imaging: Using X-rays or CT scans to examine skeletal structures for evidence of trauma, age, or species identification.

Geospatial analysis: Integrating geographic information systems (GIS) with forensic data to map crime scenes, track illegal activities, and identify hotspots for conservation efforts.

Molecular techniques: Molecular approaches, such as mitochondrial DNA (mtDNA) gene-based species identification and microsatellite markers, have significantly strengthened wildlife crime investigations. MtDNA gene-based species identification is particularly valuable for studying wildlife offences, while microsatellite markers are widely utilized for individual identification and parentage testing within populations. These techniques provide key tools for forensic analysis in wildlife conservation efforts.

Geolocation: DNA based technique: DNA analysis can help determine the geographic origin of animals or animal parts like ivory tusks because wildlife populations often have distinct genetic signatures due to their limited interbreeding with other populat-

ions from different geographic areas. This method relies on identifying unique genetic markers specific to certain populations, allowing researchers to trace the origins of samples back to their source regions (Wasser *et al.*, 2004, 2007).

Mitochondrial ribosomal RNA markers: The high level of conservation in the 12S rDNA makes it useful for studying genetic diversity at broader taxonomic levels like phyla, while the more variable 16S rDNA is better suited for exploring relationships at intermediate taxonomic levels such as families or genera. This difference in variability allows researchers to use each region effectively depending on the level of resolution needed in their studies (Gerber *et al*., 2001).

Stable hydrogen and oxygen isotopes: The global GS precipitation isotope grids serve as a key resource for future applications in wildlife and criminal forensic analysis, particularly in utilizing stable hydrogen and oxygen isotopes. These grids establish geospatial patterns of precipitation sources, offering valuable insights for various forensic investigations worldwide.

Concussion

Each species of plants and animals plays key character for maintaining Biodiversity. Loss of even a single species can disrupt the delicate balance and have far-reaching impacts on the entire ecosystem. With integration of futuristic approaches such as molecular techniques, Geolocation: DNA based technique, Mitochondrial ribosomal RNA markers and Stable hydrogen and oxygen isotopes etc. technique we can reduce the loss of biodiversity. Wildlife Forensic plays a key role in Biodiversity Conservation by providing essential tools for investigating crimes against wildlife, such as poaching, illegal trade, and habitat destruction. With DNA analysis, forensic scientists can identify species, individuals, and even geographical origins of confiscated wildlife products. This information is important for law enforcement agencies to prosecute offenders and trace the illegal wildlife trade networks, ultimately contributing to the protection and conservation of endangered species and their habitats. Therefore, Wildlife Forensic science serves as a powerful ally in the fight against biodiversity loss and extinction.

References

Arif, I. A. and Khan, H. A., (2009). Molecular markers for biodiversity analysis of wildlife animals: a brief review. *Animal Biodiversity and Conservation*, 32(1): 9-17.

Edgard, O., Espinoza, J., Esica, L., Espinoza, Pepper W., Trail and Barry, W. Baker. (2012). The Future of Wildlife Forensic Science, Wildlife Forensics: Methods and Applications, First Edition, C17: 343-358.

Gabriel, J., Bowen, Æ. and Leonard, I., Wassenaar Keith and Hobson, A. (2005). Global application of stable hydrogen and oxygen isotopes to wildlife forensics. *Oecologia*, 143: 337-348.

Gupta, S. K., Singh, P. and Yellapu, S. (2021). Molecular investigation of three leopards

death: A case of suspicious revenge killing. *Forensic Science International: Genetics*, 51: 102425.

Factors Responsible for Declination in Area of Millets Cultivation

Prabhas Kumar Shukla, Ramesh Pratap Singh, Diwakar Singh and Amit Tiwari

Demand side factors

- ✓ Due to rapid urbanization.
- ✓ By changing consumer taste and their preferences due to rising per capita income.
- ✓ Governmental policies which favours the other crops such as output price incentives and input subsidies.
- ✓ Due to supply of PDS rice and wheat at cheaper price introduced in non-traditional areas of fine cereals.
- ✓ Because of poor social status and inconvenience in their preparation (especially sorghum)
- ✓ Due to low shelf-life of grain and flour.

Supply side factors

- ✓ Enhancing the marginalized cultivation.
- ✓ Due low profitability-low remuneration for millets *vis-à-vis* competing crops.
- ✓ More number of remunerative crop alternatives in *kharif* competing with millets in question.
- ✓ Declination in production & quality - blackening of sorghum grains, fetching low price.
- ✓ Lack of incentives for millet production.
- ✓ Lack of better irrigation infrastructure.

Strategies to increase Production & Productivity

Supply Side Factors

To address the decreasing trend of area and production through supply enhancements.

- ✓ Creation of awareness about positive aspects like the suitability in the dry-land agriculture and more adaptability to the climate changes through demonstration and training programs.
- ✓ Development and distribution of HYVs and hybrids of millets among the farmers.
- ✓ Creation of Seed Hub to maintain own quality seeds to avoid purchasing seeds every year from the open market.
- ✓ Creation of systematic channel for timely distribution of improved agronomic practices and other technical assistance with utmost priority.
- ✓ Assured remunerative price through proper buy-back arrangements.

To narrow down the reduction in yield gaps and its impact on the farmers income.

- ✓ Developing and supplying location specific HYVs & Package of Practices (PoPs) mainly in the rain-fed areas.
- ✓ To fill yield gaps, proper training of the farmers and follow up measures of the improved technologies to be taken up.
- ✓ Proper weed management is required to check the yield reduction.
- ✓ To increase farmers' income, government must

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ensure the provision for regular MSP for millets and thereby regular procurement of these millets.

- ✓ Small millets need special focus under mission mode for PoPs, timely supply of inputs including seeds, financial inclusion and timely need based training.
- ✓ Soil health condition of the millets growing regions need to be recorded in Soil Health Cards.
- ✓ NGOs working on millets need to be made more involved in the grassroots level policy development.

Long Term Strategies

- ✓ Promotion of Farmer Producer Organizations (FPOs)
- ✓ Inclusive policy supports for small and minor millets.
- ✓ Developing proper market intelligence system.
- ✓ Creating farm gate processing and warehouse facilities.
- ✓ Promotion of integrated farming systems approach.

Demand Side Factors

Demand creation for millets products through Value addition

- ✓ Generation of awareness about the nutritional and health benefits of the millets and their products.
- ✓ Awareness programs to eliminate the low social status attached to the consumption of the millets and their products.
- ✓ Inclusion of millets under Mid-day-Meal (MDM) Scheme and other Government schemes.

Price support policies

- ✓ There is no provision of MSP for the minor millets including kodo and little millet from the government. This may hamper the cultivation of these crops which in turn will have a negative impact on the farmers.

Improvement of export competitiveness

- ✓ Release of pests and diseases resistant varieties to improve grain quality for reducing the competitiveness in the international market.
- ✓ Co-operative or collective cultivation for reducing the cost of cultivation and improve the bargaining power of the farmers.
- ✓ Value addition of millets products to improve the export competitiveness.
- ✓ Diversification of export basket for gaining exports like gluten free, sweet sorghum syrup, alcoholic beer, stalks based ethanol/grain based potable spirit, nutri- foods etc.
- ✓ Providing incentives to millets growers, processing and value addition enterprises.
- ✓ Provide tax benefits to value added millet products to generate demand and area expansion.

Major component of Nutri-Cereals

Activities for development: Showing clusters, providing incentives for seed production, distri-buting minikits, micro-nutrients, bio-fertilizers, needed weedicides and pesticides, plant protection equipment, sprinklers and training for farmers, etc.

Assistance with marketing: Establishing Farmers Producer Organizations (FPOs), Self Help Groups (SHGs) and establishing processing units in cluster

areas or blocks. Guaranteed purchase at the Minimum Support Price (MSP) and so on.

Assistance in Research: Assistance provided for the production of breeder seeds, establishment of seed hubs for certified Nutricereal seed production and support for the development of recipes and training for entrepreneurs and progressive farmers at the Centre of Excellence. Discover of new types of Jowar, Bajra, Ragi and small nutricereals with superior nutritional content and so forth.

Initiatives to Raise Awareness: Hosting workshops at the national and state levels, organizing district level festivals and road shows and conducting awareness campaigns through electronic, print and social media. Arranging agricultural fairs at ICAR Institutes/KVKs and incorporating Nutri-cereals into social welfare programs.

Integrated Insect-Pest Management in Cabbage and Cauliflower

Satyam Pandey and Vijay Bahadur

Abstract

Cabbage (*Brassica oleracea*) and cauliflower (*Brassica oleracea* var. botrytis) are crucial vegetable crops globally, contributing significantly to both nutritional intake and economic value. However, they are vulnerable to various insect pests and diseases that can significantly reduce yield and quality if left unchecked. Integrated Pest Management (IPM) strategies offer a holistic and sustainable approach to mitigate these challenges. This abstract highlights the principles and practices of integrated insect, pest, and diseases management in cabbage and cauliflower production. It explores the multifaceted components of IPM, including cultural, biological, mechanical, and chemical methods, aimed at minimizing pest and disease pressures while promoting ecosystem health and sustainability. Cultural practices such as crop rotation, proper spacing, and sanitation help disrupt pest and disease cycles, while biological control agents like natural enemies and microbial biopesticides offer environmentally friendly alternatives to synthetic chemicals. Mechanical control methods such as physical barriers and traps can also be effective in reducing pest populations. Furthermore, judicious use of pesticides is integrated into IPM programs, with an emphasis on selecting reduced-risk products and employing precise application techniques to minimize environmental impact and non-target effects. This abstract underscores the importance of an integrated approach tailored to the specific agroecological conditions and pest pressures of cabbage and cauliflower production systems. By combining various strategies synergistically, growers can effectively manage insect pests and diseases while promoting sustainable agriculture and safeguarding human and environmental health.

Introduction

Cabbage, comprising several cultivars of *Brassica oleracea*, is a leafy green, red (purple), or white (pale green) biennial plant growth as an annual vegetable crop for its dense-leaved heads. It is descended from the wild cabbage (*B. oleracea* var. oleracea) and belongs to the "Cole crops" or brassicas, meaning it is closely related to broccoli and cauliflower (var. botrytis); Brusells sprouts (var. gemmifera) and Savoy cabbage (var. sabauda).

A cabbage generally weights between 500 and 1000 grams (1 and 2 lb). Smooth-leafed, firm-headed green cabbages are the most common, with smooth-leafed purple cabbages and crinkle leafed savoy cabbages of both colours being rarer. Under conditions of long sunny days, such as those found at high northern latitudes in summer, cabbages can grow quite large. As of 2012, the heaviest cabbage was 62.71 kilograms (138 lb 4 oz). Cabbage heads are generally picked during the first year of the plants

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life cycle, but plants intended for seed are allowed to grow a second year and must be kept separate from other cole crops to prevent cross-pollination. Cabbage is prone to several nutrient deficiencies, as well as to multiple pests, and bacterial and fungal diseases. Cabbage was most likely domesticated somewhere in Europe in incient history before 1000 B.C. Cabbage use in cuisine has been documented since Antiquity. It was described as a table luxury in the Roman Empire. By the middle Ages, cabbage had become a prominent part of European cuisine, as indicated by manuscript illuminations. New variates were introduced from the Renaissance on, mostly by Germanic-speaking peoples. Savoy cabbage was developed in the 16th century. By the 17th and 18th centuries, cabbage was popularised as staple food in central, northern, and Eastern Europe. It was also employed by European sailors to prevent scurvy during long slip voyages at sea. Starting in the early modern era, cabbage was exported to the Americas, Asia and around the world.

They can be prepared many different ways for eating; they can be pickled, fermented (for dishes such as sauerkraut), steamed, stewed, roasted, sautéed, braised, or eaten raw. Raw cabbage is a rich source of vitamin K, vitamin C, and dietary fiber. World production of cabbage and other brassicas in 2020 was 71 million tonnes, led by China with 48% of the total. The major cabbage producing states are Uttar Pradesh, Odisha, Bihar, Assam, West Bengal, Maharashtra and Karnataka.

Insect pest of cabbage

- ✓ Cabbage butterfly (*Pieris brassicae, P. candida* and *P. napae*).
- ✓ Aphids (*Brevicoryne brassicae*)
- ✓ Diamond Back moth (*Plutella xylostella*),
- ✓ Tobacco caterpillar (*Spodoptera litura)*
- ✓ Cabbage Borer (*Hellula undalis*)
- ✓ Leaf webber (*Crosidolomia binotalis*),
- ✓ Cabbage green semilooper (*Trichoplusia ni*)

Aphids (*Brevicoryne brassicae*): Yellowish green nymphs and adults suck cell sap and devitalize plants. Affected parts become discolored and malformed. High humidity favours rapid multi-plication of this pest. The aphids are mostly observed on the lower surface of the leaves.

Control: Spraying of Monocrotophos (0.05%) or Malathion (0.1%) at 10-15 days interval contains aphid population effectively. To prevent recurrence of the pest granular insecticides like Phorate @ 1.0 kg a.i. ha^{-1} should be applied to soil.

Leaf Webber (*Crocidolomia binotalis*): It is one of the most destructive pests of cabbage. Eggs are laid in clusters on the undersurface of the leaves and held together by gelatinous glue. Green caterpillars web up the leaves and live inside the knotted mass. Flowering and pod formation is adversely affected.

Control: Removal and destruction of webbed bunches of leaf help to check the further spread of the disease. Dusting the crop with Carbaryl (4%) or spraying with Malathion (0.05%) is effective.

Cabbage Borer (*Hellula undalis*): The adult female lays eggs on the growing point or on the older leaves. The pale-whitish caterpillars mine the foliage, feed

on the shoots and finally bore into the stem. As a result the infested plants are killed or produce side shoots, which do not form heads.

Control: Spraying the crop with Malathion (0.1%) or dusting 4% Carbaryl gives excellent control of the larvae.

Diamond back moth (*Plutella xylostella*)

- ✓ Young caterpillars cause small yellow mines on leaves.
- ✓ Scrapping of epidermal leaf tissues producing typical whitish patches on leaves.
- ✓ Full-grown larvae bite holes in the leaves and feeds on curd.

Control

- ✓ Remove and destroy all debris and stubbles after harvest of crop
- ✓ Grow mustard as trap crop at 2:1 ratio (cabbage: mustard) to attract DBM for oviposition at least 10 days ahead of planting of main crop.
- ✓ Spray mustard crop with dichlorvos 76 WSC 0.076% to avoid dispersal of the larvae.
- ✓ Pheromone traps @ 12 ha^{-1}.
- ✓ Crop rotation with cucurbits, beans, peas, tomato and melon.

Cabbage green semilooper (*Trichoplusia ni*): Scrabbing of leaves initially and defoliation

Identification of pest

- ✓ Egg Greenish-white, spherical and sculptured eggs. Eggs laid singly on ventral surface of leaves.
- ✓ Larva - Slender and green in colour with light wavy lines.
- ✓ Adult: Stout, brown moth, head and thorax grey in colour, abdomen white
- ✓ Forewings grey wavy in colour with a slendery – marking.

Control

- ✓ Hand pick and destroy the caterpillars.
- ✓ Set up light trap @1 ha^{-1}.
- ✓ Spray insecticides like Malathion 50EC @ 0.1% ha^{-1}.

Cabbage butterfly (*Pieris brassicae, P. rapae*)

- ✓ Defoliation
- ✓ Bores into the heads of cabbage

Identification of pest

- ✓ Velvetty bluish green in colour with black dots.
- ✓ Yellow dorsal and lateral stripes covered with white hairs.
- ✓ Pupa: chrysalis which takes place in leaves and stem.
- ✓ Adult: White butterfly

Control

- ✓ Collect and destroy caterpillars in the early stage of attack.
- ✓ Conserve parasitoids like *Cotesia glomeratus*
- ✓ Spray insecticides like quinalphos 25EC @ 1000 ml.

Tobacco caterpillar (*Spodoptera litura*)

- ✓ Damage leaves and heads of cabbage and cauliflower.
- ✓ Damage leaves of radish and beet root

Identification of pest

Egg: Masses appear golden brown

Larva

- ✓ Young caterpillars are light green with black head or black spots.
- ✓ Gregarious in the early stages
- ✓ Well grown caterpillars are grey or dark brown

Adult

- ✓ Forewings: Brown colour with wavy white marking.
- ✓ Hindwings: White colour with a brown patch along the margin.

Control

- ✓ Plough the soil to expose and kill the pupae.
- ✓ Grow castor along border and irrigation channel as trap crop.
- ✓ Flood the field to drive out the hibernating larvae.
- ✓ Set up light trap @1 ha^{-1}.
- ✓ Pheromone traps (Pherodin SL) @ 15 ha^{-1} to attract male moths.
- ✓ Collect and destroy egg masses in castor and tomato.
- ✓ Hand pick grown up larvae and kill them.

Eco-friendly Management of Insects and pests

Before Planting

- ✓ Deep ploughing in the month of summer to expose immature stages of insect pest like tobacco caterpillar.
- ✓ Hand picking and destruction of *P. brassicae* eggs and larvae in nursery as well as main crop to reduce the pest multiplication.
- ✓ Grow African bold seeded mustard as trap crop at 22:2 ratio (Cabbage: Mustard) to attract DBM for oviposition at least 10 days ahead of planting of main crop.

After Planting

- ✓ Regular monitoring of the plants randomly.
- ✓ Hand picking and destruction of leaf webber and egg masses and larvae to reduce further multiplication of pests in the field.
- ✓ Hook out the head borer and destroy mechanically.
- ✓ Spray neem seed powder extract 4% @ every 10 days interval starting from 30 days after planting (DAT) (0.1%) to keep the pest in check.
- ✓ Spray Cartap hydrochloride 0.5% at 10, 20 and 30 DAS (nursery) and primordial stage against DBM.
- ✓ Encourage bio-control agents.

Conclusion

Integrated insect and pest management in cabbage is a comprehensive approach that combines various strategies to effectively control pests while minimizing environmental impact and preserving crop health. Through careful planning and implementation, integrated pest management (IPM) strategies can significantly reduce the reliance on chemical pesticides and promote sustainable cabbage production.Integrated insect and pest management in cabbage offers a holistic and sustainable approach to pest control, promoting environmental stewardship and long-term viability of cabbage production. By integrating cultural, biological, mechanical, and chemical control methods, growers can effectively manage pests while minimizing negative impacts on human health, beneficial organisms, and the environment.

References

https://www.vikaspedia.in/agriculture/crop-production/package-of-practices/vegetables-1/cabbage

E-lecture content on cabbage

https://nhb.gov.in/pdf/vegetable/cabbage/cab007.pdf

https://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectveg_cole%20crops_pest&disease.htm

Importance of Vetiver Cultivation

Anand M. and M. Velmurugan

Introduction

The Poaceae family of grasses includes vetiver, which grows on a variety of soil conditions. The plant's underground portion is made up of many tiny, light-colored, gray to reddish-colored roots that are covered in a viscous essential oil that has a nice, lingering smell. The root of the vetiver plant is distilled to produce the commercial oil. In India, the plant is known as 'aromatic root'. The major constituents are vetivone, vetiverols, vetiverenyl, vetivernate, benzoic acid and palmitic acid. The useful portion of the plant is the root, which has a very pleasant perfume and is used to scent clothing either on its own or in sachet form. Vegetable roots have been used for millennia to weave baskets, hand fans, and mats that, when wet and hung in homes like curtains, cool the air and release a delightful scent. One of the most precious and significant raw materials utilized by perfumers is vetiver oil, which is extensively used in cosmetics, perfumeries, and soap scenting. It functions as a natural fixative as well. Veterinarian oil mixes well with other oils, especially rose, sandalwood, and patchouli oils. It is said to have stimulating and refrigerant qualities and is used medicinally as an anthelminthic and carminative for flatulence. It is administered locally to relieve bodily aches. The stem and flower peduncles are used to make brooms and decorative baskets, while the young leaves are used for thatching and as bedding and food for horses and cattle. The plant is widely utilized in arid zones to prevent soil erosion and has achieved recognized as one of the best soil-binders.

Types and varieties: The grass growing wild in North India and that cultivated in South India are two different types. Thus there are two main types namely, flowering or seeding and non-flowering or non-seeding. The one that grows in North India is mainly the flowering type, while that which is cultivated in south India is the non-flowering type.

The North Indian type is poor in oil yield, but its oil quality is superior, whereas the south Indian type yields more oil, but the quality is inferior.

The CIMAP has developed two superior clones, KS-1 and KS-2 from a collection from Bharatpur. These have a yield which is almost comparable to the existing high yielding material. However the quality of oil from both the clones was rated the best among the clones evaluated.

An improved tetraploid strain "Sugandha" has also been released by the CIMAP and is reported to be superior in terms of oil-yield over the correspo-

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nding diploid parent. This is attained by an enhancement in the root biomass and an increase in the percentage of oil content in the roots. The new strain can yield 1.4% oil content in fresh roots and 21.2 q ha^{-1} of roots, against 1.15% oil and 18.5 q ha^{-1} of roots in the control.

Pusa hybrid numbers (1-30) have been evolved by NBPGR, New Delhi. Of these F_1 hybrids Hyb-26 gives higher yield of roots (14.5 q ha^{-1}) with an oil content of 1.50%. Whereas hybrids 26, 7 and 16 perform better in saline and alkaline soils with high root and oil yield. Under Bangalore conditions, hybrid-8 has been found to be better. Its roots yield 1% essential oil and possess 70-85% vetiverol content. The yield of root ranged from 12-15 q ha^{-1} when harvested at 15 months age. A vetiver clone ODV-3 developed at Aromatic and Medicinal Plants Research Station, Odakkali is reported to give god root and oil yield in Kerala. The CIMAP, Lucknow has released few new varieties based on the oil odour value. They are Kesari, Gulabi and Dharini.

Cultivation

Soil and Climate: Nearly any type of soil can be used to cultivate vetiver. However, since the roots produced yield very little oil, light soils should be avoided. Red lateritic soil that is rich in organic matter and has good drainage are appropriate because the roots that grow there are thicker and contain more essential oil. With a pH range of 8.5 to 10.0, it may be cultivated in both alkaline and saline soils. For appropriate growth, development, and essential oil yield, the crop prefers a tropical or sub-tropical climate. It grows lushly in areas with moderately humid climates, temperatures between 21 and 44°C, and 1000 to 2000 mm of yearly rainfall.

Land Preparation: The land is ploughed to a depth of 20-25 cm repeatedly and the soil is mixed with the recommended dose of manure and fertilizers and made ready for planting.

Propagation: Vetiver is propagated from seeds or slips. Seeding is found to be profuse in the crop, in areas where it occurs in the wild and regeneration takes place from self-sown seeds and the rains received. In south India where the crop is cultivated on a large scale, the non-seeding type is grown. This is propagated from slips obtained from the uprooted clumps of the previous crop. These clumps, when broken, give a number of slips. Slips that are separated from the clump and have 15-20 cm of the shoot portion, constitute the material for planting.

Planting: Vetiver is planted in rows 45 cm apart with a plant to plant distance of 30 cm. The planting is usually done during the months of June- July, at the advent of the rainy season. If irrigation facilities are available, it is better to plant during March- April. However in that case, frequent irrigation will be required. Two or three slips are planted in each hole of 5-8 cm depth and the soil is pressed around the hole. Late planted crop yields coarse roots which in turn, yield inferior quality oil. A spacing of 60 x 25 cm is also recommended to allow 60000 plants ha^{-1}.

Manures and fertilizers: In order to obtain economic yields, the vetiver crop may be supported with 10 t FYM, 25 kg ha^{-1} each of N, P and K. While

the entire quantity of FYM, half N and a full dose of P and K are applied at the time of planting, the remaining half of N is given after about 6 months of planting. A fertilizer dose of 60 kg N, 22.5 each of P_2O_5 and K_2O is recommended.

Irrigation: In areas where rainfall is good and well distributed throughout the year and humidity is high, supplemental irrigation is not necessary. However, in drier areas, about 8-10 irrigations will be required in order to obtain the optimum yield.

Interculture: Once the plants have established and grown into bushes, the weed problem is not severe because of the nature of the bushes. However, in the newly established plantations, 3-4 weedings are necessary until the bushes are formed.

Harvesting and yield: The timing of harvesting is crucial since variations in environmental variables affect the proportion of oil and root output. For the highest oil yield, the crop planted in July should be harvested after 18 months. Harvesting is often carried out by hand, excavating the bush and its roots between December and February, when it is dry. Before distillation, the roots are first separated from the base, cleaned, and dried in the shade for one to two days. While lengthy sun drying lowers the output, this enhances the quality of the essential oil. The roots may yield three to four tons per hectare. It is deemed adequate to collect 1% or less of the essential oil. Up to 14-18 q ha^{-1} of root yield have been recorded.

Conclusion

Native to the Indian subcontinent, vettiver is commonly found in tropical Asia, Africa, and Australia. The root of the vetiver plant is distilled to produce the commercial oil. The plant is referred to as “khus khus” in India. Khus translates to “aromatic root.” Benzoic acid, palmitic acid, vetivone, vetiverols, vetiverenyl, and vetivernate are the main ingredients. The useful portion of the plant is the root, which has a very pleasant perfume and is used to scent clothing either on its own or in sachet form. Plants are spaced 45 cm apart in rows, with a 30 cm gap between each plant. It is advised to apply 60 kg of N and 22.5 kg of P_2O_5 and K_2O fertilizer. The roots may yield 3-4 t ha^{-1}. It is deemed adequate to collect 1% or less of the essential oil. Up to 14-18 q ha^{-1} of root yield have been recorded.

References

Chomchalow, N. and Hicks, A. (2001). Health potential of Thai traditional beverages. *Assumption University Journal of Technology*, 5: 20-3

Lavania, U. C. (2002). Primary and secondary centres of origin of vetiver and its dispersion. In: Chomachalow, N. and Barang, M. (Eds.), Proceedings of IInd International Conference on Vetiver: Vetiver and Environment, Royal Development Projects Board, Bangkok, Thailand, 424-426.

National Research Council. (1993). Vetiver Grass: A thin green line against erosion. Washington, D.C., National Academy Press, 169

Exploring the Importance of Plamyrah

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Introduction

Palmyrah palm (*Borassus flabellifer* L.) belongs to palmae, chromosome number 2n=32 and native to tropical Africa. It is a dioecious tropical crop of significant commercial importance. Historically, diverse plant parts such the roots, leaves, seeds, and fruits have been used for a variety of purposes. Palmyrah is also called toddy palm and sugar palm. It is cultivated throughout India, Sri Lanka, Bangladesh, Burma, the Philippines, Malaysia and several east African nations.In the semi-arid states of Tamil Nadu, Andhra Pradesh, Gujarat, Odisha, West Bengal, Bihar, Karnataka, and Maharashtra, palmyrah brightens the barren environment. At the moment, Tamil Nadu is home to half of India's estimated 102 million palmyrah palms. More than 50 percent of Tamil Nadu's 51.90 million palm trees are clustered in the Southern district of Thoothukudi. In 1978, the Tamil Nadu government designated palmyrah.

Palmyrah (*Borassus flabellifer* L.), the state tree of Tamil Nadu, is a gift from nature to humankind. It is a plant that provides the community with several ecological, medical, economic, and sociological advantages. It is a plant from heaven that could resist extreme weather and natural disasters. It is one of the most advantageous species and each and every portion of it has economic and medical worth. The plant has a close relationship to India's cottage, agricultural, and rural livelihood sectors. The plant's applications can be broadly divided into non-edible, edible, and value added uses. The entire tree can be used for economic purposes as well as to carry out traditional tasks in Tamil culture. It is regarded as nature's eternal gift and is referred to as “Kalpakatharu” in Tamil, which means the tree that grants all a person's requests. The ancient palm of palmyrah is known as the “Wishing Tree” or “a palm that yields anything and everything” because of its extraordinary capacity to produce several economically significant goods. Every portion of the palm is used almost entirely.

Due to the fruit's therapeutic and nutritional benefits, palmyrah is in high demand worldwide. In Sri Lanka, around 1500 tons of fruits are annually accessible during the seasons when the female palm's inflorescences begin to mature and bear fruits. For one season, a palm may produce 200-300 fruits. September and October are the fruiting season. The fruit is big, fibrous, and often has three portions that resemble nuts with a seed encased in each. The juvenile fruit kernel of the palmyrah has a layer of

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gelatinous endosperm or kernel, as well as some sweet tasting water, enclosed in a tough shell. The endosperm is referred to as "Nungu," in Tamil which is the juvenile fruit kernel of a palmyrah. Under appropriate conditions, the endosperm of mature fruits hardens. During August month palmyrah fruit ripens, while September and October the ripe fruits fall from the tree. After using the pulp from the palmyrah fruit, the seeds of the fruits were collected, and sown in beds with three or four levels of seeds and the moisture level of the seeds is properly maintained. The seed's shoot root axis descends to the soil during germination, while the distal piece that is still inside the seed grows into the haustorium both during and after germination. The seed generates a stalk that gives rise to the product palmyrah tuber, while the palmyrah seed produces the mouthwatering white, spongy edible portion known as the haustorium. Before being harvested, this shoot reaches a height of 20-30 cm.

Palmyrah haustorium is a delicious spongy white edible portion formed at the time of germination. During germination of the tuber, the embryo develops and enlarges to form cotyledon structure, it is called haustorium. The embryo receives the nutrients through the haustorium. The haustorium will therefore be more nutrient dense since it will contain carbohydrates, protein, amino acids, and other trace nutrients and bioactive substances that are very good for our health. The fruit endosperm also has several health promoting activities like anti-inflammatory, antibacterial, anti-cancer, and anti-diabetic properties (Vasudevan *et al.*, 2023). Palmyrah tubers were collected when they were fully mature with high fibre, starch content. Young fruit kernels, haustorium, and freshly boiled tubers from palmyrah are nutrient-rich foods. They are valued for their nutritional value as well as their total phenolic content and vitamin C, both of which exhibit antioxidant characteristics. To maintain nutritional needs, prevent chronic diseases including cancer, cardiovascular disease, and age related pathologies, and boost overall health, people should increase their consumption of these palmyrah products. A proximate analysis revealed that it has a small amount of fat but is a high source of fiber, protein, and carbohydrates.

The remaining tubers in the seed bed after harvesting of palmyrah are thrown to nature even though they have greater advantages for people. The haustorium, a tasty and nutrient dense portion of the seed, makes up most of the remaining material. The haustorium, which is now harvested at the very end after the tubers have been dug up is nevertheless, tasteless, and watery. Additionally, the tubers produce sugars, and their starch content decreases significantly, making them of low quality for processing. As a result, it is very beneficial to analyze the haustorium for its nutrients and palatability to determine the right harvesting period for both the haustorium and tubers of palmyrah to keep their actual detectability and to get all their nutrients at ideal levels. The palmyrah seed's haustorium, which forms during germination, trans-

ports nutrients to the embryo. People in rural areas take it raw and fresh, and it is good. Scientific studies have demonstrated that increasing consumption of these offers various health promoting and disease preventing effects are due to particular compounds known as phyto-chemicals, including polyphenols. Different areas of the plant have concentrations of secondary metabolites. The phytochemical like oleic acid and unsaturated fatty acid possesses cardio-protective effect (Prasad *et al.*, 2022). Most these palms secondary metabolites are commercially exploitable because they are used as active pharmaceutical ingredients in novel medications and are responsible for the species antioxidant, anti-inflammatory, anti-allergic, anti-microbial, anti-mutagenic, anti-platelet, and vasodilatory functions.

Conclusion

Palmyrah (*Borassus flabellifer* L.) belongs to palmae, chromosome number 2n=32 and native to tropical Africa. It is a dioecious tropical crop of significant commercial importance. Palmyrah tubers are fully mature, they are harvested. The delightful white, spongy edible portion called palmyrah haustorium, which is formed enlarges during germination to produce cotyledony structure. The embryo receives the nutrients through the haust-orium. The haustorium will be more nutrient dense since it will contain carbohydrates, vital amino acids, and other trace nutrients and bioactive substances that are very good for our health

References

Srivastava, A., Bishnoi, S. K. and Sarkar, P. K. (2017). Value addition in palmyra palm (*Borassus flabellifer* L.): A potential strategy for livelihood security and poverty alleviation. ICAR Research Complex for Eastern Region, Research Centre. *Rashtriya Krishi*, 12(1): 110-112.

Prasad, B., Kumar, A. A., Vignesh, S., Chidanand, D. V. and Baskaran, N. (2022). Exploring the nutritional profiling and health benefits of *Palmyra haustorium* (palmyra palm). *South African Journal of Botany*, (IF 3.111)

Bayton, Ross P. (2007). A review of Borassus (Arecaceae). *Kew Bulletin*, 62(4): 561-585.

Glanista, T., Ponnuchamy, N., Sri Thayalan and Sri Vijeindran. (2018). Preservation of *Palmyrah Haustorium*, Young Fruit Kernel and Boiled Tuber with Lengthen Shelf-Life Consisting their Native Characters. *Annals of Biological Research*, 9(2).

Jody, H. and John, McLaughlin. (2000). Edible palms and their uses. University of Florida, Institute for Food and Agricultural Sciences. Fact Sheet MDCE-00-50-1.

Karuppusamy, A., Shanmugam, S. and Thangaraj, P. (2011). Nutritional Analysis and Antioxidant activity of Palmyrah (*Borassus flabellifer* L.) Seed Embryo for potential use as Food Source. *Food Science Biotechnology*, 20(1): 143-149.

Lim, T. K. (2012). Edible Medicinal and Non-Medicinal Plants. Springer, the Netherlands, 371-380.

Millets Provide Nutritious Fodder for Animals

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Introduction

Millets were the first crops to be domesticated by the humankind in Asia and Africa which later on spread across the globe as critical food sources to the evolving civilizations. Millet consumption in India is also mentioned in the oldest Yajurveda texts and confined to the traditional consumers in the rural and tribal areas. Millets have been a good part of the staple diet among many communities. One finds many millet preparations in traditional cuisines surviving to this day in different parts of India, Korea, Japan, Russia, China, Russia, Ethiopia, Turkey etc. Millets are thus environmentally, ecologically, economically friendly sources of food, fodder and feed. Further they are also excellent sources of animal feed and nutrition as it is evident from the fact that millets have evolved to survive in extremely harsh environmental conditions without any need for human intervention.

Millets are primarily grown as grain crops on marginal lands in dry areas of temperate, sun-tropical and tropical regions of the world. In fact the nutritional qualities of millets were not fully known, crops in the past. However, it is now well-know that millet farming could contribute to livelihoods, food availability as well as food security. In recent times because of its nutritional profile, millets have assumed greater importance as food for humans as well as feed for animals. Two years ago, the UN General Assembly adopted India's resolution to declare "International Year of Millets 2023". It offers numerous benefits to farmers, consumer health, foreign trade, the environment, and the country's overall economy. With better awareness in millet cultivation and consumption there is a production of millets in India. Millets are small seed grasses, tough cereal crop that can be cultivated in hot, drought-prone or semi-arid regions, unpredictable climates and nutrient-depleted soils.

Millets are multiple varieties of millets are produced in the country such as Pearl Millets (Bajra), Sorghum (Jowar), Finger Millet (Ragi), Foxtail, Kodo, Barnyard, Proso, Little Millet, and Pseudo Millets like Buckwheat and Amaranths. India is the largest producer in the world. Animal nutrition for dairy cattle, buffaloes, goats, poultry and aquaculture in India, primarily comprises agricultural wastes like rice/wheat hay, oil cakes, silages, pellet feed, premixes and supplements. Millets can be promoted in animal husbandry especially at last-mile rural

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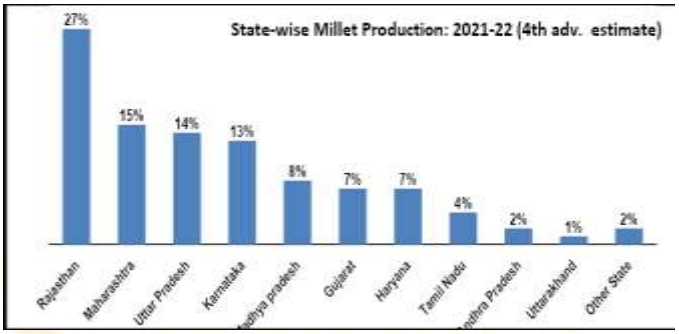
areas and make the farmer self-sufficient by ensuring a sustainable income source despite the uncertainties in agriculture. The states like Uttar Pradesh, Maharashtra, Karnataka, Rajasthan, Andhra Pradesh, etc. actively involved in animal husbandry and dairy, and contribute to millet production with higher cultivation rates. Therefore, it is time to understand the benefits of millet for animals and their nutrition costs or nutritional values. This can create a sustainable value chain and an economic & environment-friendly approach to animal husbandry.

Importance of Millets in Animal Nutrition

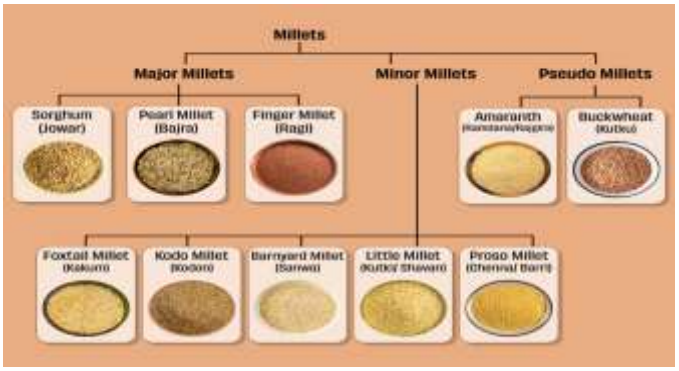
India is possessing large animal population in the world. Feeding this enormous animal population with nutritious feed is one of the challenges. Further animal nutrition in India primarily comprises of agricultural wastes like rice/wheat hay, oil cakes, silages, pellet feeds, premixes and supplements. Millets can be promoted for providing good quality animal fodder and thus millets can play a great role in supporting animal husbandry. In India the states like, Uttar Pradesh, Karnataka, Maharashtra, Rajasthan, Andhra Pradesh, Telangana etc, are actively involved in animal husbandry, dairying, goat, pig, poultry and fish sectors. It is important for farmers to understand the benefits of millets for animals and their nutrition costs or nutritional values. This can create a sustainable value chain and an economic and environment-friendly approach to encourage and promote animal husbandry.

Salient Features of millets for Animal Feeds

The millets are one of the cheapest sources of energy, high content of digestive fibre, protein, vitamins and minerals. Whereas under stress tolerance conditions, millets provides nutritious food as compared to others cereals with high fibre content, minerals and slow digestibility. The millets can constantly help to meet out the needs of their animal feed and fodder; will continue to be grown by dry land and resource poor farmers in the foreseeable future and millets are the key for the sustenance of human and livestock population in an era of perceptible climatic changes.



✓ **Types of Millets:** Millets are generally categorized into major and minor. Pearl Millet and Sorghum comes under major millet. While Finger Millet, Kodo Millet, Foxtail Millet, Proso Millet, Little Millet, Barnyard Millet, and Browntop Millet comes under minor millets. India is the largest producer of millets in the world.



- ✓ **Low Water Requirement:** Agriculture sector is the major consumer of water resources and approx 70 per cent of total water consumed globally is used for agricultural production. Due to global warming, frequent surface water droughts condition is accelerating and arise the problems for surface water irrigation. As per global trends 2040, are most vulnerable to water security risk in upcoming 20 years, hence again millets come across as a great option to solve the problem. Millets are drought resistant; requiring a very low amount of water, approximately 3000-5000 litres of water is required to produce 1 kg of rice, 900-1000 litres of water to produce 1 kg of wheat whereas 200-300 litres is required to produce 1 kg of millet.
- ✓ **Millets are great for Soil Health:** Poor soil health is one of the major environmental issues. Millets helps in preventing soil depletion and improve its fertility and overall soil health.
- ✓ **Great for Farmers:** Because millets can grow in less fertile soil require less maintenance to grow, they can be beneficial for farmers. They can be great in reducing the economic burden on farmers and providing economic security to them.
- ✓ **Short Duration:** Millets have capacity to attain maturity in a short duration compared to other fodder yielding crops. Crop like sorghum Multicut/matures in 110-120 days, Pearl millet matures in 110 days, Proso millet require 70 days to be ready for harvest and Foxtail millet (Kakun) matures in 65-70 days etc. The quality of short duration among many types of millet for cultivation has attached advantage with these crops. Thus millets emerge as short duration fodder crops.
- ✓ **Low Nutrient Uptake:** Production of cereal demands more water and fertilizers than millets. When compared to other cereal grains, fodder crops and many commercial crops, millets do not take up much from the soil. Their nutrient requirements are far less than those of the other food, feed and commercial crops. This qualifies millets to be the best animal feed crops that can be produced with least cost.
- ✓ **Greater Resistance to Pests and Diseases:** Millets are not susceptible to various diseases and pests either in the field or during storage after the harvest. Hence these crops do not demand large number of sprays of chemical pesticides thus they are good crops for animal feed.
- ✓ **Inherent Capacity to Mitigate Global Warming:** A healthy environment; air, water, food, and other are vital to all living beings in the world and are essential to the existence of life. Unfortunately, due to human activities, the environment is deteriorating immensely, resulting in many negative consequences. Millets are highly capable of playing a pivotal role in mitigating the negative effects of global warming because they do not contribute much to water depletion and can help to prevent overall soil depletion.

- ✓ **Possess Stronger Root System:** Millets have also played an important role in nurturing soils and improving their fertility and texture, thereby increasing the yield and hence the returns to the farmer. Once the root system is established, millets can survive many dry weeks. Once it starts raining, the plants jump back to life and yield something by the end of the season. Millets are thus fairly effective at aggregating nutrients and if we conscious in closing the nutrient loop locally, one can realize a manifold increase in soil health.
- ✓ **Acclimatize to different Soils:** Millets can grow virtually anywhere and in any type of soils. The quality of soil is not a barrier to growth, as they can grow even in sandy soils with differing pH balances. Millets cultivation improves conservation of soil moisture.
- ✓ **No cost on irrigation infrastructure:** Millets being rain fed crops do not require standing water in their fields, so no need for big dams, forests going under reservoirs and elaborate canal systems to get water to the farms.
- ✓ **Health benefits:** Health benefits of millets are also believed to have nutritional health benefits for humans and obviously for animals too. These benefits include an increase in digestive system, reduction in cholesterol, the prevention of heart diseases, an increase in energy levels, high content of probiotics and hypoallergenic nature and improvement of the muscular system. Due to higher fiber content, millets slow down digestion, thereby promoting efficient absorption of nutrients. Millets are also rich in vitamins (A, B and C) and minerals (Ca, K, and Fe).
- ✓ **Animal Health Friendly:** Millets are not only environmentally friendly crops but can bring best results for animal health preservation. Water contamination due to chemicals and fertilizers also affects the health of humans, animals, and plants. Health issues of animals linked to pesticides and fertilizers. All of this can be reduced by growing millets, since these crops can be grown without much use of pesticides and fertilizers. Thus millets have a much smaller environmental footprint than that of rice or wheat and prevent pollution through their limited need for agro-chemicals, making millets the most environmentally friendly choice of grain.
- ✓ **Nutritious for Animals:** Millets are extremely nutritious grains. Their high nutrient content makes them desirable not just to humans, but also to birds and other animals too. The birds have co-evolved with these grains and therefore have beaks adapted to hulling these grains while ruminants such as cattle have a digestive system that can digest the hard cellulosic fiber in their husk. Under stress tolerance conditions, millets provide nutritious food as compared to others cereals, with high fiber content, minerals and slow digestibility. The millets can constantly help to meet out the needs of their animal feed and fodder. So all the typical by products of processing millets for consumption gets utilized

as an additive to bird and cattle feed.

- ✓ **Inclusion in chicken diets:** Including up to 50% whole pearl millet grain in the diet of broiler chickens does not negatively impact their performance. In fact, it has been found to significantly improve their growth and feed efficiency. However, substituting up to 50% of corn in layers diets with sorghum has similar effects on egg production rates. Additionally, broilers body weight gain was not affected when millet replaced corn in their diets.
- ✓ **Inclusion in ruminants' diets:** Millet grain *viz.* finger and pearl millets were evidently used to replace conventional grains, in the feed of small ruminants. An early, lactating and growing goat found that feed intake and milk production were not affected by the replacement of corn with pearl millet. However, they recorded a depression in the daily growth rate and feed-to-gain ratio when corn was completely replaced with pearl millet. Millet grain is also considered useful in the replacement of maize in big animals; pearl millet grain could fully replace maize in high-supplement diets. The processing of millet grain increases the digestibility of dry matter and dietary nutrients of grazing beef cattle during the dry season.
- ✓ **Low cost of Growing:** Millets do not depend on a high nutritive index of the soil they're grown in. So they do not need any supplemental help from fertilisers. They are also extremely resistant to pests, so pesticides are rarely needed for their growth, making it extremely lucrative for farmers to grow the crop and profit from it.

Millets as Animal Feed

Sorghum (Jawar): Sorghum is one of the major millets that have several applications as animal feed. As compared to a maize plant, sorghum is approximately 30 to 40 percent more water-use efficient. In animal nutrition, sorghum grain is mostly used as an energy source and it is a good feedstuff for poultry, pigs, and other ruminants. Grinding is a simple and least expensive method of preparing sorghum grain for the cattle.

Dairy animals: For dairy animals, sorghum is grown for fodder for grazing purposes or cut green to make silage and hay thus for Modern dairy units promote sorghum silage as an important feed. The dry sorghum stalks are preserved as fodder for a long time and cut into pieces and fed to the animals for a longer time. As a drought-tolerant species, sorghum improves water use efficiency while supporting relatively high levels of production in dairy cattle. Nutritionally, the protein content and neutral detergent fiber (NDF) digestibility of the sorghum and corn silage are similar. However, sorghum silage is about 15% units higher in NDF content, causing it to be more "rumen filling" than corn silage, which could reduce total diet intake if sorghum silage is fed at the same amount as corn silage.

Poultry: New varieties of grain sorghum are an excellent source of protein and energy for broilers and egg layers. Particle size is more important for feed manufacturing than nutrient uptake by poultry.

Over-processing of the grain may cause chemical cross-linking and reduce nutrient availability. Compared to corn, grain sorghum contains reduced quantities of yellow xanthophylls required for egg yolk pigmentation and skin coloration for broilers. Grain sorghum can be used at up to 70% in a broiler and layer rations and 55% in turkey rations replacing all corn. The nutrient profile of sorghum is complementary to protein sources typically formulated in poultry rations anywhere in the world and is very similar to corn (maize).

Goats and Aquaculture: Sorghum straw can be incorporated into the complete diet of goats and it's an average weight gain of 66 g daily. Omnivorous fish such as carp and tilapia can digest and metabolize sorghum-based diets. In common carp, the nutrient digestibility of sorghum compared with that of wheat bran and rye is shown in the below table.

Parameters	Rye Meal	Sorghum Meal	Wheat Bran
Protein Digestibility	91.89%	71.86%	80.01%
Fat Digestibility	79.84%	76.71%	82.01%

Sorghum or pellets containing 25% protein are used to feed common carp in ponds. The results showed that feeding on sorghum led to lower growth and higher body fat as compared with feeding on the pellet diet. It may have light levels of allergens or tannins and checking the nutritive quality before feeding is advised.

Pearl Millet (Bajra): Bajra or pearl millet is another important millet crop that is useful as feed for animals. The nutritive value depends on cultivar type growing conditions, and methods of preservation.

Dairy animals: It is estimated that the crude protein content of green bajra ranges from 6-20 per cent. The fresh forage is palatability and digestibility by ruminants. As pearl millet grain is concerned, it is hard-hulled and should be finely grounded before feeding to the livestock. The coarse grinding leads to the hard hull splintering into sharp fibres which can result in internal irritation to livestock. Pearl millet grain can be replaced up to 10-30 per cent of maize silage or maize grain in dairy cows with no deleterious effect on milk yield or milk composition. Feeding pearl millet to lactating dairy cows may reduce the supplemental protein requirement traditionally added to maize -based diets.

Poultry: In case of poultry, when compared to maize or sorghum, pearl millet is found to have equal or higher nutritive value. Reconstitution with or without enzymes is interesting as it enhances metabolizable energy and N retention. Laying hens can be fed on pearl millet as a maize replacement in soybean/maize-based diets up to 15 per cent of the diet for ungrounded pearl millet. In order to guarantee egg production, yolk colour, and poly-unsaturated fatty acids, pearl millet-based rations can be fed to laying hens with flaxseed or soybean oil supplementation.

Goat and Aquaculture: Pearl millet forage can be fed to goats. The crude protein intake and digestibility of pearl millet forage are higher than for other forages in goats. Overall, pearl millet can replace maize to an extent proving economic benefi-

ts. Omnivorous fish such as carp and tilapia can digest and metabolize sorghum-based diets.

Finger Millet (Ragi): Finger millet or ragi is one of the important millet, which is cultivated as fodder grass in India. It provides excellent hay and is used as green forage for cattle, sheep, and goats. The straw resulting from grain harvest can be grazed directly by the animals.

Dairy animals: Finger millet straw is of poor nutritive value, it must be supplemented with nitrogen and energy sources in order to meet maintenance or production requirements as with other cereal straws. Its nutritive value can be improved by urea and ammonia treatment, but supplementation must be adapted accordingly. Finger millet is an energy feed valuable for its high carbohydrate content, however, protein content (7-10%) is often slightly lower than that of maize grain and its fibre content is higher (crude fibre 4-9% DM). It is also much less rich in protein than pearl millet. Because of its lower nutritive value, finger millet is used when the prices of other cereals are comparatively high. The finger millet straw can be used as forage in diets for crossbred dairy cows supplemented with a balanced concentrate mixture (energy and protein), which will improve the milk production (increase in milk yield, fat and solids-not-fat content of milk) but reduced milk urea content.

Poultry: Use of finger millet is comparatively less especially in poultry feed which may be due to its lower protein and higher fiber content; it is of lower quality for poultry than maize, sorghum, and pearl. Several trials found that finger millet can substitute safely up to 25 per cent of maize grain (about 15% of the diet) without affecting weight gain, carcass yields, and immunity in commercial broiler diets.

Goats and Aquaculture: In some areas, Ragi straw is fed to goats but a higher protein supplement should be given along for profitable results. In female goats, Ragi straw is known to induce better lactation. Millet pearls can be used in feeds for tilapia fingerlings totally replacing energy and protein of corn without effecting performance and carcass quality of the animals.

Conclusions

Millets are the best crops choices which can offer a promising alternative to expensive animal nutrition for dairy, aquaculture, sheep and goats. The immediate actions would be to research and set standards for real time commercial applications, considering indigenous animals and ongoing animal husbandry practices. The Ministry of Animal Husbandry and the National Veterinary Institutes may take up extensive research projects and arrive at data that could be implemented to make animal husbandry economical and more profitable for farmers in the long run.

Unlocking Genetic Secrets: The Power of CTAB DNA Isolation in Plant Research

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Abstract

A single DNA isolation procedure might not be appropriate because different plant species differ in their metabolic makeup. The procedures for isolating DNA have been continuously updated and standardised. The Cetyltrimethylammonium bromide (CTAB) extraction method has been adapted for use in the majority of plant DNA isolation procedures. A plant's species and the portion of the plant that is used are taken into consideration while adjusting the concentration of chemicals used in the extraction process. In order to establish or adjust protocols for greater precision, it will be helpful to comprehend the function of each chemical (*viz*. CTAB, Nacl, PVP, ethanol, and isopropanol) utilised during the DNA extraction process. It has been summarised that the chemicals utilised in the CTAB method of extracting DNA have likely intricate yet highly evolved purposes for researchers and students.

Introduction

With the generation of data to speed up crop development, maximise plant selection, and deepen our understanding of plant biology, modern genomics techniques hold the possibility of revolutionising the field of plant biology. High-quality DNA extraction from a range of unique plant species and sample types is necessary for these procedures and applications. Fast, reliable, adaptable, and resilient DNA extraction procedures are necessary to stay up with this quickly developing area. Plant tissues, however, present a number of difficulties for even the most well-established DNA extraction techniques. Plants have extremely tough cell walls, and their cells are packed with substances that make extraction difficult and limit the use of plants in molecular biology applications later on. To conduct molecular research, high-quality DNA must be isolated. Compared to animal DNA extraction, maintaining yield and quality of DNA during plant DNA extraction is one of the more challenging tasks due to the plant's rigid cell wall, which is composed of cellulose along with other variable levels of chemical components like proteins, lipids, polysaccharides, and polyphenols that act as contaminants during DNA extraction. These components are highly troublesome for isolating DNA since their amounts vary depending on the species of plant, the section of the plant used, the growth stage, and the environment. Cereals, for instance, are abundant in carbs, whereas therapeutic plants are high in polyphenols, with stressed plants

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having higher levels of the compound. By standardising basic DNA extraction protocol, these impurities may be eliminated throughout the extraction process.

For plant tissues, fresh leaves that are 15-20 days old are often chosen. These leaves are typically burst by mechanical force in a pestle and mortar or tissue analyzer. In the absence of liquid nitrogen, CTAB buffer can be used straight away or reheated before grinding. The primary goal of different DNA isolation techniques is to create a comparatively fast, low-cost, and reliable process for extracting higher-quality DNA with a higher yield. Leaf samples often have high concentrations of polyphenols, tannins, and polysaccharides. The fundamental idea behind DNA isolation is that highly intact DNA is released into solution by disrupting the cell wall, nuclear membrane, and cell membrane. Contaminating biomolecules like proteins, polysaccharides, lipids, phenols, and other secondary metabolites are then removed using enzymatic or chemical techniques, and the DNA is precipitated.

Materials

- ✓ CTAB buffer: 2% cetyl trimethylammonium bromide, 1% polyvinylpyrrolidone, 100 mM Tris-HCl, 1.4 M NaCl, 20 mM EDTA, or CTAB Extraction Buffer.
- ✓ Polypropylene tubes (don't use polycarbonate tubes with phenol and chloroform)
- ✓ Centrifuge (at least 14,000 x g)
- ✓ RNase A Solution (10 mg ml^{-1} in water, DNase-free).
- ✓ Isopropanol
- ✓ 70% Ethanol
- ✓ 2 ml polypropylene centrifuge tubes
- ✓ Centrifugal Vacuum Concentrator (e.g., SpeedVac)
- ✓ TE Buffer (10 mM Tris, pH 8, 1 mM EDTA)
- ✓ Phenol/Chloroform/Isoamyl Alcohol (25:24:1 ratio) stored under TE buffer, pH 8

Process of CTAB

- ✓ Prepare plant samples by either cryogenically grinding tissue in a mortar and pestle after chilling in liquid nitrogen or grinding freeze-dried plants at room temperature to obtain a fine powder suitable for DNA extraction.
- ✓ Next, transfer the ground plant tissue to a polypropylene tube, and for every 100 mg of homogenized tissue, add 500 µl of CTAB Buffer. Mix thoroughly and vortex.
- ✓ Then, place the tube in a 60°C water bath for 30 minutes, followed by centrifugation of the homogenate for 5 minutes at 14,000 x g. Transfer the supernatant to a new tube.
- ✓ Add 5 µl of RNase A solution and incubate at 37°C for 20 minutes. Then, add an equal volume of phenol/chloroform/isoamyl alcohol (25:24:1), vortex, and centrifuge the sample for 1 minute at 14,000 x g to separate the phases.
- ✓ Repeat the extraction until the upper phase is clear, then transfer the upper aqueous phase to a new tube. Add 0.7 volume of cold isopropanol and incubate at -20°C for 15 minutes to precipitate the DNA.

- ✓ Centrifuge the sample at 14,000 x g for 10 minutes, decant the supernatant without disturbing the pellet, and wash with 500 µl of ice-cold 70% ethanol. Remove residual ethanol by drying in a SpeedVac.
- ✓ Ensure the pellet is dried sufficiently to remove alcohol but without completely drying the DNA. Finally, dissolve the DNA pellet in 20 µl TE buffer (10 mM Tris, pH 8, 1 mM EDTA), warming if necessary to dissolve the pellet.

Preparations and Precautions: Key Considerations before conducting CTAB DNA extractions

When to Take DNA Extractions

The entire CTAB procedure, from mortar and pestle grinding to resuspending sticky DNA pellets, may process a limited number of samples in around two hours. The technique consists of over 20 steps, and the time required to finish DNA extraction rises significantly with the quantity of samples. Make sure you allocate enough time in your schedule to finish the entire protocol.

Managing Dangerous Substances

Using liquid nitrogen for the first grinding phase requires caution since, even in brief exposure, it can quickly freeze skin tissue and result in cold burns. Working with phenol and chloroform also poses a biosafety risk because the former can result in chemical burns and the latter has the potential to cause cancer. The usage of these hazardous chemicals is a big worry for a lot of food testing laboratories. The use of phenol and chloroform also produces organic waste, necessitating specific disposal techniques and storage bins. Before you begin your DNA extractions, make sure you have the appropriate safety measures in place.

Preparing the Tissue of the Plant

Sample-to-sample variations in tissue grinding can result in notable differences in DNA extraction efficiency and quality. Although this procedure still requires a lot of time and limited throughput, you can also use a blender to create more consistent tissue disruption across samples. This is an essential step for a successful DNA extraction process since the more finely your tissue is powdered, the more effective your DNA extraction will be.

Phase Separation: Plant DNA is extracted from cellular debris using a phenol/chloroform/isoamyl alcohol solution. The mixture separates into three phases: an aqueous phase, an interphase, and an organic phase when vortexed. It can be difficult to remove all of the aqueous phase without upsetting the interphase, even though doing so takes time and labour. This is because extracting the aqueous phase must be done repeatedly. Consequently, your overall DNA yield and quality may be reduced as a result of contaminants from the organic phase and interphase that you may carryover or leave behind.

PCR Inhibitors: Polysaccharides, lipids, polyphenols, and/or other secondary metabolites are among the types of biochemicals found in plant tissues that can coprecipitate with DNA. This can hinder the use of thermostable DNA polymerases in downstream processes like PCR. The development

and optimisation of a “one size fits all” CTAB strategy is challenging because the structure and concentration of these chemicals can differ significantly between different plant species.8,9 Furthermore, even after thorough ethanol washes, phenol and other salts used during your CTAB treatment may still be present. Moreover, these contaminants may cause problems for applications farther down the line, such as PCR and NGS.

Conclusion

CTAB DNA extraction represents a fundamental technique in plant molecular biology, offering researchers a reliable means of obtaining high-quality genomic DNA. Through meticulous attention to experimental details, such as tissue selection, reagent preparation, and adherence to safety protocols, this method ensures consistent and reproducible results. As a cornerstone in plant genetic research, CTAB extraction continues to play a crucial role in advancing our understanding of plant biology, facilitating discoveries that contribute to agricultural innovation, biodiversity conservation, and broader scientific understanding.

References

Emaus, M. N., Cagliero, C., Gostel, M. R., Johnson, G. and Anderson, J. L. (2022). Simple and efficient isolation of plant genomic DNA using magnetic ionic liquids. *Plant Methods*, 18(1): 37.

https://opsdiagnostics.com/notes/protocols/ctab_protocol_for_plants.htm

Heikrujam, J., Kishor, R. and Mazumder, P. B. (2020). The Chemistry behind Plant DNA Isolation Protocols. *IntechOpen*. 2020 May 19; DOI: 10.5772/intechopen.92206.

https://zymoresearch.eu/blogs/blog/ctab-protocol-for-isolating-dna-from-plant-tissues

Why *Phytophthora* Pathogens Keep Killing Plants? A Debatable Question

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Abstract

Phytophthora is a genus of plant-damaging fungi belonging to the class oomycetes (water molds), whose member species are capable of causing enormous economic losses on crops worldwide. Its cell wall contains cellulose, growsthrough filamentous hyphae and produces oospores and zoospores. As of 2022, 210 species have been described, although it is thought that another 100-500 species were undiscovered within the *Phytophthora* genus, there is a diversity between species related to host plants, infected tissues and genome size. Most iconic examples of phytophthora causing epidemics includes Irish potato famine in 1845-1852 by *Phytophthora infestans*, tomato late blight (*P. infestans*), cocoa black pod and papayablight (*P. palmivora*), stripe canker on the cinnamon tree and other ornamental and forest trees (*P. cinnamomi*) and soybean root rot (*P. sojae*) (Giachero *et al.*, 2022).

Introduction

The genus *Phytophthora* has played a significant role in both human history and the history of plant pathology. During 1840's, an "unknown agent" caused epidemics of late blight in potatoes in the United States and Europe, culminating in the famous Irish Potato Famine of 1845. In Ireland, as a result of a combination of factors, the croplosses led to the death of over a million people and caused another million to flee the country (The history place). At this time, the cause of plant diseases like late blight was not known and the origin of disease remains a subject of debate. The severity of this blight prompted a few scientists to thinker deeper into finding the cause, leading to the origins of plant pathology as a science.

Reverend Miles Joseph Berkeley became the main supporter of the "fungal theory" of late blight (1845) based on his observations of mold-covered infected potato leaves under the microscope. In 1861, Heinrich Anton de Bary provided evidence that late blight was indeed caused by the "fungus." De Bary coined the name *Phytophthora* from the Greek word phyton means "plant" and phthora means "destruction" the "plant destroyer". Diverse new species of *Phytophthora* are regularly being described from croplands, forests and water ecosystems around the world. To date, more than 200 species have been formally described, most of them in the last 15 years. More species are expected to be discovered or described as surveys of water, riparian forest buffer plants and forest ecosystems. There has been an exp-

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onential expansion in the number of new species described in recent years (Brasier *et al.*, 2022).

Phytophthora in India scenario

The pathogeninfects the roots, stems, leaves and fruit at any stage of plant growth. *P. capsici* is Phytophthora foot rot caused by *Phytophthora capsici*, is one of the most serious threats to the production of black pepper (*Piper nigrum* L.) throughout blackpepper growing regions of the world including India (Anandaraj, 2005).

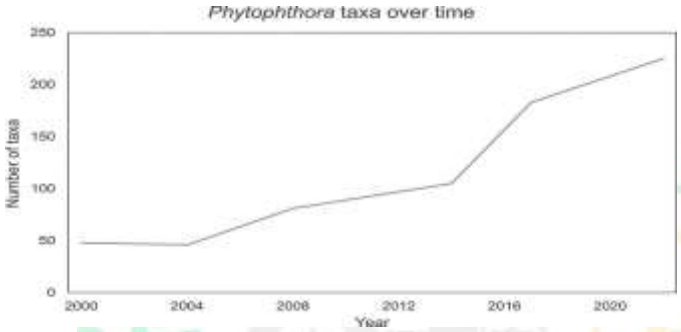


Fig. 1: Number of species in the *Phytophthora* genus

Heterothallic and requires both A_1 and A_2 mating types for sexual reproduction. These two mating types are reported to coexist in several areas of black pepper cultivation in Indonesia and Malaysia. The epidemic development of black pepper foot rot depends on environmental conditions, drainage, soil moisture, soil fertility, cultivar and cultural practices (Anandaraj and Umadevi, 2015). *P. capsici*, was first described by Leonian (1922) as the blight pathogen on chilli (*Capsicum annuum* L.) and considered to be host specific. *Phytophthora* isolates obtained from black pepperwere previously classified as *Phytophthora palmivora* based solely on morphologicalcharacters. The black pepper isolates were grouped under *P. palmivora* MF_4 based on the classification. Based on the morphological characters and host range, Aragakiand Uchida (2001) classified a sub group of *P. capsici* in to *P.tropicalis*. But the isolates in India share the characters of both *P. capsici* and *P. tropicalis* in rDNA analysis and host range as they infect both *Piper nigrum* and *Capsicum annuum*.

In India, cocoa is affected by three distinct species *viz*., *P. palmivora, P. capsici* and *P. citrophthora*. Based on protein electrophoresis Chowdappa and Chandramohanan (1995) concluded that the isolates of *P. palmivora* and *P. capsici* form distinct groupswhereas *P. citrophthora* formed two subgroups. Chowdappa *et al.* (2003a, 2003b) working with *P. capsici* from plantation crops like black, pepper, betel vine and cocoasuggested the use of ITS regions of rDNA for taxonomic purposes and for assessing intra-specific population variation in *P. capsici*. ITS sequences for *Phytophthora* isolates from betel vine (*Piper betle*), brinjal (*Solanum melongena*), guava (*Psidium guajava*), roselle (*Hibiscus subdariffa*), black pepper (*Piper nigrum*), sesame (*Sesamum indicum*), taro (*Colocasia esculenta*), chilli (*Capsicum annuum*), pointed gourd (*Trichosanthes dioica*), papaya (*Carica papaya*) were reported by Roy *et al.* (2009) and opined that *P. nicotianae* the most prevalent species on betel vine besides, *P. capsici* and *P. palmivora* was not recorded in eastern India. Among *P. infestans* the A2 mating type has displaced the A1 population in temperate highlands while in sub-tropical plains, A1 is still dominating. The *Phytophthora* isolates from citrus and *P. palmivora* isolates from coconut were predom-

inantly of A_2 mating type whereas in case of *P. capsici* and *P. colocasiae* isolates, majority were of A_1 mating type. Genetic diversity and fingerprinting of *Phytophthora* isolates using different molecular markers such as SSR, AFLP etc. suggested that *Phytophthora* isolates are at rapid pace of evolution with high level ofdiversity among isolates. Studies on mDNA haplotyping revealed that Indian population of *P. infestans* is composed of Ia and Ib and the population of new mt DNA haplotype Ia is on the rise (Data Unpublished).

Why *Phytophthora* keep killing plants?

Almost all species within the genus *Phytophthora* are formidable plant pathogens. Hence, what makes these organisms such effective plant pathogens? The following factors are involved:

- ✓ The ability to produce different types of spores such as sporangia and zoospores for short-term survival and spread, and chlamydospores and oospores for longer term survival.



Fig. 2: Ability of zoospore

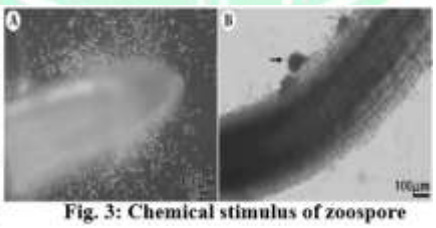


Fig. 3: Chemical stimulus of zoospore

- ✓ Rapid sporulation on host tissue within 3-5 days of infection. This results in arapid build-up of secondary inoculum in a multicyclic fashion, leading to epidemics under suitable favourable environmental conditions.
- ✓ Ability of zoospores of *Phytophthora* to be attracted to root tips through a chemicalstimulus (positive chemotaxis) as well as root-generated electric fields (electrotaxis), coupled with the mobility of zoospores to actually swim to the actively growing root tips, encyst, and infect young, susceptible root tissue.
- ✓ Ability to survive in or outside the host tissue as oospores or chlamydospores for long periods. Oospores are also known to survive passage through the digestive systems of animals such as snails.
- ✓ Production of sporangia, which can be airborne and may travel reasonable distances in raindrops, run-off and irrigation water, and on wind currents, to infect neighbouring fields. These sporangia can directly infect host tissue. These same sporangiospores also have the ability to differentiate into 4-32 zoospores under humid and cool conditions and cause multiple infections from the one sporangium.Nevertheless, zoospores can travel only short distances, as they are susceptible to desiccation.



Fig 4: Produced zoospores travel reasonable distance

- ✓ *Phytophthora* pathogens belong to the Kingdom Stramenopiles and as such have different biochemical pathways to the true fungi. Many fungicides are therefore notvery effective against phytophthora pathogens.
- ✓ *Phytophthora* pathogens thrive under humid and wet conditions, which makes them difficult to control, as protectant fungicides are difficult to

apply and least effectiveunder such conditions.

Because of all these factors which favours the pathogen to survive throughout the year and keep killing plants

References

Anandaraj, M. (2000). Diseases of black pepper. In: Black pepper (*Piper nigrum*). (Ed. Ravindran, P.N.) pp. 239-268. Harwood Academic Publishers,The etherlands.

Anandaraj, M. and Umadevi, P. (2016). The post genomic era: novel approaches for studying plant diseases and their management. *Indian Phytopathology*, 69(4): 1-9.

Anandaraj, M. (2005). Management of fungal diseases of black pepper. *Focuson Pepper*, 2(1): 27-37.

Brasier, C., Scanu, B., Cooke, D. and Jung, T. 2022). *Phytophthora*: an ancient, historic, biologically and structurally cohesive and evolutionarily successful generic concept in need of preservation, *IMA Fungus*, 13(2): 121-25.

Chowdappa, P. and Chandramohanan, R. (1995). Electrophoretic protein patterns of three species of *Phytophthora* associated with black poddisease of cocoa (*Theobroma cacao* L.). *Journal of Bioscience*, 20: 637-644.

Leonian, L. H. (1922). Stem and fruit blight of peppers caused by *Phytophthoracapsici* sp. nov. *Phytopathology*, 12(6): 401-408.

Chowdappa, P., Brayford, D., Smith, J. and Flood, J. (2003a). Identification of *Phytophthora* species affecting plantation crops by RFLP of PCR-amplified internal transcribed spacer regions of ribosomal RNA. *Current Science*, 85(6): 34-36.

Chowdappa, P., Brayford, D., Smith, J. and Flood, J. (2003b). Molecular discrimination of *Phytophthora* isolates on cocoa and their relationship with coconut, black pepper and bell pepper isolates based on rDNArepeat and AFLP fingerprints. *Current Science*, 84(1): 1235-1238.

Roy, S. G., Bhattacharyya, S., Mukherjee, S. K. and Khatua, D. C. (2009). Molecular identification of *Phytophthora* spp. affecting some economically important crops in Eastern India through ITS-RFLP and sequencing of the ITS region. *Journal of Phytopathology*, 157(12): 666-674.

Tissue Culture of Sugarcane: Unlocking Potential for Sustainable Agriculture

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Sugarcane is a vital crop worldwide, serving as a primary source of sugar and biofuel production. However, conventional cultivation methods face challenges such as diseases, low yield, and environmental impact. Tissue culture offers promising solutions to these issues by providing a means to propagate disease free, high yielding, and genetically superior sugarcane varieties.

Understanding Tissue Culture

Tissue culture involves the aseptic culture of plant cells, tissues or organs in a nutrient-rich medium under controlled environmental conditions. In sugarcane, this process typically begins with the selection of elite genotypes with desirable traits such as high sugar content, disease resistance and stress tolerance. Small pieces of tissue, known as explants, are then excised from the selected plants for culturing.

Propagation and Multiplication

The explants are surface sterilized to eliminate contaminants and placed onto a sterile growth medium containing essential nutrients, vitamins and plant growth regulators such as auxins and cytokinins. Under controlled conditions of light, temperature and humidity, the explants proliferate and differentiate into callus, a mass of undifferentiated cells.

Shoot induction and Regeneration

From the callus, shoots are induced by manipulating the concentrations of growth regulators in the medium. These shoots are then transferred to a separate medium to encourage their elongation and development into plantlets. Through successive subculturing and manipulation of growth conditions, a large number of plantlets can be rapidly produced from a single explant, ensuring genetic uniformity and accelerated multiplication.

Acclimatization and Field Establishment

Once the plantlets reach a certain size, they are carefully acclimatized to ex-vitro conditions by gradually exposing them to ambient environmental conditions. This process helps the plantlets adapt to the external environmental before they are transferred to the field for further growth and evaluation.

Advantages of Tissue culture in Sugarcane Production

- ✓ **Rapid multiplication:** Tissue culture enables the rapid production of disease-free planting material, reducing the time required for conventional seed propagation.
- ✓ **Genetic improvement:** It facilitates the selection and propagation of elite varieties with desirable traits, contributing to genetic enhancement and crop improvement programs.

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- ✓ **Disease Management:** Through stringent sterilization protocols, tissue culture minimizes the risk of transmitting diseases and pathogens, ensuring healthier plants and improved yield.
- ✓ **Environmental Sustainability:** By producing uniform and healthy plants, tissue culture reduces the need for chemical inputs and promotes sustainable agriculture practices.

Challenges and Future Directions

While tissue culture offers significant benefits, challenges such as high initial investment, technical expertise, and genotype-specific protocols need to be addressed. Research efforts focused on optimizing protocols, enhancing genetic variability, and integrating tissue culture with other biotechnological tools hold promise for further advancing sugarcane production.

Conclusion

Tissue culture represents a powerful tool for the sustainable production of sugarcane, offering solutions to key challenges facing the industry. By harnessing the potential of biotechnology, researchers and growers can continue to innovate and improve the efficiency, resilience, and sustainability of sugarcane cultivation, ensuring a steady supply of this vital crop for generations to come.

Scientific Process of Vermicompost Production in Small Holder Farming System

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Introduction

Outputs and bi-product should be effectively utilised in any small holder farm production system to maximise profit. Effective utilisation of farm waste can be ensured through production of vermicompost. In general, vermicompost has positive impact on increasing soil fertility without polluting the environment. Vermicompost is a method of making compost with the use of earthworm, which eats biomass and excreta in a digested form (Fudzagbo and Abdulraheem, 2020). The unutilised bi-product of livestock like cow dung can be effectively used in vermicompost production. Vermicomposting involves consumption and stabilization of organic matter by earthworms (Natarajan and Devi, 2014). Vermicomposting organic waste could have dual beneficial effects by generating an economically viable animal feed protein in the form of worm biomass, while alleviating the negative effects of poor organic waste management (Lalander *et al.*, 2015). Economic returns from farming activities can be increased by use of vermicompost as manure which can replace significant amount of costly chemical fertiliser. Among the composting techniques, vermicom-posting is considered as having a high potential for efficiently recycling agricultural organic materials such as crop residues and animal manure in smallholder farms (Gebrehana *et al.*, 2022). Soil health as well as the soil texture can be improved by continuous application of vermicompost in the field. Crops produced by using vermicompost as manure are good for human health and nutritional quality of those crops are far better than the crops grown by using chemical fertiliser. Vermicompost can be produced very easily at farm household with easily available resources.

Materials required for vermicompost production

For production of vermicompost very limited amount of materials which are easily available in the farm household and locality are used. Materials like cow dung, bi-products of crops or crop residues, weeds, residues of vegetables, rotten leaves etc are required for vermicompost production which is easily available in the farm household level. Apart from those materials, wastes from agricultural industries, wastes of villages and towns can also be utilised for production of vermicompost.

Vermicompost production process

Vermicompost can be produced very easily at the household level as no specialised materials/ inputs or machineries are required. The production process of vermicompost is given in the following paragraphs:

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- ✓ **Selection of earthworm for vermicompost production:** For production of vermicompost the easrthworm which are available on the top soil are used. The earthworms which lives at the bottom of earth cannot be used for vermicompost production. African earthworm (*Eudrilus eugeniae*) which is known as 'African Night crawler' is widely used for vermicompost production. Apart from that earthworm, *Eisenia fetida*, *Perionyx excavates* etc are used for vermicompost production.
- ✓ **Selection of site for vermicompost production:** The site for vermicompost production should have enough ventilation. Places with direct sunlight may be avoided for vermicompost production site. Abandoned room, animal shed, poultry shed etc are suitable site for vermi-compost production. The site for vermicompost production should be protected from direct sunlight or rain water.
- ✓ **Construction of vermicompost tank or pit:** For vermicompost production one pit may be constructed with 3 feet length, 2.5 feet breadth and 1.5 feet depth. The pit should be built by using bricks and cement. Though the size of the pit can reduce or enhanced depending on the available area. Vermi-pit can also be made by using plastic tub or cardboard box. There must be a slope in the vermin-pit to facilitate drainage in the tank. The depth of vermin-pit should not be excessive as more feed and less number of earth worm takes more time for vermicompost production.
- ✓ **Preparation of vermin-bed:** A 3 centimetre layer of wood dust/ saw dust or rice husk or coco husk may be spread at the bottom of the pit. After that, 3 centimetre thick layer of coarse sand are spread over that layer. Another 3 centimetre thick layer of soil containing at least 60 percent moisture is spread as third layer in the vermin-bed, though addition of soil is optional. After that, 2 to 3 centimetre thick layer of decomposed cow dung and other wastes is spread as the fourth layer. Preparation of good quality bed is the prerequisite for high quality vermicompost production. Proper aeration in the vermin-bed may be ensured by the crumbly state of all the materials for vermicompost production.
- ✓ **Selection of organic wastes as food for earthworms:** For production of quality vermi-compost sufficient amount of organic wastes are required which acts as food for earthworm. Earthworm can consume food up to 2 to 3 times of their body weight. Cow dung, goat droppings, excreta of ducks, poultry birds, rabbits are considered as good inputs for vermicompost production.
- ✓ **Addition of organic waste in vermicompost tank or pit:** Partially decomposed organic wastes which contain at least 60 percent of moisture are added in the vermicompost bed. After that, earthworms are added in the vermi-compost pit. For per cubic meter of tank 350 to 400 kg of organic waste can be added which is

sufficient for 1 kg of earthworm. Vermicompost can be available within 45 to 60 days. Around 35 to 40 percent of food is converted in vermi-compost.

- ✓ **Maintaining adequate moisture in the vermicompost pit:** Around 60 percent of moisture should be maintained in the vermi-compost pit. Occasionally water may be sprinkled to maintain right amount of moisture, though directly water may not be poured in the tank. Gunny bags, paddy straw may be spread over the tank and water may be sprinkled to maintain adequate amount of moisture.
- ✓ **Collection of vermicompost from the pit:** Vermicompost may be collected weekly basis. When the organic wastes become crumbly and blackish in colour it suggests the vermicompost is ready for collection. Vermicompost should be collected regularly to maintain proper aeration in the pit. After collection of vermicompost it may be stored in heaps.
- ✓ **Recollection earthworm from vermicompost pit:** After collection of vermicompost earthworm may be collected by placing raw cow dung balls in 4 to 5 places in the vermicompost pit. After 24 hours earthworm will be stuck in the cow dung balls and those balls are placed in bucket of water. In that process earthworm will be separated from the cow dung balls. In another way collected vermicompost with earthworm are kept in sunlight in heaps. Earthworm then moves to bottom of heap and can be collected easily.

Conclusion

Vermicompost can be produced in farm household by using locally available resources. Vermicompost not only ensures the utilisation of farm wastes but it also produces manure which contains good amount of nutrients. Good quality of vermicompost contains around 1.5 to 2 percent of nitrogen, 1 to 2 percent of phosphorus, 1 percent potassium, and around 17 to 18 percent of organic matter. With this rich nutrient contain the vermicompost can easily replace the harmful chemical fertiliser. By application of vermicompost soil health can also be improved which results in better productivity. Effective utilisation of farm wastes and replacement of chemical fertiliser cost enhances the farm profitability which enhances the farm profits.

References

Gebrehana, Z. G., Gebremikael, M. T., Beyene, S., Wesemael, W. M. L. and De Neve, S. (2022). Assessment of trade-offs, quantity, and bio-chemical composition of organic materials and farmer's perception towards vermi-compost production in smallholder farms of Ethiopia. *Journal of Material Cycles and Waste Management*, 24(2): 540-552.

Natarajan, N. and Devi, K. N. (2014). The use of earthworm *Eudrilus eugeniae* in the breakdown and management of poultry waste. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 8(9): 40-43.

Fudzagbo, J. and Abdulraheem, M. I. (2020). Vermicompost Technology: Impact on the Environment and Food Security. *Agriculture & Environment E-Newsletter*, 1(1): 87-93.

Lalander, C. H., Komakech, A. J. and Vinnerås, B. (2015). Vermicomposting as manure management strategy for urban small-holder animal farms - Kampala case study. *Waste Management*, 39: 96-103.

Significance of Fodder and Forage in Indian Livestock Sector

Prakash K. N., Manjanagouda S. Sannagoudar, Shantharaja C. S. and Vanishree G.

Abstract

Availability of quality feed and forages has been considered as the major bottleneck in harnessing the potential of the livestock sector in India. Cultivated fodder is limited to less than 4.5 per cent of the total cropped area. At present, country faces a net deficit of 63% green fodder, 24% dry crop residues and 64% feeds. Projections show a further increase in demand by 2025 due to changing feeding and more dietary reliance on livestock and its products. Only way to meet the fodder needs is to look for increased productivity per unit land area and also through integration of fodder crops in the cropping system.

Introduction

Livestock play an important role in sustaining livelihood, nutritional security and economic growth of Indian Agriculture. India had achieved horizontal growth in terms of animal number but, there is need to achieve vertical growth with respect to animal productivity. Animal sector is the primary source of energy for agricultural operations and major source of animal protein for masses. Therefore India is the home of major drought, milch and dual purpose breeds of cattle. Indian dairy production systems are complex and generally based on traditional and socioeconomic considerations. However, there has been a rapid change in way of Agriculture in terms of cropping systems, water resources, diversification of crops, increasing use of mechanical power, transformation from sustenance farming to market oriented farming, changing food habits, etc., All these factors have their impact on animal husbandry practices. Forages are the back bone of livestock industry and foundation of animal health and their production depends on availability of fodder. The scarcity of green forages and grazing resources in the country has made livestock to suffer from malnutrition resulted in decreasing production potentiality at below average compared to many developed countries.

Although, India stands first in milk production (176 m t) in the world, but average milk yield is very low (5 litres animal^{-1}) compared to developed countries (24 litres animal^{-1}). Deficit supply of green fodder is one of the main reasons for low milk yield along with other reasons like imbalanced nutrition, good quality fodder and soon on. In India, due to increased population pressure and

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competition from the food crops for land and water is not possible to increase the area under fodder crops further. The only way to bridge the large gap between demand and supply of fodder is through maximizing the fodder production per unit area and unit time. Another possibility is through better utilization of existing farming systems, utilizing marginal, sub marginal dry lands and problematic soils for developing fodder resources. Simultaneously efforts should be made in the genetic improvement of the livestock for better utilization of available fodder for most effectively, identification and introduction of new high yielding non traditional crops for green fodder and strategies to develop and adopt dual type grain cum fodder crop varieties to cater the demand of grain and fodder with available land resource.

Significance of feed and fodder

The livestock rearing in India is changing fast and there has been a raise in demand of milch animals as compared to dual and draft breeds. Population of indigenous breeds declined more than milch breeds and improved milch breeds over local milch breeds. Therefore more quality and quantity of fodder required for growing animals with following significance.

Feed and fodder cost constitute about 60-70 per cent of cost of milk production thus cultivated fodder has an important role in meeting requirement of nutrients and roughage in our country to produce milk most economically as compared to concentrates. In view of peculiar digestive system, provided by nature, ruminants need feeds, which are not only meet their nutrition requirement but also fill the rumen to satisfy animals for their production as well as the needs of microbes for promoting digestion. The fodder crops meet these requirements very effectively and hence are important for ruminant production system. It is evident that mixed coarse roughages like wheat straw, paddy straw and ragi straw its intake and digestion are improved. Fodder from common cereals like maize, sorghum, oat, bajra, napier grass, etc., are rich in energy and leguminous crops like lucern, berseem, cowpea are rich in crude protein. These leguminous crops are good source of minerals which are critical for rumen microbes as well as animal system. The green fodder crops are known to be cheaper source of nutrients as compared to concentrates and hence useful in bring down the cost of feeding and reduces the need for purchase of feeds/concentrates from the market. Where ever, surplus fodder is there then, that fodder can store as silage or hay for the lean season.

Problems or limitations for forage and fodder production

Forage and fodder improvement has its own limitations related to forage breeding, plant genetic resources, plant protection measures, forage quality, palatability and see production need to be appropriately addressed adopting in integrated approach. Some of the general constraints limitations in forage crop improvement and production are as:

- ✓ Non availability of sufficient quantity of quality fodder seeds and also non availability of dual purpose verities.

- ✓ Non synchronous flowering/anthesis and spikelet maturity, abscission of spikelts after maturity in grasses and the presence of large number of sterile glumes in grasses.
- ✓ Overlapping of vegetative and reproductive growth phases, uneven pod setting, non synchronous maturity and seed shattering in forage legumes.
- ✓ Apomictic nature of most of the tropical grasses that limits their genetic improvement.
- ✓ Non availability of good quality seed and planting material.

Strategies to increase fodder production

- ✓ There is need to promote scientific fodder production through improved agronomic practices and availability of improved seed varieties to farmers.
- ✓ Development of high yielding fodder varieties suitable for dryland and for irrigated areas.
- ✓ Regeneration and promotion of silvi-pasture, horti-pasture, agri-pasture and wasteland which will not only meet shortage of feed and fodder along with putting waste land under production.
- ✓ Promotion of enrichment of straw and feed supplements as entrepreneurial activity than treatment as farmer level.
- ✓ There is utmost need to organize method/result demonstrations and field days to popularize the technology among the farmers.
- ✓ Conservation of fodder either as silage and hay will be useful during the lean season Again by this we can enrich the fodder with minerals, protein and vitamins.
- ✓ Growing leguminous fodder trees or shrubs in the of field bunds to increase the fodder availability and protein supplement.
- ✓ A comprehensive grazing policy needs to be formulated and both grazing and forage cultivation has to be considered complementary to each other and simultaneous efforts are required to improve both.
- ✓ Fodder crops as intercrops in plantation crops like coconut, arecanut and in other plantation crops.
- ✓ Growing short duration fodder crops like maize, jowar, bajra, oat, cowpea, cluster bean, etc., in rice fallows to utilize the residual moisture.
- ✓ Shade tolerant grasses can be grown in the forests area as grass cover will reduce the soil erosion and animals can graze.
- ✓ Uncultivated permanent or temporary fallow land can be utilized for growing grasses.
- ✓ Establishment of grasses on hedge strips is a common form of erosion control in the humid area.
- ✓ Strategies should focus on developing dual type grain cum fodder varieties.
- ✓ Stay green quality protein maize varieties should encourage under cultivation.
- ✓ Application of biotechnology to evolve genetically improved varieties tolerant to abiotic and biotic stresses and enhancing forage productivity in berseem, lucern, oat, forage sorghum, range grasses, legumes as well as fodder trees.

- ✓ Processing and nutrient enrichment of low quality roughage and designing economic feeding systems for different categories of live-stock under different rearing systems.
- ✓ Year round fodder production through combination of perennials and annuals.
- ✓ Integration of forage production with food and other crops.
- ✓ The important aspect of fodder production should adjust the cultivation with that of main crops and harvest per the needs. This can be practices in all classes of farmers both under irrigated and rainfed conditions.
- ✓ Forage crops are grown in crop sequences in rainfed areas, only *rabi* crops are taken on conserved moisture through fallowing in the rainy season instead short duration forage crops like cowpea, rice bean and pear millet can be taken as these will conserve the soil moisture and suppress weeds besides providing forage. Under irrigated condition inclusion of fodder crops like cowpea, berseem etc., in sequences improve the soil productivity due to dense canopy and addition of more quality of stubble biomass and in addition leguminous forage enrich soil by fixing atmospheric nitrogen.
- ✓ The short duration forage can be adjusted in gap periods of main season crops as catch crops on residual moisture. Ex. Maize + cowpea/ sorghum/ pearl millet after harvest of *rabi* season crops and before planting of rainy season crops. Leguminous forages like horse gram (*Macrotyloma uniflorum* L.), moth bean (*Vigna aconitifolia* L.) and grasspea (*Lathyrus sativus* L.) are suitable for cultivation on residual moisture after the harvest of late paddy.
- ✓ Cotton, sugarcane, maize and sorghum offer scope for growing short statured forage intercrops crops like cowpea, moth bean and cluster bean in the interspaces without affecting their yields. Besides fixing the nitrogen, some of these forages benefit the main crop indirectly, for example, moth bean reduces root rot disease while cowpea controls spotted bollworm. Similarly, cultivation of pangola grass (*Digitaria decumbens* L.) in tobacco has been reported to control root knot nematode.
- ✓ Crops like pearl millet and barley which have have good regeneration capacity and these crops can be harvested 40-50 days after sowing to harvest green forage yields (100-150 q ha^{-1}) without adversely affecting the grain yields. Likewise, maize (grain) can be planted at 30 cm spacing, alternate rows may be harvested for forage 45-50 days after planting to get around 20 tonnes ha^{-1} green forage.
- ✓ Dual purpose crops should be encouraged as these crops give forage as byproduct. Preference must give to such crops in their cropping schemes so as to get substantial amounts of forage along with main product (grain). Among vegetables, turnip, carrot, pea, cauliflower, cowpea, guar, *etc.* are the important examples while in commercial crops. These crops besides main

product yield food green fodder for animal feeding.

- ✓ Mixed cropping of cereals/grasses and legumes is commonly practiced to improve herbage quality, increase biomass production and economize on fertilizer usage. Besides, it also ensures efficient land utilization, suppression of weeds and insurance against aberrant weather conditions. In India with warm climate, most of the grasses and cereals do not have enough protein to support animal growth and production. It was found that by associative cropping of graminaceous and leguminous forages the nutritive value of the mixed herbage could greatly be improved. Thus, besides enriching the soil productivity and ensuring better utilization of plant nutrients from different soil layers, mixed cropping produces nutritious herbage since the legume component contains higher amounts of protein, calcium and phosphorus.
- ✓ Bunds around fields occupy 2-10 per cent of the cultivated area and growing of appropriate forages/bushes stabilizes the bunds through protective cover and soil binding action of roots, besides providing considerable amount of forage for feeding animals.

Biopesticides: A Sustainable Approach for Insect Pest Management

Prakash K. N., Vanitha Khandibagur, Gopi S., Manjanagouda S. Sannagoudar, Shantharaja C. S. and Vanishree G.

Abstract

Climate change is anticipated to enhance the prevalence of pest and diseases and facilitate the spread of invasive species. The change in rainfall pattern and increase in temperature directly affects the development, distribution of insect pest. The dose or type of synthetic chemical pesticides applied to control the pest population has harmful effect on the environment, biodiversity and ultimately the consumers. To cope with potential adverse effects of some synthetic chemical pesticides an innovative approach like biopesticides can be incorporated. Biopesticides are less toxic to the user and also to the non target organisms therefore making them most desirable and sustainable tool for pest management. Many of these pesticides are developed into commercial products. Biopesticides used alone or in combination with conventional crop protection products, thus they function as an alternative to chemical insecticides to manage pest in the crop field and they serve as the best component of IPM.

Introduction

Bio means life or living organism. Pesticide refers to substance or mixture of substances intended for preventing, destroying or controlling any pest. Biopesticide is a formulation made from naturally occurring substances that can intervene the life cycle of insect pests in such a way that the crop damage can be minimized. Further this method compliment or supplement other methods of pest control. Biopesticides may be derived from animals (Nematodes), plants (Chrysanthemum, Neem) and microorganisms (*Bacillus thuringiensis*, *Trichoderma*, *Nuclear polyhedrosis virus*). Biopesticides put forth their inhibitory effects through multiple mode of action such as growth regulators, gut disruptors, metabolic poison, neuromuscular toxins and non specific multi-site inhibitors (Sparks and Nuen, 2015).

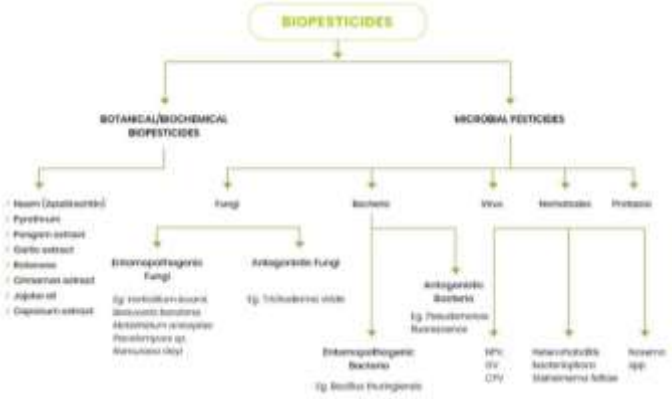
Classification of biopesticides

- ✓ **Biochemical/Botanical pesticides:** These are naturally occurring substances that control pests by non-toxic mechanisms. Biochemical pesticides include substances that interfere with mating such as insect sex pheromones (hexalure, cuelure), as well as various scented plant extracts i.e Neem, Derris, Nicotiana and Rhyania (El-

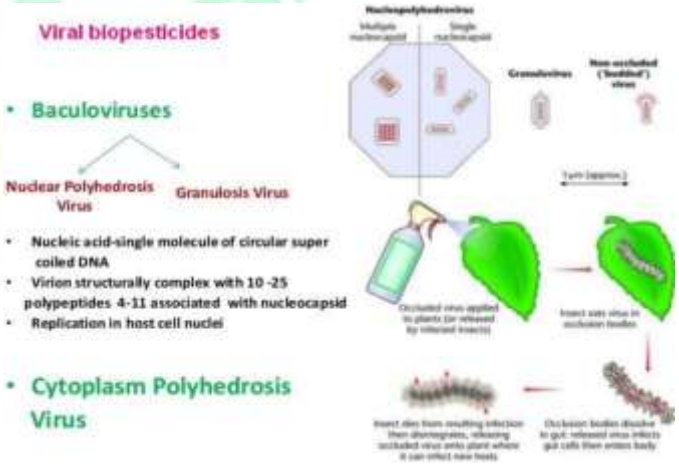
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Wakeil, 2013) and PGR (Plant growth regulators).

✓ **Microbial pesticides:** Consist of a micro-organism like bacteria, fungi, baculovirus and protozoans as the active ingredient acting against pests in agro ecosystem. They control many different kinds of pests, although each separate active ingredient is relatively specific for its target pests. Bacterial entomopathogen include *Bacillaceae, Serratia, Pseudomonas, Yersinia, Chromobacteria, Streptomyces* etc. While fungi consist several strains of *Beauveria, Metarhyzium, Verticillium, Lecanicillium, Hirsutella, Paecilomyces* etc. Entomopathogenic nematodes include species in the genera *Heterorhabditis* and *Steinernema* associated with symbiotic bacteria belonging to the genera *Photorhabdus* and *Xenorhabdus* (Senthil-Nathan and Sengottayan, 2015).

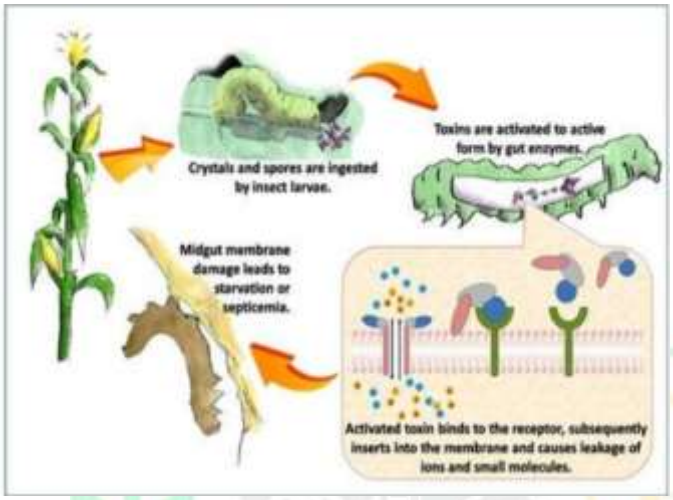


✓ **Plant-Incorporated-Protectants (PIPs):** These are the substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt protein and introduce the gene into the plant's genetic material. Then the plant manufactures the pesticidal protein that destroys the pest when it feeds on the plant. Both the protein and its genetic material are regulated by EPA. Cry proteins were the first generation insecticidal PIPs expressed in GM crops containing transgenes from soil bacterium *Bacillus thuringiensis* (Kimberly and Michael, 2017) similarly toxic complex proteins from *Xenorhabdus* and *Photorhabdus,* α-amylase inhibitors, protease from Baculovirus, double-stranded ribonucleic acid (dsRNA) and Mir1-CP from maize are some of the pesticidal protein (Shingote *et al*., 2013).



✓ **Bioagents:** These include predators and parasitoids and disease causing fungi, bacteria and viruses which are natural enemies of pests. Sugarcane *Pyrilla* has been controlled in many states by the introduction of parasitoid *Epiricanea melonoleuca.* Scale insects have been controlled by predator *Coccinella septempunctata.* The egg parasitoid, *Trichogramma chilonis* is released @ 2,40,000 acre^{-1} to control the cotton bollworm. Similarly *T. chilonis and T. japonicum* is successfully used against sugarcane

top shoot borer and rice yellow stem borer @1,00,000 acre^{-1}, respectively (Arshad Anwar, 2017). The larval parasitoid *Goniozus nephantidis* and *Bracon brevicornis* are released @ 1200 acre^{-1} to control coconut leaf eating caterpillar, *Opisina arenosella* (Misra, 2014). These are to be released at innundative doses.



Advantages of biopesticides

- ✓ Biopesticides are usually inherently less toxic than conventional pesticides.
- ✓ Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad spectrum pesticides that may affect other organisms such as birds, insects and mammals.
- ✓ Biopesticides often are effective in very small quantities and often decompose quickly, resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides.
- ✓ When used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly reduce the use of conventional pesticides, while crop yields remain high.

Conclusion

Challenges such as pesticide-related pollution, post-harvest chemical consumption through bioaccumulation, biodiversity losses, and insurgence of secondary pests can be overcome by use of bio pesticides. These negative consequences are not associated with the use of biopesticides. They are capable of bringing down the pest population below economic threshold level without harming non target organisms in almost all the agro ecological situations. Extensive and systemic research has greatly enhanced their effectiveness and the popularity of biopesticides. Although they are effective in controlling crop pest, their production not able to meet less than 1% of the cropped area. Thus there is a scope to enhance production and use biological agents in the days to come as the demand is on the increase every year.

References

El-Wakeil, N. (2013). Retracted article: Botanical pesticides and their mode of action. *Gesunde Pflanzen*, 65: 125-149.

Kimberly, M. Parker and Michael, S. (2017). Environmental fate of insecticidal plant-incorporated protectants from genetically modified crops: A knowledge gaps and research opportunities. *Environmental Science and Technology*, 51: 21.

Sparks, T. C. and Nauen, R. (2015). IRAC: Mode of action classification and insecticide resistance management. *Pesticide Biochemistry and Physiology*, 121: 122-128.

Md Arshad Anwar. Bipesticides and bioagents: novel tool for pest management book, CRC Press.

Misra, H. P. (2014). Role of Botanicals, Biopesticides and Bioagents in Integrated Pest Management. July, Odisha Review.

Senthil-Nathan and Sengottayan. (2015). A review of biopesticides and their mode of action against insect pests. *Environmental Sustainability*.

Shingote, P. R., Moharil, M. P. and Dhumale, D. R. (2013). Distribution of *vip* genes, protein profiling and determination of entomo-pathogenic potential of local isolates of *Bacillus thuringiensis*. Bt Research, 4: 45-54.

Challenges and Opportunities in Implementing Variable Rate Application (VRT)

Kamendra

Introduction

The agricultural landscape is undergoing a transformation, driven by technological innovations aimed at optimizing resource use and enhancing productivity. At the forefront of this transformation is Variable Rate Application (VRA), a precision agriculture technology that promises to revolutionize how inputs are applied in the field. Traditionally, farmers have employed a one-size-fits-all approach to input application, treating entire fields uniformly with fertilizers, pesticides, and seeds. However, this approach fails to account for the inherent variability within fields, resulting in inefficient resource use and suboptimal yields. Enter VRA, a game-changer that allows farmers to tailor input application rates based on spatial variability in soil properties, crop health, and other factors.

The concept of VRA is rooted in the principles of precision agriculture, which seeks to maximize efficiency and sustainability by applying inputs only where and when they are needed. By harnessing advanced technologies such as GPS guidance systems, sensors, and data analytics, VRA enables farmers to create customized prescription maps that dictate variable input rates across their fields.

How VRA Works

At the heart of VRA is the notion of site-specific management, which recognizes that different parts of a field have unique requirements. Soil characteristics, topography, moisture levels, and historical yield data are among the factors considered when generating prescription maps. These maps guide the deployment of equipment equipped with variable rate controllers, which adjust input application rates on the fly as they traverse the field.

For example, in areas with low soil fertility, fertilizer application rates may be increased to replenish nutrients and support healthy crop growth. Conversely, in areas prone to pest infestations, pesticide application rates may be intensified to protect crop yields. By tailoring inputs in this manner, VRA maximizes resource efficiency, minimizes environmental impacts, and optimizes yields.

Evolution of VRA

The concept of VRA has evolved significantly since its inception, driven by advancements in technology and agronomic understanding. Early implementations of VRA relied on rudimentary methods such as manual soil sampling and basic yield monitoring. However, with the advent of precision agriculture technologies, VRA has become more sophisticated and accessible.

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Today, farmers have access to a wide array of tools and services for implementing VRA, ranging from satellite imagery and drones for remote sensing to cloud-based software platforms for data analysis and prescription map generation. Moreover, equipment manufacturers have integrated VRA capabilities into their machinery, making it easier for farmers to adopt and implement this technology on their operations.

Challenges in Implementing Variable Rate Application (VRA)

Despite its potential benefits, the adoption and successful implementation of Variable Rate Application (VRA) are not without challenges. These obstacles range from technological barriers to logistical and regulatory complexities, requiring careful navigation and strategic solutions.

- ✓ **Data Management and Analysis Complexity:** One of the primary challenges in implementing VRA is the complexity of managing and analysing the vast amount of data required to create prescription maps. Integrating data from multiple sources, including soil maps, satellite imagery, and yield monitors, requires sophisticated data management systems and analytical capabilities. Many farmers may lack the expertise or resources to effectively collect, process, and interpret these data, hindering their ability to implement VRA successfully.
- ✓ **Technology Integration and Compatibility:** The seamless integration of various technologies, such as GPS guidance systems, sensors, and precision equipment, is essential for the effective implementation of VRA. However, ensuring compatibility among different hardware and software components can be challenging, especially when dealing with equipment from multiple manufacturers. Farmers may encounter interoperability issues that require technical expertise to resolve, potentially leading to delays and increased implementation costs.
- ✓ **Decision-Making Complexity:** While VRA offers the promise of precision agriculture, it also introduces new layers of decision-making complexity for farmers. Deciding on optimal input application rates requires a nuanced understanding of agronomy, soil science, and data analysis. Farmers must consider factors such as soil fertility, crop health, weather conditions, and market dynamics when creating prescription maps. Making informed decisions in this context requires both expertise and access to timely and accurate information, posing a challenge for many farmers, particularly those with limited resources or technical capabilities.
- ✓ **Infrastructure and Connectivity Limitations:** Access to reliable internet connectivity and infrastructure is critical for the successful implementation of VRA, yet many rural areas still lack adequate broadband coverage. Limited connectivity can impede data transmission, software updates, and remote monitoring capabilities, undermining the effectiveness of VRA systems. Addressing infrastructure gaps

and expanding broadband access in rural areas is essential to ensure equitable access to VRA technologies and maximize their potential impact on agricultural productivity and sustainability.

- ✓ **Regulatory and Policy Uncertainties:** The regulatory and policy environment surrounding agricultural practices can pose significant challenges for the implementation of VRA. Farmers may encounter barriers or uncertainties related to regulatory compliance, data privacy, environmental stewardship and product labelling. For example, concerns about data ownership and privacy may arise when sharing farm-level data with third-party service providers or government agencies. Clear and adaptable policies that support innovation while addressing societal concerns are essential to foster the widespread adoption of VRA and ensure its long-term viability.
- ✓ **Cost and Return on Investment:** The initial investment required to adopt VRA technology can be substantial, including the purchase of precision equipment, software licenses, and data management systems. While VRA has the potential to improve resource efficiency and yield outcomes, farmers must carefully evaluate the costs and benefits to justify the investment. The return on investment may vary depending on factors such as farm size, crop type, and local market conditions, making it challenging for some farmers to justify the upfront costs.
- ✓ **Education and Training:** Effective implementation of VRA requires a skilled workforce capable of understanding and leveraging advanced technologies and data analytics. Many farmers may lack the necessary training and expertise to fully utilize VRA tools and interpret prescription maps accurately. Providing access to education and training programs tailored to the needs of farmers can help bridge this knowledge gap and facilitate the adoption of VRA on a broader scale.
- ✓ **Seasonal Variability and Adaptation:** Agricultural systems are subject to seasonal variability and unpredictability, which can pose challenges for the implementation of VRA. Factors such as weather patterns, pest outbreaks, and crop health fluctuations can influence the effectiveness of VRA prescriptions and require adaptive management strategies. Farmers must continuously monitor and adjust their VRA practices throughout the growing season to respond to changing conditions and optimize outcomes.
- ✓ **Scaling and Accessibility:** While VRA technologies have become more accessible in recent years, barriers to adoption still exist, particularly for small-scale and resource-constrained farmers. Scaling VRA implementation beyond large commercial operations may require innovative approaches to technology dissemination, such as cooperative models, equipment sharing programs, or public-private partnerships. Ensuring that VRA solutions are affordable, user-friendly, and accessible to farm-

ers of all sizes and backgrounds is essential for maximizing its impact across diverse agricultural landscapes.

- ✓ **Risk Management and Resilience:** Implementing VRA introduces new risks and uncertainties that farmers must navigate, including technical failures, data inaccuracies, and market fluctuations. Developing robust risk management strategies that account for these uncertainties is critical for ensuring the resilience of VRA systems. Farmers may need access to risk management tools, insurance products, and support services to mitigate potential losses and build confidence in adopting VRA as a long-term strategy for improving farm sustainability and profitability.

Opportunities in Implementing Variable Rate Application (VRA)

- ✓ **Enhanced Resource Efficiency:** By precisely matching input application rates to field variability, VRA enables farmers to optimize resource use. This not only improves cost-effectiveness but also reduces environmental impacts associated with excessive fertilizer or pesticide application. By minimizing waste and runoff, VRA contributes to the sustainability of agricultural practices.
- ✓ **Improved Yield and Profitability:** The ability to tailor inputs based on specific field conditions can lead to improved crop yields and profitability. By addressing localized soil nutrient deficiencies, pest pressures, or moisture levels, VRA helps maximize the potential of each acre. This increased productivity can translate into higher farm incomes and economic resilience.
- ✓ **Innovation and Collaboration:** The advent of VRA has spurred innovation and collaboration across various sectors. Ag. tech companies, research institutions, and farmers are collaborating to develop and refine VRA technologies and practices. Open data initiatives and knowledge-sharing platforms facilitate the exchange of information and best practices, driving continuous improvement in agricultural productivity and sustainability.
- ✓ **Adaptation to Climate Change:** In the face of climate change and its unpredictable impacts on agriculture, VRA offers a proactive adaptation strategy. By enabling farmers to respond dynamically to changing environmental conditions, VRA enhances resilience and reduces vulnerability to climate-related risks. Adaptive management practices, supported by VRA, can help mitigate the adverse effects of extreme weather events and shifting growing seasons.
- ✓ **Consumer Transparency and Traceability:** For consumers increasingly concerned about food quality and safety, VRA contributes to greater transparency and traceability in the food supply chain. By documenting inputs and application rates at a granular level, VRA helps ensure compliance with food safety standards and certifications. This transparency builds trust

and confidence among consumers, driving demand for sustainably produced agricultural products.

- ✓ **Precision Resource Management:** VRA enables farmers to precisely match input application rates to the specific needs of their fields, optimizing the use of resources such as fertilizers, pesticides, and water. By targeting inputs only where they are needed most, VRA minimizes waste, reduces environmental impacts, and maximizes resource efficiency. This precision resource management approach not only improves farm profitability but also contributes to long-term sustainability by minimizing the environmental footprint of agricultural production.
- ✓ **Data-Driven Decision-Making:** VRA relies on advanced data analytics and decision support tools to generate prescription maps and guide input application rates. By leveraging farm-level data, including soil maps, satellite imagery, and historical yield data, farmers can make more informed decisions about input management. This data-driven approach enhances the accuracy and effectiveness of VRA prescriptions, leading to improved crop yields, reduced input costs, and enhanced farm profitability.
- ✓ **Customization and Flexibility:** One of the key advantages of VRA is its ability to customize input application rates based on the specific variability within each field. Farmers can tailor VRA prescriptions to address localized soil nutrient deficiencies, pest pressures, and other factors that impact crop performance. This level of customization allows farmers to adapt their management practices to changing field conditions and respond dynamically to emerging challenges, enhancing resilience and mitigating risks associated with climate variability and market fluctuations.
- ✓ **Integration with Precision Technologies:** VRA can be seamlessly integrated with other precision agriculture technologies, such as GPS guidance systems, automated machinery, and remote sensing tools. This integration enables farmers to leverage a suite of advanced tools and technologies to optimize farm management practices and improve overall operational efficiency. By combining VRA with technologies like automated steering systems and real-time monitoring sensors, farmers can streamline field operations, reduce labor costs, and achieve higher levels of precision and accuracy in input application.
- ✓ **Value-Added Services and Market Opportunities:** The adoption of VRA opens up new opportunities for value-added services and market differentiation for farmers. By documenting input application rates and practices, farmers can demonstrate their commitment to sustainable and environmentally responsible farming practices, enhancing their marketability and access to premium markets. Additionally, farmers can capitalize on emerging

trends such as precision agriculture consulting, agronomic services, and data analytics to diversify their revenue streams and create new business opportunities within the agricultural sector.

- ✓ **Research and Innovation:** The implementation of VRA drives innovation and research in agricultural technology and agronomy, leading to the development of new tools, practices, and methodologies for improving farm productivity and sustainability. Researchers, industry partners, and farmers collaborate to explore new frontiers in precision agriculture, pushing the boundaries of what is possible and driving continuous improvement in farm management practices. This culture of innovation fosters a dynamic and vibrant agricultural sector, driving economic growth and supporting rural communities.

Conclusion

As the agricultural sector continues to evolve, Variable Rate Application (VRA) stands out as a transformative technology with the potential to revolutionize modern farming practices. Despite the challenges it presents, the opportunities offered by VRA for enhancing sustainability, productivity, and resilience are profound.

By addressing key challenges such as data management complexity, technology integration, decision-making complexity, infrastructure limitations and regulatory uncertainties, farmers and stakeholders can unlock the full potential of VRA. Collaboration among researchers, policymakers, industry partners, and farmers is essential for developing holistic solutions that drive the widespread adoption of VRA and pave the way for a more sustainable and productive agricultural future.

From precision resource management to improved yield and profitability, from fostering innovation and collaboration to adapting to climate change and enhancing consumer transparency, VRA offers a multitude of benefits that can transform agricultural practices for the better.

As farmers and stakeholders embrace VRA and overcome its implementation challenges, they will unlock its full potential to drive a more efficient, resilient, and sustainable agricultural sector. With a commitment to innovation, collaboration, and continuous improvement, VRA has the power to shape the future of farming and create a more sustainable food system for generations to come.

Enhancing Nitrogen Use Efficiency with Liquid Fertilizer Applicators

Kamendra, Manish Kumar, H. S. Pandey, C. S. Sahay, Deepak Thorat and Satish Kumar Singh

Introduction

In the world of agriculture, where every seed planted holds the promise of feeding nations, the role of fertilizers cannot be overstated. Among these essential nutrients, nitrogen stands out as a critical element, fuelling crop growth and yield. Its pivotal role in synthesizing essential non-protein compounds vital for crop metabolism, biochemistry, and physiology underscores its importance in agricultural production.

However, despite the paramount importance of nitrogen fertilizers, the efficient utilization of nitrogen by crops remains a persistent challenge. Studies indicate that a significant portion of applied nitrogen is lost, with losses reaching up to 50% under varying soil and climate conditions. In a bid to maximize crop yields, farmers often resort to high rates of nitrogen fertilizer application. However, this practice frequently leads to low Nitrogen Use Efficiency (NUE) and adverse environmental consequences, including soil compaction and disruption of soil nutrient balance.

Moreover, the indiscriminate use of chemical fertilizers, coupled with escalating production costs, poses significant environmental risks such as soil and groundwater contamination. As the global population continues to grow, mitigating these environmental impacts while ensuring sustainable agricultural practices becomes increasingly imperative. Thus, the adoption of innovative technologies aimed at enhancing Nitrogen Use Efficiency (NUE) and minimizing environmental degradation presents a pressing need in modern agriculture.

Urea, a widely utilized fertilizer in wheat production across Asia, is particularly susceptible to nitrogen loss through various pathways if not promptly incorporated into the soil post-application (Fig. 1 and 2). To address these challenges, several countries and organizations have developed deep placement applicators, such as Urea Super Granule (USG) and Urea Mega Granule (UMG), aiming to improve fertilizer use efficiency. However, global initiatives regarding liquid urea applicators have been minimal, presenting an opportunity for further exploration and adoption. Recent research has emphasized the importance of precise fertilizer placement for maximizing efficiency and promoting plant growth. The injection of liquid fertilizer into the soil emerges as a promising strategy to mitigate nitrogen loss through volatilization, minimize surface runoff pollution, and enhance plant nutrient uptake.

Liquid fertilizer applicators offer numerous advantages over traditional granular fertilizers, including low cost, easy absorption, high efficacy,

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and rapid application. When directly injected into the soil, liquid fertilizers provide benefits such as faster nutrient absorption through the root system and reduced ammonia emissions compared to surface-applied granular fertilizers.

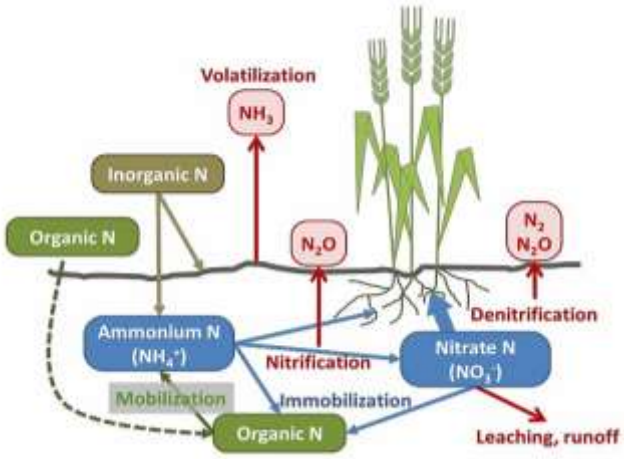


Fig. 1: Nitrogen losses at different stages between the moment of application and crop up-take (Teenstra *et al*., 2015)

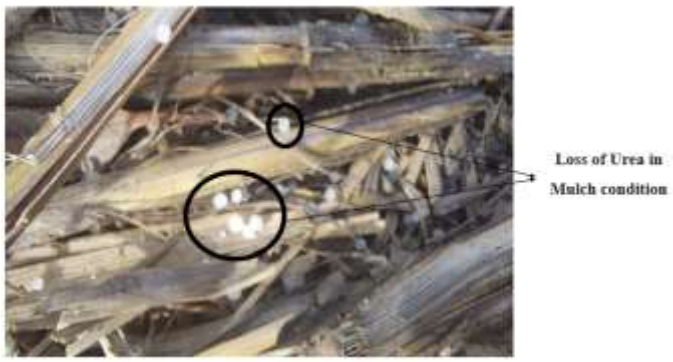


Fig. 2: Loss of urea due to use of broadcasting method

India, a powerhouse in agricultural production, relies heavily on fertilizers to meet its growing food demands. Therefore, the adoption of liquid fertilizer applicators represents a critical step towards sustainable agriculture, emphasizing the importance of precision placement and efficient nutrient delivery for maximizing crop yields while minimizing environmental impact.

Recent advancement in liquid fertilizer applications

Kelley *et al.* (2005) investigated wheat production factors in southeastern Kansas (1992-2001), finding that previous crop, nitrogen (N) rate, and placement method significantly impacted grain yield. They concluded that higher N rates and subsurface-knife placement enhancing yield. Nyord *et al*. (2008) explored liquid biofertilizer application, highlighting that disc coulter injection at 5-7 cm depth reduced ammonia loss to 2-3%, contrasting with surface application's 20-35% loss. High-pressure injection showed promise in the lab but failed to reduce ammonia volatilization in field conditions. Chen *et al*. (2016) examined urea-15N placement on wheat in China, emphasizing that banded N placement significantly boosted grain yield by 15% and reduced N loss compared to broadcast, suggesting it as a viable N management practice. From collected literatures it was found that the there is no suitable liquid fertilizer applicator is available for top dressings in wheat crop.

In response to the challenges associated with traditional broadcasting methods and aiming to mitigate nitrogen losses while enhancing nitrogen use efficiency, the ICAR-Central Institute of Agricultural Engineering (CIAE), Bhopal has developed a tractor-operated liquid fertilizer applicator specifically designed for wheat crops. This innovative prototype was evaluated in the experimental fields of CIAE, Bhopal, to assess its performance and effectiveness.

The liquid fertilizer applicator represents a significant advancement in agricultural technology, offering a more precise and efficient alternative to conventional broadcasting methods. By delivering liquid fertilizers directly to the root zone of wheat crops, this specialized equipment minimizes nitrogen losses, optimizes nutrient uptake, and promotes healthier plant growth. Moreover, the use of liquid fertilizers facilitates a reduction in application time and cost, further enhancing the overall efficiency of the fertilization process. Therefore, to address the challenges associated with broadcasting, reduce the N losses and enhance the nitrogen use efficiency ICAR-Central Institute of Agricultural Engineering, Bhopal has developed a tractor operated liquid fertilizer applicator for wheat crop. By addressing key challenges associated with traditional fertilization practices, this innovative technology has the potential to significantly improve agricultural productivity and sustainability. The development of the tractor-operated liquid fertilizer applicator by ICAR-CIAE represent a notable contribution to modern agricultural practices. By harnessing the benefits of precision nutrient delivery, this technology has the capacity to revolutionize fertilization techniques, offering farmers a more efficient and sustainable approach to crop production. The performance of the developed prototype was evaluated in the experimental field of CIAE, Bhopal. It was found the liquid fertilizer applicator reduces the N- loss, saves time and cost, and increases the yield.

Working of Liquid Fertilizer Applicator

The developed liquid fertilizer applicator, designed by the ICAR-Central Institute of Agricultural Engineering (CIAE) in Bhopal, integrates several essential components to revolutionize fertilization techniques. This innovative equipment includes a tank, pump, tractor, coulter, distribution system, and injectors, each playing a vital role in its operation. The tank serves as the reservoir for the liquid fertilizer solution, ensuring a continuous and steady supply throughout the application process. The tractor provides the necessary power to operate the pump and propel the applicator across the field.

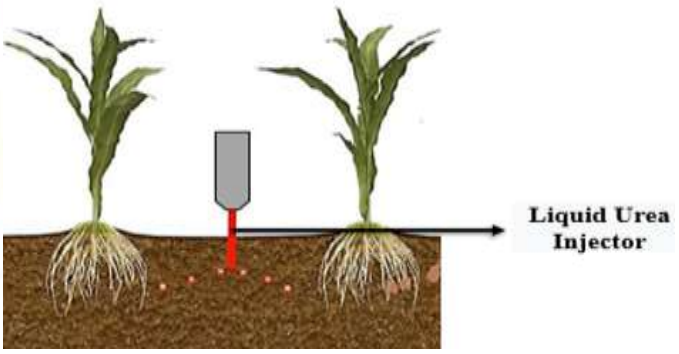


Fig. 3: Injecting liquid fertilizer into the subsurface of the soil

Meanwhile, pump facilitates the transfer of the liquid fertilizer from the tank to the distribution system. The distribution system, consisting of hoses, pipes, and nozzles, facilitates uniform delivery of the fertilizer solution across the width of the field, covering the entire planting area efficiently. As the applicator moves forward, the coulter, opens the soil ahead, creating furrows for precise fertilizer injection. This process ensures optimal nutrient placement directly into the soil, maximizing absorption by the crops. Furthermore, the injectors

release the fertilizer solution into the open furrows, guaranteeing close contact with the plant roots for optimal nutrient uptake (Fig. 3).

Advantages of Liquid fertilizer applicator

- ✓ **Precision Nutrient Placement:** Liquid fertilizer applicators allow for precise placement of nutrients directly at the root zone of plants. Unlike conventional broadcasting methods, which often result in uneven distribution and nutrient wastage, liquid applicators deliver fertilizers in a targeted manner. By injecting liquid fertilizers directly into the soil, these devices ensure optimal nutrient uptake and utilization by crops, leading to improved growth and yield.
- ✓ **Minimizing Environmental Impact:** One of the most significant advantages of liquid fertilizer applicators is their ability to minimize environmental pollution. By delivering fertilizers directly to the root zone, these devices reduce the risk of nutrient runoff and leaching into water bodies. This helps to mitigate water pollution and preserve aquatic ecosystems. Additionally, the precise placement of nutrients minimizes nitrogen volatilization, reducing greenhouse gas emissions and atmospheric pollution.
- ✓ **Enhanced Fertilizer Efficiency:** Liquid fertilizers applicator offers superior efficiency compared to traditional granular fertilizers application. The liquid form allows for better nutrient absorption by plant roots, resulting in higher fertilizer use efficiency and reduced wastage. Moreover, liquid fertilizers can be customized to meet specific crop nutrient requirements, ensuring optimal plant nutrition and maximizing yields.
- ✓ **Versatility across Crops and Soils:** Liquid fertilizer applicators are highly versatile and can be used to suit different crop types and soil conditions. Whether it's row crops or vegetables, this equipment can be customized to deliver the right amount of nutrients at the right time, optimizing crop growth and health.

Conclusion

The development and adoption of liquid fertilizer applicators represent a significant advancement in modern agricultural practices. By addressing key challenges associated with traditional broadcasting methods and aiming to mitigate nitrogen losses while enhancing nitrogen use efficiency, this innovative technology offers a more precise and efficient alternative for fertilization. The liquid fertilizer applicator developed by ICAR-Central Institute of Agricultural Engineering (CIAE), Bhopal, has demonstrated promising results in reducing nitrogen losses, saving time and costs, and ultimately increasing crop yields.

The liquid fertilizer applicator's ability to deliver nutrients directly to the root zone of crops minimizes environmental impact, promotes sustainable agriculture, and ensures optimal nutrient uptake by plants. Moreover, its versatility across different crops and soils, coupled with the precision in nutrient placement, makes it a valuable equipment

for farmers striving to improve productivity and sustainability in their agricultural practices.

The widespread adoption of liquid fertilizer applicators holds the potential to revolutionize fertilization techniques, offering farmers a more efficient, sustainable, and environmentally friendly approach to crop production. By harnessing the benefits of precision nutrient delivery and maximizing fertilizer efficiency, these technologies pave the way for a more resilient and productive agricultural sector, capable of meeting the challenges of feeding a growing global population while safeguarding the environment for future generations.

Automated Protected Structures: Turnkey System

B. Subhash

Abstract

An automated protected structure is a specialized structure which protects the crops much better than the crops cultivated inside the normal protected structure. So, here the various crops are grown more intensively so that the health and care of the peculiar crops are cultivated and exported to various parts of our country as well to various parts of our neighboring countries. The initial costs for setting up this automated protected structure is high but further management is feasible. And there are several advantages and dis-advantages which has an impact over protected structures. The automated protected structures have several components which emphasis the fluent functioning of this structures. This automated protected structure enhances the protection of various diseases and pests of the crops grown inside it and a wealthy yield can be obtained out of it.

Introduction

An automated protected structure is type of closed greenhouse structure which consists all the basic amenities present in greenhouse which is fully electrified. A cropping method known as "Protected cultivation" involves growing plants in a regulated environment. The concept of cultivating plants in regulated environments dates back to the Roman era. The Roman gardeners grew vegetables for daily consumption using artificial techniques akin to the protected system (Janick *et al.*, 2007). The Netherlands is home to many of the biggest poly homes in the world today, some of them are so big that they can produce a lot of vegetables annually (Muijzenberg and Erwin, 1980). The globe over, protected farming is quite popular since high-value crops are planted in these structures. A good climate is essential for growing crops, but the climate has changed in recent years. The yield and productivity of crops are decreased by the harsh weather conditions, such as heat waves and cold waves. It is very challenging to cultivate veggies in an open field during the winter in north India.

Due to the fact that vegetables are extremely weather-sensitive. It is very difficult to grow vegetables in open fields in north India during the summer and winter months. Nevertheless, a variety of protected structures have been developed to grow some high-value crops continuously by offering favourable environmental conditions and shielding them from the extreme heat and cold (Negi *et al.*, 2013). Research indicates that the majority of people in the upper Himalayan regions live in rural areas and rely primarily (70%) on agriculture-based lively-hoods for their well-being. The agricultural production system can only operate up to 2400 mete-

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rs above mean sea level since the climate is extremely harsh and the growing season is short in high-altitude regions (Kumar *et al.*, 2006), discovered that the hills' agro-ecological conditions present a great deal of opportunity for growing vegetables off-season and boost farm income through the use of protected cultivation, in which the microclimate around the plant body is completely or partially controlled according to the needs of the plant species grown. Using greenhouses is the most effective way to combat climate diversity. A poly house can be covered with a variety of materials, including plastic for the walls and roof, and it gets heated as sunlight enters the building and is absorbed inside. The roof and wall of the structure contain the heated air that has been generated by the heated interior surfaces, preventing the heated air near the ground from rising forever and escaping. Commercial poly houses are frequently state-of-the-art fruit, vegetable, and flower production facilities. These poly homes may be automatically operated by a computer and include equipment such as lighting, heating, cooling, and screening installations. Producing vegetables under protected settings entails shielding the plants from harsh weather conditions, such as extreme heat, hail, sunlight, and heavy downpours, during the growing season (Singh *et al.*, 1999). Over the past 10 or so years, protected cultivation of premium vegetables and cut flowers has demonstrated enormous promise. Because of the technology, growers with smaller land holdings are also opening up opportunities, even though the greater productivity levels still have an economic impact on agriculture. Given that protected cultivation is an enormous assemblage of various agricultural facets (Sabir and Singh, 2013). Bhatnagar *et al.* (1990) revealed that capsicum was cultivated under greenhouses during the winter in the hilly region of Uttar Pradesh, yielding 50 q ha^{-1} more than those planted in open fields (24 q ha^{-1}). Agriculture is growing along with technology, which is changing daily. India has long been a nation primarily focused on agriculture, with a subtropical climate that is ideal for productive farming. People have suffered a great deal of losses even though crop production efficiency and overall turnover have decreased recently compared to previous years. Although conventional agricultural production techniques were thought to be sufficient in the past, customers are now requesting off-season yields.

A turnkey system is a structure which is covered with transparent or translucent material large enough to grow crops under partial or fully controlled conditions to get the favorable conditions to get the better growth and productivity.



Fig. 1: Turnkey System of Greenhouse

Advantages of Trunkey System

- ✓ In less time, it offers efficiency and simple ventilation.

- ✓ High light transmittance makes it possible to consume extra and uniform product.
- ✓ During the project phase and soil survey, earthquake resistance values are computed in conjunction with the construction.
- ✓ Larger and higher caliber output.
- ✓ Permit the establishment of the best climate conditions for every crop and stage.
- ✓ Off-season Vegetables.
- ✓ Better management of illnesses, weeds, and pests.
- ✓ Increased defense against severe weather conditions and/or control
- ✓ More productive resources are used more effectively.
- ✓ Depending on the type of greenhouse, the type of crop, and the environmental control systems, the yield could be 10-12 times higher than with outdoor farming.
- ✓ Crop reliability rises with greenhouse cultivation.
- ✓ Perfect for crops such as flowers and veggies.
- ✓ Love Crop output for floriculture throughout the year.
- ✓ Love Production of fruit and vegetable crops during off-season.
- ✓ Transplants that are both disease-free and genetically superior can created on a constant basis.
- ✓ Effective use of chemicals and pesticides for pest management and illnesses.
- ✓ Love crops have a very low water requirement that is simple to manage.
- ✓ Love cultivating grafted plant-lets and maintaining stock plants and plantlets that were micro-propagated.
- ✓ Tissue-cultured plant hardening
- ✓ Love Creation of flawless, high-quality produce.
- ✓ Most helpful in keeping an eye on and managing the instability of diverse natural systems.
- ✓ Love Hydroponic (soil-less culture) methods of today And Aeroponics.

Disadvantages of Trunkey System

- ✓ A High Initial Investing Prospect.
- ✓ Upkeep Charges.
- ✓ Restricted control over airflow, hence reducing the farmer's alternatives.
- ✓ Because of their larger footprint, naturally ventilated polyhouses are more expensive to build in terms of labor and material costs.
- ✓ The need for high-quality materials drives up the price.
- ✓ Irrigation becomes challenging because different plants in a polyhouse have varying requirements for watering.

Components of Trunkey System of Greenhouse

Protected Structure

Technical Detailing

Fan and Pad System Poly House Components

- ✓ **Roof:** A Fan & Pad System Poly House's translucent cover.
- ✓ **Gable:** A Fan & Pad System Poly House's translucent wall.
- ✓ **Material for cladding:** Translucent material

affixed to the walls and roof of a poly house with a fan and pad system.

- ✓ **Cladding material that is rigid:** Cladding material that has this level of stiffness that any structural deformation could cause harm on it. For example, Glass Flexible cladding material: cladding that has this level of flexibility. Flexibility that prevents any structural deformation from occurring harm done to it. Example: Polymer film. The purpose of a gutter is to gather and remove snow and rainwater that falls at a higher ground between two spans.
- ✓ **Column:** The fan and pad system-bearing vertical structural element. An element known as a purlin joins the columns and sheathing supporting bars.
- ✓ **Ridge:** The tallest horizontal portion of the roof's summit.
- ✓ **Girder:** A horizontal structural component that joins gutter columns tallness.
- ✓ **Bracings:** To provide the structure with wind support.



Fig. 2: Components of Greenhouse

- ✓ **Arches:** Covering materials that members support.
- ✓ **Foundation pipe:** The ground-to-structure connection.
- ✓ **Span width:** In a multi-span gutter, the distance between the gutters' centers housing.

Scope of Trunkey System of Polyhouse

The field of Indian horticulture has enormous potential. The potential areas in India with the greatest potential for protected farming, if they are organized publicly, are

- ✓ **Cultivation in difficult agroclimatic:** Most of India's uncultivated land is located beneath difficult climatic conditions, such as deserts, uncultivated fallow lands, and barrenness. For the indigenous population, even a small portion of this area put under greenhouse horticulture might yield significant benefits.
- ✓ **Greenhouses surrounding large cities:** Throughout the year, there is a significant demand in large cities for fresh vegetables and ornamentals. There is also a need for expensive and off-season crops in large cities. As a result, greenhouse farming is encouraged to meet urban needs.
- ✓ **Farming produce exports:** There is a respectable market for agricultural products worldwide, primarily for cut flowers. Export promotion will undoubtedly be aided by the promotion of greenhouse farming and sheltered homeward crop cultivation.
- ✓ **Using greenhouses (GH) to propagate plants:** These days, greenhouse technology is being considered. Considered a suitable method for seedling growth and trimmings that require management to be made for him or her expansion. The GH facility might boost the capa-

city and the product's manufacturing quality.

- ✓ **Greenhouse Biotechnology:** Source Materials. The products produced by tissue culture should be propagated at the chosen speed. The fisheries or Controlled nutrient film technique (NFT) is required, conditions in the environment where plants develop.
- ✓ **Greenhouse for unusual and nutritious plant growing plants:** India has a large variety of medicinal herbs and uncommon plants with large scales, such as orchids gardening. Maybe the greenhouse has the right kind of style of the surrounding circumstances for the intense cultivation among such plants.



Fig. 3: Trunkey System of Polyhouse

Design and Development of Low Cost Automation in Polyhouse

India is mostly an agricultural nation. Today, different types of crops are grown in different parts of India according to the country's environment. For example, crops that require a cold climate are grown in the country's north, while those that require a hot climate are grown in the west. Therefore, to ensure appropriate climate conditions to the plants Poly home farming is a recently established form of farming. Its primary goal is to offer improved and more suited weather for the crops. In a short amount of time, it offers greater income with less labour. It optimizes the use of water and land resources and lessens reliance on rainfall. Polyhouse. The farmer can get money from farming by cultivating a variety of crops quickly.

Litrature Analysis

According to the author, a polyhouse shields plants from the impacts of the weather, allows for inspection, and so on, all of which are very sensible for agricultural output. Key components of Polyhouse environment monitoring and control include automation and high efficiency. Utilizing ZigBee-based WSN technology to enable protected agriculture in Polyhouses is a revolutionary approach that surpasses the limitations of wire connection systems. Since light enters the Polyhouse evenly and the sensor must be positioned such that it receives direct sunlight, the Polyhouse is a great choice. The initial cost for setting up an automated protected structure is Rs. 700 to Rs. 1000 per square meter. Also the cost depends on the material, size, shape, transport, and structure.

It is concluded that the higher (optimal) temperature and lower relative humidity during the winter months (December to February) under the playhouse contributed to the better growth, development, and yield of tomatoes by positively influencing the morpho-phenological and physiological events of tomato plants. Since there aren't many nurseries in India that provide planting materials for greenhouse, make a reservation before covering the greenhouse

with a plastic sheet to prevent planting delays.

Prior to scheduling a plant, take into account the following factors

- ✓ Which type is in high demand on the market?
- ✓ Report on Variety Yield Performance.
- ✓ Which type is appropriate for your climate?
- ✓ Disease and vermin update

Due to its season-bound nature, tomato plants experience restricted growth and development throughout the chilly winter months of December through February. This section has reviewed and compared a number of Polyhouse systems built on diverse technologies.

Connected Technology/ Wired Technology

In wired technology, the microcontroller and input sensors are directly connected. The sensors' analog output is routed to the ADC, which then provides the controller with the digital output for additional processing. The output devices are used to carry out the essential operations in order to achieve the desired circumstances. Certain surrounding conditions, such as The soil moisture content, light intensity range, ambient temperature, and humidity % within the polyhouse are in control.

Utilization GSM Technology

Since local air conditions vary, it becomes essential to maintain environmental balance in order to improve crop quality. One option for maintaining consistent environmental conditions is to employ an Android-based system. Via the GSM (Global System for Mobile Communication) feature, the user can receive updates regarding the field condition as SMS messages. The farmer can monitor the state of environmental conditions from any remote point using their cell phone. As a result, less human labor is required to maintain the ideal state. When a PIC microcontroller is utilized, an additional ADC is not needed, which lowers the circuit's complexity and power consumption. If a microcontroller other than the PIC is utilized, such as the ARM and AT89S52, which are Lack of an integrated ADC results in higher power consumption, raising the system's cost. The Arduino platform, which includes an integrated ADC and is simple to program, can be used to fix this issue.

Intentions: The rain sensing roof's top cover mechanism, which covers the poly house roof on the left and right ends automatically, was developed and analyzed. The creation of an automatic vent door opening mechanism with temperature detection coupled to an axial blower will force hot, humid air out of the polyhouse and keep the temperature within a predetermined range.

Components' Use

Bearing: The component that gives the two pieces the desired motion is a bearing. They have two parts: a movable part and a fixed part. By managing the forces, such as axial and radial forces, bearings help lessen friction and prevent motion.

Motor: A device that transforms electrical energy into mechanical energy is an electric motor. It operates on the tenet that a current-carrying conductor in a magnetic field experiences a mechanical force, the size of which is determined by

F=1311 Newton and whose direction is determined by Fleening's left hand rule. From a construction standpoint, a DC generator and a DC motor are identical. Indeed, the identical D.C. The machine can function as a generator, compound wound, series wound, or shunt wound alternatively. It will be observable that a force acts on each conductor, tending to rotate the armature counterclockwise.

Timer Belt: A component that transmits rotational motion from one pulley to another is a timing belt. An inner surface contains a tooth on the timer belt. When used in an internal combustion engine, a timing belt is also known as a cam belt or timing chain. It aids in synchronous cam shaft end crank rotation, which is necessary for the engine valve to operate properly.

Blower: A blower is a piece of machinery that moves scraps by blasting air at a high velocity via a nozzle. Leaves, grass, a plastic handbag, etc. Here, shattered rose petals are blown out with a blower.

Sprayer: This gadget is used to spray fluid, as its name suggests. Herbicides are sprayed in this project using a sprayer. The rose plant exposed to pesticides, fertilizers, and even alcohol.

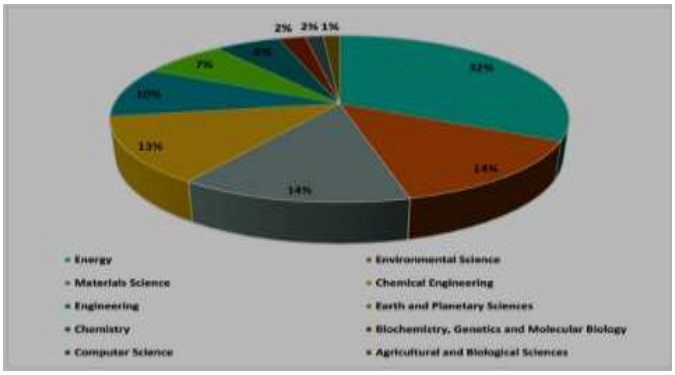


Fig. 4: Human Work % for Constructing the Automated Protected Structure

Conclusion

Although polyhouse farming has been introduced to replace traditional farming, traditional farming is still quite popular in India. It contributes to the production of better crops faster, with less time and labor expense. It lessens dependency on rainfall and maximizes the use of available land and water. Growing numerous crops helps farmers make a living through polyhouse farming. Water waste is decreased and an appropriate irrigation system is provided by polyhouse farming. The primary benefit lies in the ability to regulate the system's operation based on varying atmospheric conditions for different crop varieties.

Referrences

Kumar, N., Bhatt, R. P. and Biswas, V. R. (2006). High altitude vegetable farming: status and prospectus. In: Gupta HS, Srivastva AK, Bhatt JC, editors. Sustainable production from agricultural watershed in North West Himalaya. VPKS, 226-239.

Jonnala, P. and Shaik, S. (2013). Wireless Solution for Polyhouse Cultivation Using Embedded System. *IEEE Int. Conference on Renewable Energy and Sustainable Energy*, 978-1-4799-2075-4/13/$31.00 ©2013 IEEE, pp. 21-25.

Gautam, I. and Reddy, S. R. N. (2012). Innovative GSM Bluetooth based Remote Controlled Embedded System for Irrigation. *International Journal of Computer Applications*, 47(13): 1-7.

Bhatnagar, R. R., Vedprakash, R. C. and Srivastav, R. C. (1990). Production of vegetables in poly house greenhouse during winters in mid hills of Uttar Pradesh. *Progressive Horticulture*, 22: 97-100.

Baldwin, K. R. (2006). Soil Quality Considerations for Organic Farmers", Organic Production, Center for an environmental farming systems, pp. 1-14.

Janick, J., Paris, H. S. and Parrish, D. C. (2007). The Cucurbits of Mediterranean Antiquity: Identification of Taxa from Ancient Images and Descriptions. *Annals of Botany*, 100: 1441-1457.

Jonnala, P. and Sathyanarayana, G. S. R. (2015). A Wireless Sensor Network for Polyhouse Cultivation using Zigbee Technology. *ARPN Journal of Engineering and Applied Sciences,* 10(10): 4413-4418.

Khandelwal, S. A. (2012). Automated Green House Management Using GSM Modem. *Int. Journal of Computer Science and Information Technologies*, 3: 3099-3102.

Kang, Y., Chang, Y., Choi, H. and Gu, M. (2013). Current and future status of protected cultivation techniques in Asia. *Acta Horticulturae, ISSN*: 0567-7572.

Sengunthar, G. R. (2013). Greenhouse Automation System Using Psoc 3. *Journal of Information, Knowledge and Research in Electronics and Communication Engineering*, 02(02): 779-784.

Mukherjee, A., Rakshit, S., Nag, A., Ray, M., Kharbikar, H. L., Shubha, K., ... and Burman, R. R. (2016),Climate change risk perception, adaptation and mitigation strategy: An extension outlook in mountain Himalaya. In *Conservation Agriculture* (pp. 257-292). Springer, Singapore.

Pavithra, D. S. and Srinath, M. S. (2014). GSM based Automatic Irrigation Control System for Efficient Use of Resources and Crop Planning by Using an Android Mobile. *IOSR Journal of Mechanical and Civil Engineering*, 11(4): 49-55.

Pawar, A. M., Patil, S. N., Powar, A. S. and Ladgaonkar, B. P. (2013). Wireless Sensor Network to Monitor Spatio Temporal Thermal Comfort of Polyhouse Environment. *Int. Journal of Innovative Research in Science, Engineering and Technology*.

Rangan, K. and Vigneswaran, T. (2010). An Embedded Systems Approach to Monitor Green House. 978-1-4244-9182-7/10/$26.00 ©2010 IEEE, pp. 61-65.

Sabir, N. and Singh, B. (2013). Protected cultivation of vegetables in global arena: A review. *Indian Journal of Agricultural Sciences*, 83(2): 123-35.

http://www.agrohortiworld.com/greenhouse-turnkey-project.html

https://5.imimg.com/data5/SELLER/Doc/2021/9/RV/AR/XI/5766423/fan-and-pad-house.pdf

Colour from the Harvest: Utilizing Fruits for Eco-friendly Cloth Dyes

Rutuja Narendra Deshmukh and Priya Suresh Gawande

Introduction

Fruits have found a niche application in the cloth dyeing industry, offering natural and sustainable alternatives to synthetic dyes. Harnessing their pigments, fruits provide a diverse palette of colors, ranging from vibrant reds to earthy browns. This natural dyeing method aligns with growing consumer demand for eco-friendly textiles and reduces the environmental impact of the dyeing process. In this introduction, we'll explore the specific uses of fruits in cloth dyeing, highlighting their unique characteristics and benefits for both producers and consumers.

Fruits have been used historically in the textile industry as natural dyes to color fabrics. While the use of natural dyes has somewhat diminished with the advent of synthetic dyes, there is a growing interest in eco-friendly and sustainable dyeing methods, which includes the resurgence of natural dyeing techniques. Here are some specific uses of fruits in the cloth dyeing industry.

Reds and Pinks: Fruits like pomegranate, cherries, raspberries, and strawberries contain natural pigments that can impart red and pink hues to fabrics. These pigments are often extracted from the fruit skins or pulp and used as dyes.

Yellows and Oranges: Citrus fruits such as oranges, lemons, and grapefruits contain natural dyes in their peels and pulp that can produce yellow and orange shades when used to dye fabrics. Additionally, fruits like turmeric and saffron are also used for their yellow-orange pigments.

Blues and Purples: Blueberries and blackberries are examples of fruits that can yield blue and purple colors for dyeing textiles. The anthocyanin pigments present in these berries are responsible for the blue-purple hues.

Browns and Beiges: Certain fruits like walnuts and avocado pits contain tannins and other compounds that can produce brown and beige tones when used as natural dyes. The husks of nuts like walnuts are particularly rich in tannins, which can be extracted and used for dyeing.

Green Tones: While green is a less common color obtained directly from fruits, combining yellow dyes (from sources like onion skins or turmeric) with blue dyes (from sources like indigo or woad) can create various shades of green.

Mordants and Fixatives: Some fruits also contain natural mordants or fixatives that help improve the colorfastness and adherence of natural dyes to fabrics. For example, citric acid found in citrus fruits can act as a mordant for certain dyes.

While natural dyes from fruits can produce beautiful and unique colors, they often require specific preparation methods and may not always

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offer the same level of color consistency or fastness as synthetic dyes. However, their use aligns with the growing demand for sustainable and environmentally-friendly textile practices.

Conclusion

While fruits are not typically associated with the cloth dyeing industry, there are specific instances where they have been utilized for their dyeing properties. However, the widespread adoption of synthetic dyes has largely overshadowed their use.

Despite this, there's a growing interest in natural, eco-friendly dyeing methods, which could potentially revive the use of fruits in the cloth dyeing industry. Further research and innovation in this area may uncover new opportunities for integrating fruits into sustainable dyeing practices, offering both environmental benefits and unique aesthetic possibilities.

Nematode Pests in Solanaceous Crops: Unveiling the Subterranean Threat

Mansi Machal

Abstract

Several major nematodes are linked to a multitude of vegetable crops in India. These include nematodes root-knot nematodes (*Meloidogyne* spp.), cyst nematodes (*Heterodera* spp.), lesion nematodes (*Pratylenchus* spp.), reniform nematodes (*Rotylenchulus* spp.), lance nematodes (*Hoplolaimus* spp.), stem and bulb nematodes (*Ditylenchus* spp.), and many others. Vegetables belonging to the families' solanaceae (potato, tomato, chilli), cucurbitaceae (bitter ground, cucumber, pumpkin, bottle gourd), leguminaceae (cowpea, bean, pea), cruciferae (cauliflower, cabbage, broccoli, Brussels sprouts, sprouts), okra, and several other root and bulb crops (onion, garlic, lettuce, celery, carrot, radish) are susceptible to root-knot nematodes. Over 95% of the global population of root-knot nematodes is made up of four species: *M. incognita*, *M. javanica*, *M. arenaria*, and *M. hapla*. Onion, garlic, potato, pea, carrot, and other common crops are frequently attacked by stem and bulb nematodes (*Ditylenchus* spp.). Nematodes mostly transmit from one location to another through infected planting materials, water draining into irrigation systems from infected areas, soil adhering to tools, vehicle tyres, and plantation workers' shoes. Application of neem cake, cultural practices, FYM enrichment, bio-pesticides, and other organic amendments are recommended methods of management.

Introduction

Vegetables are a vital part of a human's nutrition providing vitamins, minerals, dietary fibre, antioxidants, low fat, and calories. India accounts for over 15% of the global vegetable production and is the world's second-largest producer after China. India ranks second in the world for the production of potatoes, onions, gourds, brinjal, cabbage, lettuce, pumpkin, squash, and other vegetables. India is also the leading producer of okra and ginger among other vegetables. India produced 185.88 million metric tonnes of vegetables in 2018-19, with 10.10 million hectares under cultivation, according to the National Horticulture Database released by NHB. Numerous factors, both abiotic and biotic, influence vegetable production. Vegetables serve as excellent hosts for an array of plant-parasitic nematodes, making them one of the most significant and economically damaging biotic agents. Vegetable crops suffer significant losses due to PPN's overall. Typically found in soil or water, including seas, nematodes are the most abundant organisms on the earth. Certain nematode species parasitize both plants and animals. Plant-parasitic nematodes are minute, round, eel-

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like, non-segmented parasites with stylets that reside in soil and harm plants by feeding on their roots or other plant tissues. Nematodes that parasitize plants devour roots, either from within the root or from the outside. Nematodes parasitic on plants use their living hosts' tissue as food to grow and reproduce. Crop resilience against fungal diseases is compromised by these nematodes. They deprive plants of nutrients, interfere with the movement of water and minerals, and provide ideal conditions for secondary diseases like bacteria and fungi to get into the roots and cause rot.

Solanaceous crops, which include tomatoes, potatoes, peppers, and eggplants, are essential components of global agriculture and play a crucial role in human nutrition. However, the productivity of these crops is often hampered by various pests and diseases, among which nematodes are a significant concern. Nematodes are microscopic, worm-like organisms that live in the soil and can cause substantial damage to the roots of solanaceous plants, leading to yield losses and reduced crop quality. The most notable PPN genera linked to vegetables include *Globodera* spp., *Meloidogyne* spp., *Rotylenchulus reniformis*, *Pratylechus* spp., and *Tylenchorhynchus* spp. Nematode infestations in solanaceous crops can have severe economic implications. The damage caused by nematodes not only reduces yield but also affects the quality of harvested produce. Additionally, weakened plants are more susceptible to other diseases, further compounding the challenges faced by farmers. Therefore, managing these PPN's becomes crucial to minimising the losses they create.

Root-knot nematode (*Meloidogyne* spp.): Berkeley recorded RKN for the first on cucumbers in 1855 in England. It has been recorded that almost all vegetable crops are susceptible to the species of root-knot nematode. While *M. hapla* is restricted to the temperate zone, *M. incognita* and *M. javanica* are found in the plains' warmer regions. But with tomatoes, brinjal, okra, peppers, cabbage, cucumbers, cucurbits, etc., *M. incognita*, *M. arenaria*, *M. javanica*, and *M. hapla* this is a major issue. The only infectious stage is the juvenile second stage (J_2). The duration of the life cycle varies between 25 and 30 days, depending on the host and other environmental factors. This nematode commonly infects vegetable crops such as bitter gourd, cauliflower, cabbage, tomatoes, carrots, radish, okra, brinjal, and garden beans. Infected plants exhibit yellowing and stunting. Plants that are severely infested also exhibit early plant death. Depending on the host plant and nematode species, different root galls produced by the root-knot nematode of different sizes and intensities. In addition to causing direct harm, the tiny wounds left by the nematode pave the way for further soil-borne infections such as *Phyotrophthora*, *Rhizoctonia*, *Fusarium*, and *Verticillium*, which worsen diseases inflicted on by organisms.

Cyst nematode (*Globodera rostochinensis, G. pallida*): This nematode is an endoparasite that lives a sedentary life and mostly restricted in areas with temperate climate. Due to the efficient implementati-

on of domestic quarantine, which forbids the movement of seed potatoes from infested areas, it is primarily restricted to about 4000 hectares of the Nilgiris, Palani, and Kodai Kanal hills in the southern states of India; however, reports of it from Himachal Pradesh have also been made recently. Potatoes are the primary host of this nematode, although it can also spread to other solanaceous plants like tomatoes, eggplants, and other weeds due to its restricted host range. Juveniles in their second stage (J_2) infect the host by entering through the root tip. Under Nilgiri hills conditions, the life cycle takes about 35-50 days to complete, and a second generation might also occur. After female's death, they become cysts, and contain as many as 500 eggs. Inside the cyst, the eggs remain viable in soil for a long period of time (up to 8 years). In India, only two pathotypes i.e., Ro 1 and Ro 2 of *G. rostochienesis* and all the three pathotypes of *G. pallida* i.e., Pa 1, Pa 2 and Pa 3 are found as mixed populations. Infected plant shows yellowing of leaves and stunting of plants with patchy appearance, early senescence and proliferation of lateral roots. Initially, small immature females of white and yellow colour are found on the roots at flowering time. Females can also be observed on the tuber surface but with less frequency.

Reniform nematode (*Rotylenchulus reniformis*): Reniform nematode is a semi-endoparasite and causes damage to beans, carrot, cabbage, cauliflower, cucumber, brinjal, pea, cowpea, radish, okra and lettuce. The preadult females are parasitic. The nematode initiates infection by destroying the epidermal cells and cause necrosis. Disintegration of phloem cells occur in the stellar region of plants. Severely infected plant severe necrosis shows necrosis and destruction of feeder roots, and yellowing and wilting of above-ground plant parts. Juveniles of female survive for 6 months in desiccated soil and for several months in moist soil. The 4th stage larvae are better adapted to adverse conditions. The adult females are reniform in shape with their head and neck inside the root whereas the posterior reniform shaped body is seen outside the root. The female lays 150-200 eggs in gelatinous matrix.

Lesion nematode (*Pratylenchus* spp.): This nematode is migratory endoparasitic in nature, ten species of which have been found from the rhizosphere of vegetable crops. But under Indian conditions only *P. indicus* has been found to be most prevalent. This is the important nematode pest of vegetables like tomato and brinjal etc. All life stages of this nematode are capable of infection by penetrating the root tissue. This nematode completes its egg to egg life cycle in 30 to 90 days depending upon the species, host plant and environmental conditions. Above ground symptoms such as stunted, chlorotic plants lacking vigour, poor fruiting and die back can be observed in infested plants. Root symptoms are in the form of necrotic lesions which may coalesce with one another as the infection spreads and may girdle the root system. These lesions are the ideal sites for secondary infection by other microorganisms such as fungi, bacteria etc.

which leading to disease complex.

Management

- ✓ The nursery needs to be raised in nematode free soil.
- ✓ Nematode infested seedlings should not be used for planting.
- ✓ Soil solarisation is an effective measure for vegetable crops raised in the nursery beds. Soil solarisation in nursery beds using polythene sheets during summer reduces the soil infestation of nematodes.
- ✓ Rotation of crops like tomato, brinjal, okra and chilli with non-host crops like mustard, sesame, maize, wheat and rice.
- ✓ Incorporation of decomposed farm yard manure, poultry and green leaf manure reduces the nematode infestation by promoting the predaceous nematodes and other antagonistic fungi which checks the parasitic nematodes.
- ✓ Use of resistant cultivars like Kufri Swarna, Kufri Thenmalai etc.

Conclusion

An economic significance can be attributed to numerous nematode genus and species. A management programme can be developed with an accurate diagnosis of nematodes. In order to choose the best course of action, the nematodes must be removed to minimise damage. Crop rotation, chemical treatments, resistant and tolerant cultivars, and cultural practices are examples of commonly used approaches. The ability to reduce the yield losses brought on by nematodes requires understanding of the biology of the disease and the execution of suitable control strategies. Chemical use is unfeasible, and cultural and commercial approaches fall short of complete control. The main tactic for sustainable and ecologically sound control is breeding for resistance and tolerance. Research on nematodes' race and pathotype is especially vital, and there is a pressing need for international collaboration in this field to control these significant infections.

References

Bahadur, A. (2021). Nematodes Diseases of Fruits and Vegetables Crops in India.

Collins, S. and Wilkinson, C. (2015). Pratylenchus penetrans: A horticulturally significant root lesion nematode.

Pinheiro, J. B., Silva, G. O. and Pereira, R. B. (2015). Nematoids in potato culture [Nematoides na Cultura da Batata] Embrapa Hortaliças.

Yadav, S. and Patil, J. A. (2021). The Emerging Nematode Problems in Horticultural Crops and their Management.

Agricultural Drones for Future Farming

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Abstract

Agricultural drones are the future of farming, promising a paradigm shift in agricultural practises. These unmanned aerial vehicles, outfitted with cutting-edge technology, provide unprecedented insight into crop health, soil conditions, and environmental factors. Drones revolutionise farming efficiency by enabling precision monitoring, targeted interventions, and optimised resource utilisation. Their numerous applications in crop management, livestock monitoring, and environmental sensing highlight their critical role in sustainable agriculture. As technology advances, these drones will reshape the agricultural landscape, increasing productivity, reducing environmental impact, and fostering a more resilient and resource-efficient farming future.

Introduction

Agriculture, the backbone of global sustenance, is undergoing a massive transformation thanks to the incorporation of cutting-edge technology agricultural drones. These unmanned aerial vehicles, outfitted with a sophisticated array of sensors, cameras, and data analytics, herald a new era in farming precision and efficiency. Drones' pivotal role in redefining precision agriculture is at the heart of this technological revolution. They act as aerial sentinels, flying across vast fields collecting detailed information on crop health, soil composition, and environmental conditions. This wealth of data provides farmers with real-time insights, allowing for targeted interventions and strategic decision-making. These drones transform the way farmers interact with their land by meticulously monitoring crop growth, detecting diseases, assessing nutrient deficiencies, and mapping field variability.

The importance of agricultural drones goes far beyond data collection. Their incorporation represents a shift towards a more holistic and sustainable farming approach. These aerial devices maximise resource utilisation by precisely targeting areas that require intervention, reducing water, fertiliser, and pesticide waste. They provide a tailored approach to crop management, ensuring that agricultural inputs are used wisely, increasing yields while reducing environmental impact. Furthermore, the promise of drones in agriculture lies in their ability to adapt and evolve quickly. As technology advances, these drones become more agile, efficient, and capable of performing a wide range of tasks. Their applications range from livestock monitoring to weather forecasting, reshaping farming methodologies and paving the way for resilient and adaptable agricultural practises.

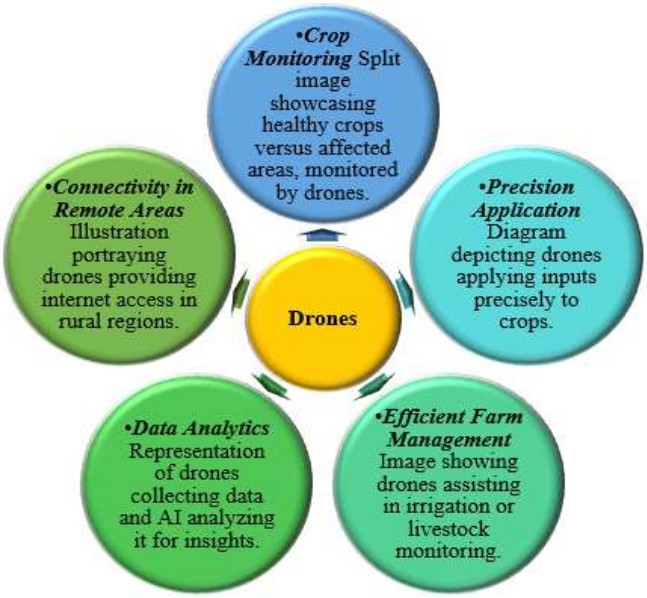
In essence, the incorporation of agricultural

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drones represents a paradigm shift towards a more sustainable and efficient agricultural landscape. Their contribution goes beyond mere innovation, serving as pillars of a revolution aimed at fostering a harmonious balance of productivity, environmental stewardship, and global food security.

Important prospects of Drone technology

- ✓ **Enhanced Crop Monitoring:** Agricultural drones provide unrivalled crop monitoring capabilities. They are outfitted with high-resolution cameras and sensors that collect detailed data on crop health, growth patterns, and potential problems such as diseases or pests. Farmers will be able to identify problems earlier, allowing for targeted interventions and preventive measures.
- ✓ **Precision in Input Application:** Drones allow for the precise application of inputs such as fertiliser, pesticides, and water. They use data-driven insights to direct resources only where they are needed, reducing waste and environ-mental impact while increasing effective-ness. This precise application saves money while reducing runoff, which benefits both farmers and the environment.
- ✓ **Increased Farm Management Efficiency:** Drones automate various farming tasks, improving resource management and labour efficiency. They help with field mapping, irrigation planning, and livestock monitoring. They free up farmers' time by automating repetitive tasks, allowing them to focus on strategic decision-making and other critical aspects of farming.
- ✓ **Data Analytics and Remote Sensing:** Agricul-tural drones' remote sensing capabilities enable the collection of massive amounts of data. This information, when combined with advanced data analytics, provides valuable insights into crop conditions, soil health, and environmental factors. This data analysis aids in making informed decisions, forecasting trends, and implementing precision farming practises.
- ✓ **Other Technology Integration:** Drones can be enhanced further by combining them with other technologies such as artificial intelligence (AI) and machine learning (ML). Drone-captured data can be analysed by AI-powered algorithms to identify patterns, predict crop yields, and provide predictive insights for better decision-making.



- ✓ **Additional Applications beyond Crop Monitoring:** While crop monitoring is the primary application, drones are increasingly

being used for other agricultural purposes. These include livestock tracking, weather forecasting, and post-disaster evaluations. Extending their applications increases their utility and impact in various aspects of agriculture.

- ✓ **Connectivity and accessibility in rural areas:** Drones can provide aerial connectivity, particularly in remote agricultural areas with limited infrastructure. They have the potential to provide internet connectivity as well as essential services to farmers, connecting them to information, markets, and support services.

These prospects demonstrate agricultural drones' vast potential to revolutionise farming practises, from precise monitoring to efficient resource utilisation and connectivity solutions in remote areas. Drone integration in agriculture is evolving, promising significant advances in farming methodologies and sustainability.

Conclusion

Agricultural drones serve as transformative agricultural landscape catalysts, encapsulating the promise of a more efficient, sustainable, and technologically advanced future. Their contribution to precision monitoring, precise resource application, and streamlined farm management heralds a new era in agricultural practises. These drones enable farmers to make data-driven decisions by providing enhanced crop insights and optimising resource use, ultimately increasing productivity while minimising environmental impact. Drone integration represents a fundamental shift towards precision and efficiency in farming that goes beyond mere innovation. As these technologies evolve and expand their applications, ranging from remote sensing to predictive analytics, their potential to reshape agricultural practises becomes clearer. Agricultural drones emerge not only as tools for increasing productivity, but also as cornerstones for fostering resilience, sustainability, and accessibility in global food production. Their continued evolution promises a future in which farming is not only more efficient, but also more sustainable and responsive to the changing needs of the world.

Recent Techniques and Modern Tools in Weed Management

Akshay A. Thakare, Manish R. Pandao and Mohit S. Janbandhu

Introduction

- ✓ Current crop production levels are not adequate to feed the projected population.
- ✓ Meeting the food and fiber demands of the world's growing population will only be possible with highly productive agricultural systems in which weed management is a critical component.
- ✓ Advancements in weed control technology have had a huge impact on agricultural productivity.
- ✓ The increase in evolved herbicide resistance.
- ✓ The lack of new MOAs threatens to make almost all existing herbicides unusable by 2050.
- ✓ Integrating old and new weed management technologies into more diverse weed management systems.

Emerging Issues in Weed Management

- ✓ Herbicide Resistance
- ✓ Weed Plasticity
- ✓ Herbicide-Resistant crops
- ✓ Misconceptions about Integrated Weed management
- ✓ Neglected Areas of Research in Weed science
- ✓ Lack of improved mode of action of herbicides
- ✓ Herbicide Related Contamination
- ✓ Lack of Trained Weed Scientists in Developing Countries
- ✓ Climate Change
- ✓ Use of traditional herbicides

Modern Technology and Tools

- ✓ Precision weed management or site specific weed management
- ✓ Unmanned Aerial Vehicles (UAV) or Drones
- ✓ Abrasive grit
- ✓ Harvest weed seed control
- ✓ Nanotechnology
- ✓ Future advancements
- ✓ New combinations

Precision Weed Management or Site Specific Weed Management



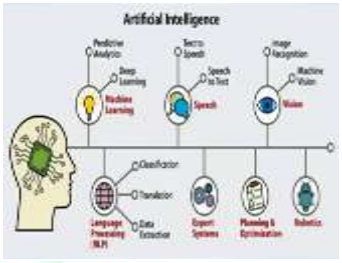
- ✓ Distribution of weeds is typically patchy, resulting in wastage of valuable compounds, increased costs, crop damage risk, pest resistance to chemicals, environmental pollution and contamination of products.
- ✓ Real-time weed detection/ recognition and control in agronomic field crops requires seamless integration and high performance of

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sensors, data processing, and actuation systems.

- ✓ Continuing technological advances in computer vision, robotics, machine learning, etc. are advancing for the improved site specific weed management.

Application of AI in Agricultural Robotics



- ✓ Agricultural robots have great potential to deliver weed control technologies that are much more adaptable.
- ✓ They potentially could direct chemical or cultivation tools to directly target weed plants.
- ✓ Agricultural robots bring recent advances in artificial intelligence (AI) to bear on the control of weeds in crop fields.
- ✓ Blue river technology, Ecorobotix, Zasso technology, etc are the companies working on agricultural robotic weed management.

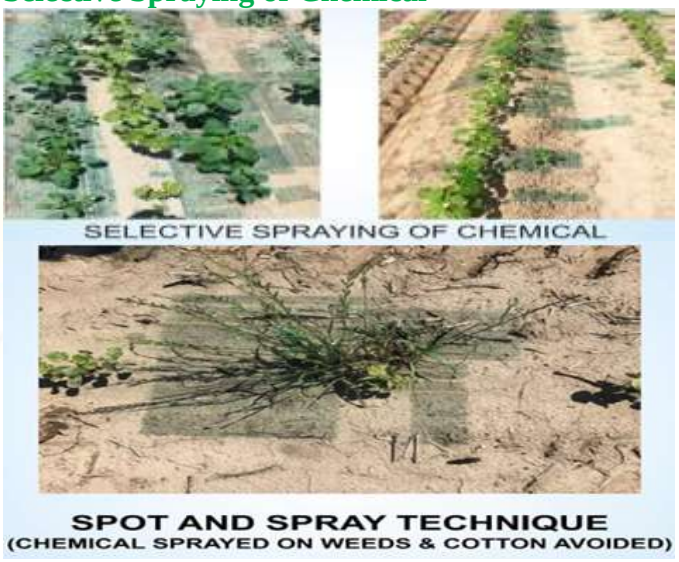
See and Spray Technique


SEE AND SPRAY MACHINE

- ✓ Precisely spraying herbicides only where needed.
- ✓ See & Spray does not rely on spacing or color to identify weeds. Instead it has unparalleled ability to recognize differences between plants in conditions that would challenge the human eye.
- ✓ Robotic nozzles target unwanted weeds in real time as the machine passes eliminates 80 per cent of the volume of chemicals normally sprayed on crops
- ✓ Custom nozzle designs enable <1-inch spray resolution.
- ✓ See & Spray is currently operating in weeding for cotton and soybeans. Source: Blue river technology.


SPRAYING NOZZLE

Selective Spraying of Chemical



Lettuce Bot Focused


LETTUCE BOT

- ✓ On lettuce thinning, a traditionally time intensive and expe-nsive task of eliminating unwanted lettuce seedlings.
- ✓ The lettuce bot automated this arduous process by taking images, identifying which plants to remove, spraying them, and verifying the accuracy and performance of the system, all in

real time.



APPLICATION OF DRONES IN AGRICULTURE

Abrasive Grit



- ✓ Abrasive weeding is a non-chemical weed management tool. Weed leaves and stems are abraded by small grits propelled by compressed air.
- ✓ This abrasion results in defoliation, stem breakage, or tissue damage leading to weed injury or, ideally, mortality.
- ✓ More recent research has focused on the development of grit applicator machines and specialized nozzles, and the potential for using organic fertilizers as grits to integrate weed and nitrogen management in one field pass.
- ✓ Grit sources like corn cob, Wallnut shells, soyabean meal, etc can be used (0.015-0.035 inch diameter).

Harvest Weed Seed Control

- ✓ Alternative nonchemical weed control practices are needed to control herbicide resistant or escaped weeds.
- ✓ Harvest weed seed control (HWSC) tactics have been developed that include both cultural and mechanical management practices to decrease the number of weed seeds replenishing the soil seed bank.
- ✓ These management practices include the use of chaff carts, narrow windrow burning, the Harrington Seed Destructor, bale direct systems and other means of targeting the chaff during harvest.

Narrow Windrow Burning


NARROW WINDROW BURNING

Chaff Car

- ✓ The simple chaff cart method consists of a chaff collection and transfer mechanism attached to a grain harvester that delivers the weed seed into a bulk collection bin.
- ✓ This method allows for the chaff and the weed seed to be collected and removed from the field. Another option is to dump the chaff material in the field and then burn the chaff piles.

Bale Direct Systems


BALE DIRECT SYSTEM

- ✓ The bale direct system consists of a large baler directly attached to the combine that constructs bales from the chaff exiting the harvester.
- ✓ This system captures the weed seed, and the bales formed can then be used as feed for livestock.
- ✓ A significant secondary benefit is the collection and removal of annual weed seeds.
- ✓ The limitations of this method are that there is a very limited market for the baled product and

there is some risk in spreading the resistant weed seeds to other fields through the distribution of the bales.

Nanotechnology New Technologies



- ✓ Such as nanotechnology, have been developed as tools to decrease the adverse effects of excessive herbicide application (Perez-de- Luque, 2017).
- ✓ Nanotechnology-based delivery systems are able to perform a sustained release of active compounds in the optimum concentration.
- ✓ Nanotechnology can provide greater safety for agricultural crops and for non-target organisms, such as pollinators (Shukla *et al.*, 2019).
- ✓ Nanoparticles can serve as "magic bullets", containing herbicides, nano- pesticide fertilizers, or genes, which target specific cellular organelles in plant to release their content.

Nanoherbicides



- ✓ None of the herbicides inhibits activity of viable belowground plant parts like rhizomes or tubers, which act as a source for new weeds in the ensuing season.
- ✓ A target specific herbicide molecule encapsulated with nanoparticles is aimed for specific receptor in the roots of target weeds, which enter into roots system and translocated to parts that inhibit glycolysis of food reserve in the root system.
- ✓ Nano surfactant based on soybean micelles has been reported to make glyphosate-resistant crops susceptible to glyphosate when it is applied with the "Nanotechnology-derived surfactant". (Abigail and Chidambaram, 2017).

Nanoformulation Approaches of Bioherbicides



- ✓ Nanoformulations of biochemical bio-herbicides have the potential to increase biocontrol efficiency because large surface areas of nanoparticles result in a lower volume of bioherbicide required, thereby increasing concentration in a smaller package with reduced costs (Pallavi and Sharma, 2017).
- ✓ Controlled release of the biotic agent or its phytotoxic metabolite(s) is one advantage that could be achieved using variations of nanoparticles and other nanoformulation technology. The biotic agent or metabolite could be attached to or incorporated within a nanocarrier that would also protect against degradation (Hershenhorn *et al*., 2016).

Conclusions

- ✓ The conventional methods like intercrops, cover crops,
- ✓ Conservation tillage, flaming, herbicides cannot be replaced suddenly.
- ✓ To have better weed management and to overcome herbicide resistance, these technol-

ogies and improved tools should be used.

- ✓ The robotic weed management, soil seed bank management, nanaotechnology, biotechnology improvement may be future options for weed control other than the conventional method of weed control.

References

Ahirwar, S., Swarnkar, R., Bhukya, S. and Namwade, G. (2019). Application of Drone in Agriculture. *International Journal of Current Microbiology and Applied Sciences*, 8: 2500-2505.

Alharby, H. F., Khalid, R. H. and Qureshi, M. I. (2019). Weed Control through Herbicide-Loaded Nanoparticles. In Nanomaterials and Plant Potential, 507-527. Springer.

Bajwa, Ali, A., Mahajan, G. and Chauhan. B. S. (2015). Nonconventional weed management strategies for modern agriculture. *Weed Science*, 63(4): 723-747.

Syed, B., Satish, S., Prasad, N. and Chouhan, R. S. (2019). Nano-agromaterials: Influence on plant growth and crop protection. In Industrial Applications of Nanomaterials, 341-363. Elsevier.

Beckie, H. J., Michael, B. A. and Flower, K. C. (2019). Herbicide Resistance Management: Recent Developments and Trends. *Plants*, 8(6):161.

Ecological Significance of Insectivorous Plants

K. V. Deshmukh and M. S. Bharati

Abstract

Insect-eating plants play a crucial ecological role by capturing and digesting insects, supplementing their nutrient intake in resource-limited environments. They contribute to nutrient cycling, influence prey populations and engage in predator-prey interactions. Their presence shapes habitat conditions, affecting prey availability and impacting plant and animal species distribution.

Introduction

Insectivorous plants are the plants that derive their nutrition by feeding on insects and other organisms. Insectivorous plants or those that consume insects for nutrition, primarily rely on trapped insects as their main source of nutrients. They typically thrive in humid regions abundant in sunlight and moisture, where nitrogen-deficient soil is common. This scarcity of nutrients prompts them to trap and digest insects to obtain vital nutrients. Examples of insectivorous plants include the Venus flytrap, pitcher plant and cobra lily which are commonly referred to as carnivorous plants. In contrast to autotrophic plants, which produce their own food through photosynthesis, insectivorous plants exhibit partial heterotrophy. This means they rely partly on insects to obtain nitrogen, leading to their classification as carnivorous. Despite this dependency on insects for nitrogen, insectivorous plants still harness energy through photosynthesis. Insectivorous plants have evolved specialized adaptations for capturing and digesting insects efficiently. These adaptations include a variety of traps, such as pitfall, snap, adhesive and suction traps, designed to capture insects upon contact. Additionally, glandular structures on their leaves, like sticky secretions or glandular hairs, immobilize and trap insects. Once captured, these plants produce digestive enzymes that break down the bodies of insects, allowing them to absorb essential nutrients.



Fig. 1: Insectivorous plants majorly found in India

These unique adaptations enable insectivorous plants to supplement their diet and thrive in environments with low nutrient availability. Various insectivorous plants thrive across India, such as the *Drosera Indica* in marshy areas, *Nepenthes khasiana* in the northeast, *Utricularia purpurascens* in aquatic habitats, *Aldrovanda vesiculosa* in freshwater bodies and *Drosera burmannii* in regions like the Western Ghats. These plants employ unique adaptations like sticky tentacles and pitcher-shaped leaves to capture insects, showcasing the country's diverse carnivo-

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rous flora.

Molecular Mechanisms of Trap Movement: Recent studies have investigated the molecular and genetic mechanisms behind trap movement in insectivorous plants, notably observed in the swift closure of Venus flytrap leaves. These investigations unveil a sophisticated interplay of ion channels, hormones (like auxin and jasmonic acid) and signaling pathways, orchestrating swift trap closure upon detecting prey stimuli.

Role of insectivorous plants in Nutrient Cycling: Insectivorous plants aid nutrient cycling in ecosystems by absorbing nutrients from captured prey and incorporating them into their tissues. As they capture and digest insects, they extract essential elements like nitrogen and phosphorus, enriching their biomass. When these plants die or shed leaves, the nutrients return to the soil, enhancing soil fertility. This benefits other organisms by increasing nutrient availability for plant growth and supporting the food web. In essence, insectivorous plants play a crucial role in cycling nutrients, ultimately promoting ecosystem productivity.

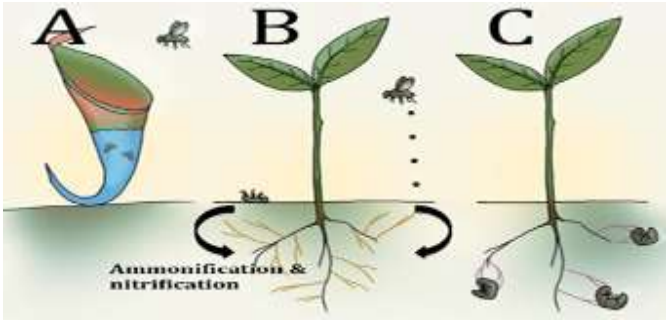


Fig. 2: Insects as a source of Nitrogen

Prey Dynamics: Insectivorous plants play a crucial role in shaping the dynamics of prey population within their habitats. By preying on insects, they directly influence the behaviour, distribution and abundance of prey species. The presence of insectivorous plants can alter the behaviour of prey species as they must navigate the risk of predation when foraging near these plants. This, in turn, may lead to changes in the spatial distribution of prey populations within the habitat. Additionally, the consumption of prey by insectivorous plants can reduce the abundance of certain insect species, influencing the overall composition of the prey community. Overall, insectivorous plants exert significant top-down pressure on prey population, contributing to the complexity and stability of the ecosystem.

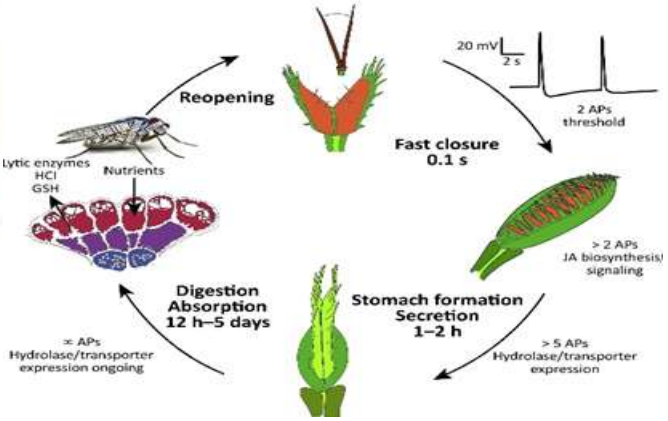


Fig. 3: Predator prey relationship

Predator-Prey Interactions: Insectivorous plants participate in intricate predator-prey interactions serving as both predators of insects and prey for other organisms. As predators, they capture and consume insects, playing a vital role in regulating insect population within their ecosystems. However, insectivorous plants are also susceptible to predation by larger organisms such as birds, amphibians and mammals. This reciprocal relationship creates complex food webs, where insectivorous plants serve

as hubs of ecological activity. These interactions contribute to the stability and resilience of the ecosystem by maintaining a balance between predator and prey population.

Habitat Conditions and Prey Availability: Changes in habitat conditions, such as soil moisture, nutrient levels and disturbance regimes can significantly impact the distribution and abundance of insectivorous plants. Soil moisture levels, for example, may affect the growth and health of these plants, influencing their ability to capture prey effectively. Furthermore, alterations in nutrient availability can impact the reproductive success and population dynamics of insectivorous plants. Additionally, shifts in prey availability, driven by factors such as climate change or habitat degradation can directly influence the growth and survival of insectivorous plant populations.

Ecosystem Services: Insectivorous plants provide a range of ecosystem services beyond nutrient cycling, including pest control and biodiversity maintenance. By preying on insects, they help regulate pest populations, reducing the need for chemical pesticides in agricultural and natural settings. Furthermore, the presence of insectivorous plants supports biodiversity by providing habitat and resources for a diverse array of organisms, from microscopic invertebrates to larger predators. The decline or extinction of insectivorous plant species could have far-reaching consequences for ecosystem functioning and stability, underscoring the importance of their conservation.

Conservation and Management: Conserving insectivorous plant species and their habitats is essential for maintaining ecosystem health and resilience. Habitat destruction, climate change and invasive species pose significant threats to insectivorous plants worldwide. Conservation efforts should focus on protecting their habitats, restoring degraded ecosystems and implementing measures to mitigate the impacts of climate change. Additionally, raising awareness about the ecological importance of insectivorous plants and their conservation needs is crucial for garnering support from policymakers, land managers and the general public. By implementing effective conservation and management strategies, we can safeguard insectivorous plants and the valuable ecosystem services they provide for future generations.

Conclusion

The ecological significance of insectivorous plants cannot be overstated. These remarkable botanical species contribute to nutrient cycling, influence prey dynamics and participate in intricate predator-prey interactions within ecosystems. Their presence shapes habitat conditions and affects the distribution and abundance of various organisms. Recognizing the importance of insectivorous plants shades light on the complexity of natural ecosystems and emphasizes the need for their conservation to preserve biodiversity. Protecting these unique plants is essential for maintaining the health and resilience of our planet's diverse ecosystems.

Happy Seeder for Sowing of Wheat in Standing Stubbles

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Abstract

The Happy Seeder is an innovative agricultural technology that aims to enhance sustainable farming practices. The Happy Seeder is designed to sow seeds directly into crop residues, addressing issues such as soil erosion, water conservation, and weed control. By conserving moisture and improving soil health, the Happy Seeder contributes to increased crop yields while reducing labor and input costs. Additionally, it promotes environmental sustainability by minimizing herbicide use and conserving resources. The Happy Seeder offers a promising solution for farmers looking to adopt conservation agriculture techniques and achieve long-term sustainability in their agricultural operations.

Introduction

Wheat (*Triticum aestivum* L.) is a key edible food item and the primary crop in the rice-wheat system in Punjab, Pakistan. In the rice-wheat cropping system, the late maturity of Basmati Super delayed wheat sowing. Wheat sowing is further delayed due to pre-sowing irrigation, followed by land preparation, which takes 7-10 days depending on the prevailing climate. To address this issue, multiple tillage techniques are utilized, which vary based on the soil type. In fine-textured soils, 4-6 ploughing and planking procedures are relatively usual, resulting in increased energy utilization and delayed seeding of wheat crop (Dawe *et al.,* 2009). Therefore, a need was developed to optimize the energy usage by improving tillage practices and developing efficient tillage operations for sowing of wheat crop. Conservation tillage practice is attractive practice for farmers because of potential reduction in production costs compared to conventional method (Botta *et al.,* 2006). After combine harvesting, the leftover rice consists of tall stubble standing about 30 to 60 cm high, as well as a significant quantity of loose straw arranged in windrows approximately 1 meter wide. The leftover debris causes issues with preparing the soil and planting the next crop (wheat). In Punjab, a significant number of farmers perform multiple tillage operations during the process of incorporation. About half of them, approximately 50%, use more than five tillage operations after partially burning rice residues, while a quarter, around 25%, perform more than five tillage operations after completely burning the residues (Gajri *et al.,* 2002). Delaying wheat planting beyond the optimal period (5 November in Punjab) resulted in a considerable yield loss of 1-1.5% every day (Sidhu *et al.,* 2007). Driven mostly by the substantial air pollution caused by stubble burning, a variety of options are now being investigated to address the issue of direct drilling into rice residue. In addition

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to the massive loss of plant nutrients and organic matter, burning generates significant air pollution, which has a negative impact on human and animal health. Crop residues must be retained urgently in order to promote soil health and production while lowering air pollution. In compared to traditional tillage, minimum and zero-till wheat technologies are more cost-effective, save irrigation water, and allow for timely planting (Malik *et al.*, 2004). Until recently, the availability of proper apparatus was a major impediment to direct drilling into dense rice stubbles. As a result, enhanced versions of the Happy Seeder (known as Turbo Happy Seeders) have been developed, with an emphasis on the capacity to work well under large straw loads while using less energy (Sidhu *et al.*, 2015).

Brief description on Happy Seeder

The Happy Seeder is a modern agricultural machine that assists in the process of sowing crops without the need for primary tillage or crop residue burning. It is primarily used in conservation agriculture, also known as zero tillage or no-till farming. The Happy Seeder consists of a row unit attached to a tractor, which cuts through crop residue and deposits seeds into the soil. It simultaneously deposits fertilizer as well, ensuring proper nutrient distribution. This machine helps conserve soil moisture, controls weed growth, and maximizes crop yield, as it provides better seed-to-soil contact and minimizes soil disturbance. By eliminating the need for extensive tillage methods, the Happy Seeder promotes sustainable farming practices by reducing soil erosion, conserving water, and improving soil health. It is particularly useful in areas where burning crop residue is prohibited due to its negative environmental impact.



Fig. 1: Happy Seeder

Overall, the Happy Seeder is a valuable tool for farmers seeking to improve efficiency, productivity, and sustainability in their agricultural practices.

Major Components of a Happy seeder

- ✓ **Tractor attachment:** The Happy Seeder is attached to a tractor, which provides the power needed for operation and pulls the machine across the field. The attachment mechanism allows for easy connection and disconnection.
- ✓ **Row Unit:** The row unit is the main part of the Happy Seeder that cuts into the soil and deposits seeds and fertilizer. It consists of cutting discs or coulters that slice through the crop residue, spaced apart to create rows for planting. Depending on the specific model, there may be multiple row units for efficient seeding.
- ✓ **Seed Metering Mechanism:** The seed metering system ensures accurate and controlled seed distribution. It typically consists of seed containers or hoppers that hold the seeds and

mechanisms like seed meters or seed plates that regulate the flow of seeds to the ground.

✓ **Fertilizer Application Mechanism:** The Happy Seeder often incorporates a fertilizer application system. This can be in the form of fertilizer hoppers that hold granular fertilizers, which are distributed alongside the seeds during the seeding process. Some models may also have liquid fertilizer applicators for precise fertilization.



Fig. 2: Components of Happy Seeder

✓ **Depth Control System:** To ensure proper seed placement, the Happy Seeder usually incorporates depth control mechanisms. These can include adjustable wheels or gauge wheels that control the depth at which the seeds and fertilizer are planted.

✓ **Frame and Wheels:** A sturdy frame supports the entire machine and provides stability during operation. The Happy Seeder is equipped with wheels that allow for easy maneuverability and control as it moves through the field.

✓ **Optional Attachments:** Depending on the specific model and requirements, additional attachments can be included with the Happy Seeder. These may include residue management devices, trash cleaners, or row cleaners, which help clear crop residue or weeds from the seedbed before seeding. These major components together make the Happy Seeder a comprehensive machine for efficient and sustainable seeding practices.

Advantages of Happy Seeder

✓ **Conservation of Moisture:** The Happy Seeder operates by sowing seeds directly into crop residues or stubble, which acts as a protective cover for the soil. This helps to conserve moisture by reducing evaporation and improving water infiltration, thus improving soil moisture retention.

✓ **Reduction in Soil Erosion:** By planting crops into the residue-covered soil, the Happy Seeder greatly reduces soil erosion, as the residue helps to shield the soil from wind and water erosion. This is particularly beneficial in regions prone to erosion, such as hilly or sloping landscapes.

✓ **Improved Soil Health:** The process of direct seeding with Happy Seeder retains organic matter from crop residues in the field, enhancing soil health. The residues act as a natural mulch, protecting the soil from temperature fluctuations, promoting nutrient cycling, and fostering the growth of beneficial soil microorganisms.

✓ **Weed Control:** The Happy Seeder helps to control the growth of weeds by providing a thick layer of crop residues on the soil surface, which suppresses weed emergence and growth. This reduces the need for herbicides, making it an environmentally friendly and cost-effective weed

management strategy.

- ✓ **Time and Labor Efficiency:** The Happy Seeder allows for simultaneous operations of stubble cutting, seed drilling, and fertilizer application, reducing the time and labor required for seeding. This can be particularly advantageous during critical planting windows or when there is a shortage of labor.
- ✓ **Increased Crop Yield:** The direct seeding method facilitated by the Happy Seeder has been found to improve crop yields in various cropping systems. The combination of improved soil moisture retention, reduced soil erosion, and effective weed control contributes to enhanced crop growth and productivity.
- ✓ **Environmental Sustainability:** By conserving moisture, reducing erosion, minimizing the use of herbicides, and promoting soil health, the Happy Seeder helps to build sustainable agricultural practices. It promotes resource conservation and contributes to overall environmental sustainability.

Overall, the Happy Seeder offers a range of benefits that make it a valuable tool for modern farming systems focused on conservation, efficiency, and sustainable agriculture.

Conclusions

Happy Seeder is a promising technological innovation in the field of agriculture. It offers several advantages that can greatly benefit farmers and the environment. By sowing seeds directly into crop residues, the Happy Seeder conserves moisture, reduces soil erosion, improves soil health, controls weeds, and enhances crop yield. It also saves time and labor, making the seeding process more efficient and cost-effective. Moreover, the use of the Happy Seeder promotes environmental sustainability by minimizing the use of herbicides and contributing to resource conservation. Overall, the Happy Seeder is a powerful tool for modern farming practices, helping farmers adopt conservation agriculture techniques and achieve sustainable agricultural production.

References

Dawe, D., Doberman, A., Ladha, J. K., Yadev, R. L., Gupta, R. K., Lal, P., Panaullah, G., Sariam, O., Singh, Y., Swarup, A. and Zhen, O. X. (2009). Do organic amendments improve yield trends and profitability in intensive rice systems? *Field Crops Research*, 83: 191-213.

Sidhu, H. S., Singh, M., Humphreys, E., Singh, Y., Blackwell, J. and Singh, S. (2007). The Happy Seeder enables direct drilling of wheat into rice stubble. *Australian Journal of Experimental Agriculture*, 47: 844-854.

Gajri, P. R., Ghuman, B. S., Singh, S., Mishra, R. D., Yadav, D. S. and Harmanjit, S. (2002). Tillage and residue management practices in rice wheat system in Indo-Gangetic Plains- a diagnostic survey. Technical Report, National Agricultural Technology Project. Indian Council of Agricultural Research, New Delhi and Punjab Agricultural University, Ludhiana, India.

Botta, G. F., Jorajuria, D., Rosatto, H. and Ferrero, C. (2006). Light tractor frequency on soil compaction in the rolling pampa of Argentina. *Soil Tillage Research*, 86: 9-14.

Malik, R. K., Yadav, A., Gill, G. S., Sardana, P., Gupta, R. K. and Piggin, C. (New Directions for A Diverse Planet). (2004). Evolution and acceleration of no-till farming in rice-wheat cropping system of the Indo-Gangetic Plains. In: Proceedings of the 4th International Crop Science Congress, Brisbane, 29 September-3 October, 2004.

Sidhu, H. S., Singh, M., Singh, Y., Blackwell, J., Lohan, S. K., Humphreys, E., Jat, M. L., Singh, V. and Singh, S. (2015). Development and evaluation of the Turbo Happy Seeder for sowing wheat into heavy rice residues in NW India. *Field Crop Research*, 184: 201-212.

Revolutionizing Dairy: The Rise of Animal-Free Alternatives in a Sustainable Future

Vishal Kumar and Akanksha

Abstract

Animal-free dairy refers to the production of dairy products without the involvement of traditional livestock. This innovative approach utilizes advanced biotechnology, such as precision fermentation and cellular agriculture, to create dairy proteins and fats without the need for animals. The process involves engineering microorganisms to produce proteins like casein and whey, which are key components of dairy products, or cultivating animal cells to mimic the milk production process. Animal-free dairy offers a sustainable and ethical alternative to conventional dairy farming, addressing concerns related to environmental impact, animal welfare, and resource usage. By reducing reliance on traditional agriculture, it has the potential to mitigate greenhouse gas emissions, decrease land and water usage, and provide consumers with a more environmentally friendly choice in dairy consumption.

Introduction

Animal-free dairy is a way of making milk products without using cows. It uses advanced technology to copy the natural processes that happen in a cow's body. Instead of getting milk from cows, scientists work with tiny living things like microbes and millet to create dairy products (Zollman *et al*., 2021). This helps reduce the need for traditional farming practices that involve animals. The type of foods that try to imitate animal products has become really popular in the last few decades. People have been making substitutes for meat, dairy, and eggs for a long time, but now more money and effort are being put into creating new and better options. This is to encourage new ideas and make these alternative products more widely available in the market.

The worldwide market for meat alternatives, mainly made from minimally processed soy products (such as tofu and tempeh), processed vegetable protein, wheat analogs, and fermented mycoprotein, was worth about $5.5 billion in 2020. It's expected to grow and reach about $11.2 billion by the year 2030 (Chouhan *et al.,* 2022).The worldwide market for dairy alternatives, which are made from plant-based ingredients like soy, almonds, oats, and rice to imitate milk, yogurt, ice cream, cheese, and more, was around $22.6 billion in 2020. It's expected to grow and reach about $40.6 billion by the year 2026 (Markets and Markets 2022). In the United States, plant-based milk alternatives make up around 10-15% of all the types of milk available. About 67% of grown-ups have given non-dairy milk a try, and one

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out of three adults drinks this alternative milk at least once a week. These products are found in roughly 12% of households in the US, ranking third in popularity after whole and 2% milk (Hale, 2021).

As plant-based alternatives gain popularity, a new field called cellular agriculture has also emerged in the world of alternative animal products (Santo *et al.*, 2020). Cellular agriculture uses synthetic biology and tissue engineering tools to make products that are the same at a molecular level as traditional animal foods but without the need for raising and slaughtering animals. This field can be broadly divided into two types: cellular products, made from live or formerly live cells, and acellular products, which don't contain cells. Cell-cultured or cultivated meat production falls into the first category. This involves obtaining stem cells from an animal, helping them grow by providing a nutrient-rich environment in a bioreactor, and then harvesting and putting them together to create final meat analog products.

Acellular products, like milk ingredients, can be made using similar methods. For instance, mammary cells that produce milk can be cultured to create milk. One main technique is precision fermentation, where microorganisms like yeast are genetically programmed to produce specific proteins. They are then mixed with nutrients and sugars in a bioreactor until those proteins are formed. These proteins are combined with minerals, sugar, water, and plant-based (or potentially fermentation-based) fats to make "Animal-free dairy" (AFD) products such as milk and ice cream. The process of making AFD is an extension of well-established precision fermentation processes, which have been used to create things like synthetic insulin for diabetes and genetically engineered rennet for regular cheese production. In recent times, these same acellular techniques have also been applied to produce non-animal food items like vanillin (a key part of vanilla flavor) and non-food products used in cosmetics, materials, and other industries.

Process, safety, and regulation

When people learned about animal-free dairy (AFD), they had both positive and negative thoughts about the technology and its effects. They consistently raised questions about how the products were made and whether they were safe for consumers. Participants wanted to know about regulatory assurances to support the advancement of AFD. This aligns with previous research that shows people trust government regulatory agencies and food companies the most for ensuring food safety. Although very few in this group strongly opposed AFD, many had questions and concerns. Most were undecided about trying the product until they got more information. The participants wanted clear communication from everyone involved in developing, regulating, and selling AFD. They believed with transparent information, they could decide whether they were interested in consuming it or not. The moderator didn't give direct answers but encouraged an open discussion among the participants.

Consumer preferences and priorities

When discussions about the potential benefits and drawbacks of animal-free dairy (AFD) came up, participants went into broader talks about what factors were crucial for their food choices. They revealed a complex and sometimes contradictory set of food preferences, highlighting existing research on the gap between attitudes and behaviors in food choices. This discussion set the stage for whether these early adopters were excited to try AFD, open to it as an option, or entirely against trying it. While some expressed strong support or disinterest in AFD, the majority of participants saw it as a viable choice among the various dairy and alternative options in the market. Whether they would incorporate AFD into their diets depended on classic food choice factors like taste and price, especially when compared to standard options. This focus on organoleptic qualities and price parity aligns with common themes in research on alternative proteins.

Mayamilk works on Microbe-based Milk Production

A company called Mayamilk in Turkey is using a special process to create alternative proteins. They use yeast cultures and a technology called precision fermentation to make proteins that are similar to the ones found in dairy products but on a large scale. Mayamilk uses big fermentors to produce these proteins from customized yeast cultures. The proteins they make don't contain antibiotics, hormones, or allergens. This unique fermentation process they use helps make their production sustainable and reduces its impact on the environment by using less land, water, and animals.

Better Bet provides Millet-based Milk

An Indian startup called Better Bet has a plant-based drink made from sprouted millets. This drink is free from lactose, dairy, cholesterol, added sugar, and artificial preservatives. It provides a well-rounded nutrition profile. The plant-based drink is fortified with essential vitamins A, B & D and has lower calories and fat. Better Bet selects ingredients from crops that are resilient to climate changes and need very little water. This approach allows them to create a cruelty-free and sustainable alternative to traditional milk.

Animal-free dairy, food technology and the future

The future of animal-free dairy holds significant promise and potential for several reasons:

Sustainability: Animal-free dairy production methods, such as precision fermentation and plant-based alternatives, are often more sustainable than traditional dairy farming. They typically require less land, water, and other resources, reducing the environmental impact associated with conventional dairy production.

Environmental Benefits: Animal-free dairy has the potential to contribute to lower greenhouse gas emissions and less deforestation compared to traditional dairy farming. By relying on alternative technologies, it can help address some of the environmental challenges associated with large-scale animal agriculture.

Ethical Considerations: As awareness of animal

welfare grows, more consumers are seeking ethical alternatives to traditional animal farming. Animal-free dairy provides a cruelty-free option, as it does not involve raising and slaughtering animals for milk production.

Innovation and Technology: Ongoing advancements in biotechnology, precision fermentation, and other related fields contribute to the development of more sophisticated and efficient methods for producing animal-free dairy. This continuous innovation may lead to improved product quality, taste, and nutritional profiles.

Health and Nutrition: Animal-free dairy products often cater to consumers looking for healthier options. They can be formulated to be lower in saturated fats, cholesterol-free, and fortified with essential nutrients, appealing to individuals who prioritize health-conscious choices.

Conclusion

In conclusion, the future of animal-free dairy presents a promising and sustainable alternative to traditional dairy production. Propelled by advancements in biotechnology, precision fermentation, and a growing demand for ethical and environmentally friendly choices, animal-free dairy offers a viable solution. With a focus on innovation, diverse product offerings, and addressing health and environmental concerns, the industry is poised to play a significant role in shaping the future of sustainable and cruelty-free dairy alternatives. Consumer acceptance and continued efforts in research and development will be crucial in ensuring the continued growth and success of animal-free dairy in the marketplace.

References

Chouhan, N., Vig, H. and Deshmukh, R. (2022). Meat substitute market. Allied Market Research. Available online at: https://www.alliedmarketresearch.com/meat-substitute-market (accessed September 8, 2022).

Hale, M. (2021). Exploring the Growth of Plant-Based Milk. Food Manufacturing. Available online at: https://www.foodmanufacturing.com/consumertrends/article/21723117/exploring-the-growth-of-plantbased-milk (accessed September 8, 2022).

Markets and Markets (2022). Dairy Alternatives Market. Available online at: https://www.marketsandmarkets.com/MarketReports/dairy-alternative-plantmilk-beverages-market-677.html (accessed September 8, 2022).

Santo, R. E., Kim, B. F., Goldman, S. E., Dutkiewicz, J., Biehl, E., Bloem, M. W., ... and Nachman, K. E. (2020). Considering plant-based meat substitutes and cell-based meats: a public health and food systems perspective. *Frontiers in Sustainable Food Systems*, 4: 134.

Zollman Thomas, O. and Bryant, C. (2021). Don't have a cow, man: consumer acceptance of animal-free dairy products in five countries. *Frontiers in Sustainable Food Systems*, 5: 678491.

Farmers Protest 2.0: Delhi Chalo

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Abstract

February 13, 2024, farmers from Punjab, Haryana, and Western Uttar Pradesh were engaged in Farmers' Protest 2.0, advancing towards Delhi. In a departure from previous protests, the movement is led by a faction distinct from the Sanyukt Kisan Morcha (SKM) and does not include key leaders from previous demonstrations. The primary goal of this protest is to demand a comprehensive set of measures from the Central government aimed at ensuring the economic sustainability of farming. One of the key requests is the accentuation of getting a legitimate assurance of at least help costs (MSP) for all harvests, combined with the execution of horticultural suggestions set forth by the MS Swaminathan panel.

Farmers Protest 2.0 is in motion: Farmers, primarily from Punjab, Haryana, and Western Uttar Pradesh, have been opposing the three farm laws for nearly two years. On February 13, they will be merging in the capital. Fully expecting this restored fight, experts in Haryana and Delhi have fixed the lines between Haryana and Delhi, as well as among Punjab and Haryana, fully intent on keeping ranchers from entering the country's capital. As opposed to past dissent, where the essential interest was the withdrawal of the homestead regulations and interest recognized by the public authority after very nearly two years of fights this time, ranchers are introducing a different arrangement of solicitations to the local government. They contend that these actions are vital for guaranteeing the monetary maintainability of farming.



Who are the main characters?

Sanyukt Kisan Morcha (SKM), an alliance of more than forty ranch associations from Punjab, Haryana, and Western Uttar Pradesh, was a significant piece of past fights. Regardless, in constant shows, a splinter bundle has ascended out of this total body. Famous homestead pioneers like Darshan Buddy, Joginder Singh Ugrahan, Rakesh Tikait, Balbir Singh Rajewal, and Gurnam Singh Charuni aren't part of this group, which is called the Sanyukt Kisan Morcha (non-political).

The SKM (non-political) involves affiliations like BKU (Dallewal), driven by Jagjit Singh Dallewal, and Kisan Mazdoor Morcha, driven by

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Sarvan Singh Pandher, confirming help from 17 property affiliations. As the Delhi Chalo strolls on February 13 philosophies, significant figures tending to SKM (non-political) integrate Pandher and Dalwal from Punjab, close to Abhimanyu Kohar from Haryana. Leaders of previous protests, such as Rakesh Tikait, are now adopting a "wait-and-watch" strategy, with a call for Bharat Bandh on February 16. Significant internal divisions within farm organizations were shown by a circumspect approach taken by SKM leaders, who opted to remain in the background.

In contrast to the substantial mobilization witnessed in previous rallies, there is a noticeable lack of enthusiasm from Khaps and Jat community organizations this time. It is crucial to recall that in earlier protests, farmers, primarily from Punjab, initiated demonstrations and carried them to the borders of Delhi. Consequently, Khaps became involved in the movement at a later stage.

What are the demands of protesting farmers?

The government's enactment of three agricultural laws, aimed at increasing farmers' income by integrating them into open markets and aligning with the government's goal of doubling farmers' wages, served as the initial catalyst for the protests. Conversely, protesters opposed these laws, fearing that farmers would become more vulnerable to the influence of private businesses.

The primary demand in the ongoing protests, among roughly a dozen others, is the legal assurance of a minimum support price (MSP) for all crops. The Commission on Agricultural Costs and Prices guides the government in establishing MSPs for nearly two dozen crops biannually. The committee's key suggestion is to raise MSPs to at least 50% above the weighted average cost of production.

What is the Swaminathan Report?

Under the stewardship of Professor M. S. Swaminathan, the National Commission on Farmers (NCF) was established in 2004, issuing a comprehensive series of five reports between 2004 and 2006. Commonly referred to as the Swaminathan report, these publications propose strategies to enhance the productivity, profitability, and sustainability of key farming systems in India.

The commission furnished recommendations on a wide array of issues, including:

- ✓ Developing strategies to ensure nationwide food and nutrition security.
- ✓ Improving the effectiveness and sustainability of agricultural systems.
- ✓ Implementing reforms to increase farmers' access to rural credit.
- ✓ Crafting programs for dryland farming that are relevant to farmers in arid, hilly, and coastal areas.
- ✓ Enhancing the quality and cost competitiveness of agricultural commodities.
- ✓ Protecting farmers from the impact of imports during global price downturns.
- ✓ Empowering local bodies to skillfully conserve the ecological foundations for enhanced agriculture.

What is the strategy behind the farmer's protest?



Prior to farmer protests, there was extensive mobilization involving a significant number of farmers, creating an emotionally charged atmos-phere. This period witnessed widespread violence and substantial economic losses for businesses and residents in and around Delhi, along with disruptions in the transportation of goods.

Presently, the mobilization seems relatively moderate, with the anticipated participation of 25,000 farmers and 5,000 tractors in the march. However, this could be an initial phase, and the number of participating farmers and other organizations might increase as the protests progress and farmers approach the borders of Delhi. The government has promptly engaged with the farmers to discourage them from marching to Delhi. Over the past week, three Union ministers Piyush Goyal, Nityanand Rai, and Arjun Munda visited Chandigarh for discussions with farmer leaders. Punjab Chief Minister Bhagwant Mann served as a mediator between the central government and farm leaders, and another meeting is scheduled for this evening in Chandigarh. The government has expressed its willingness to initiate a dialogue with the farmers.

The SKM (non-political), the overarching organization leading the current protests, has affirmed that discussions with the central govern-ment will continue, but there will be no postponeme-ment of the Delhi Chalo march. Despite indications of internal divisions within farmer organizations, Khaps and Jat community organizations have not fully thrown their support behind the protests. According to reports, the two Khaps have encouraged farmers to refrain from besieging Delhi and instead advocated for engaging in dialogue with the government. A leader from the Khap in Sonepat emphasized the substantial losses and inconvenience experienced by residents in border districts of Haryana during the previous protests, resulting in the closure of numerous businesses and industries.

The initiation of the current farmer protests may be less intense due to various factors, including low initial participation, the upcoming harvest season, and the approaching Lok Sabha elections, indicating a potentially shorter duration. The need for farmers to return to their villages during the elections may contribute to this trend. Despite the subdued beginning, the protest has the potential to escalate with increased farmer involvement, particularly if influential leaders like Tikait, Ugrahan, and Rajewal actively participate. The outcome hinges on the success of the Centre's outreach initiatives and the effectiveness of the security measures in place.

References

https://timesofindia.indiatimes.com
https://www.psa.gov.in
https://www.bbc.com
https://www.hindustantimes.com
https://indianexpress.com

Farming Tomorrow: Exploring the Authentic Future of Aquaponics in Sustainable Food Production

Rakhi Das

Abstract

The article scours into the extensive viability of aquaponics as a sustainable food production system. This innovative farming technique support the continuous production of food through applying aqua culture and hydroponics both in one system by maintaining a healthy symbiotic relationship between fish, plant and microbes. The planet of earth and its population now faces several challenges including climate change, scarcity of fertile land with water for production of food. The article highlights the system mechanism of farming how to produce two crops from single space by minimum utilizing of land and water. Day by day this system popularity is increasing gradually as an environment friendly alternative to traditional agriculture. The article's explore the practical implementation of aquaponics for social and economic upliftment by managing the natural resources as a sustainable way.

Introduction

At the present situation, sustainable production of food is a sensitive issue where challenges are more than achievement there aquaponics may create groundbreaking solution for sound production of food in a sustainable way. In this informative journey, people can know about the future authencity of the aquaponics system and its function. Generally aquaponics support the yielding the two different toxic free crops at same time from a single unit. This innovative theme integrate the aquaculture with hydroponics where fishes waste material used for plant production and plant act as natural bio filter for fishes. To handle the environmental problems related to agriculture production, aquaponics stand as a beacon offering an environmental friendly and effective approach to cultivating the food we require. The article scrabbles about into the entangled web of aquaponics; elucidate its principles, advantage and the transmuting role in tomorrow's crop production.

The communal trip of aquaponics: Traditionally agriculture crop production fully depends on fertility of land and proper irrigation. Aquaponics resolve the limitation by making a communal relation both aquaculture and hydroponics. This system balances the wastage material as a natural fertilizer for production of crops. Fish and plant both of crops can be produced in an effective way by maintaining a healthy symbiotic relationship. This innovative symbiotic relationship eliminates the need of soil for crop production with secure the environment from the pollution of conventional farming.

Exhibit an environmental protector: Day by day, the increasing population now creates a pressure on

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our globes and its environment partially. Climate changes, arid land, water scarcity, are the main barrier for crop production. Pollution from agro industry also embarrassed the nature very roughly. To lower the environmental impact from crop production sector, aquaponics emerges as an environmental protector. The recycling system and its management not only minimize the land and water scarcity compared to traditional farming it can also provide the better quality product to the new civilian.

Nourishing resilience in agriculture: In an earth, struggling with inconsistent weather pattern and delaminating fertile land, aquaponics offers a lighthouse of resilience. Aquaponics support the controlled system, which could be run for year round cultivation on long term basis. The system resilience not only protects the crops security but also pledge a consistency and reliable food production.

Reexplore the local food movements: Aquaponics is just not an idea for growing crops in a limited space, this system rejoining the relation of nature with human. Establishment of this system in urban areas brings agriculture to aquaculture closer to the consumers. This developed system helps to reduce the carbon footprint linked with transportation and meet communities with the origin of their food.

Challenges of the origin: While the potentiality of aquaponics is inarguable, challenges emerge on horizon. Balancing an elegant ecosystem within these delicate systems requisites a significant under-standing and technological expansions are crucial to address adaptability and economic incredibility. As we travel into unknown territory, it is essential to traverse these challenges thoughtfully to unlatch the whole prospects of aquaponics.

Conclusion

Farming tomorrow is not just the abundance of foods; it's about nurture a future that respects the graceful balance of our living planet. Aquaponics with its ingenuity and pledge is a sterling step towards a sustainable and flexible tomorrow. The nature of environment friendly and climate effective crop production technology not only solve the land and water scarcity related problem this innovative technology can produce crops in optimum level.

References

Das, R. (2018). Constitute a Compact Aquaponics System in Indian Premises and Confront Hurdles to Assemble this System. *Int. J. for Res. App. Sci. and Engg. Tech.*, 6: 172-176.

Fruscella, L., Kotzen, B. and Milliken, S. (2021). Organic aquaponics in the European Union: Towards sustainable farming practices in the framework of the new EU regulation. *Reviews in Aquaculture*, 13(3): 1661-1682.

Quamar, T. and Das, R. (2023). Production of organic vegetables through Aquaponics: A way forward to sustain local food plants growth. *The Pharma Innovation Journal*, 12(9S): 1150-1154.

Rakocy, J. E. (1994). Aquaponics: The Integration of Fish and Vegetable Culture in Recirculating Systems (30th Annual Meeting, July 31-Aug. 5, 1994, St. Thomas U.S. Virgin Islands).

Integrated Management Strategies against Fall Armyworm in Maize

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Abstract

This article provides a comprehensive approach to the integrated management of the Fall Armyworm (FAW) in maize. It covers the morphological characteristics, alternate hosts and diversity, nature of damage, biological lifecycle, and management strategies for FAW. The guide highlights the role of IPM in integrating naturally available tactics for FAW management, promoting high-quality IPM options. The article also discusses the use of eco-friendly methods, biological control, and the application of neem oil as part of the integrated management approach. Furthermore, it underscores the significance of early monitoring and scouting, as well as the use of entomopathogens and natural enemies for the sustainable control of FAW in maize fields.

Introduction

Maize (*Zea mays* L.) is India's third most significant crop, after rice and wheat. It is used as food, feed, and fodder as well as a variety of industrial products such as starch, oil, protein, alcoholic drinks, sweeteners, cosmetics, and biofuel. With 83% of its products going towards the starch and feed industries, maize has thus established itself as a significant industrial crop. In India, 8.69 million hectares of maize are under cultivation, yielding productivity and production of 21.81 million tons and 2509 kg ha^{-1}, respectively. The primary producing states of maize in India are Andhra Pradesh, Karnataka, Bihar, Maharashtra, Rajasthan, Madhya Pradesh, and Uttar Pradesh. In Karnataka, the largest area under cultivation is found in the districts of Shimoga, Belgaum, and Hassan.

Spodoptera frugiperda (Lepidoptera: Noctuidae), also known as the fall armyworm (FAW), is an invasive pest that poses a threat to Indian agriculture and farmers. It was initially discovered in maize fields at the College of Agriculture, Shivamogga, Karnataka, in May 2018. Fall armyworms are native to subtropical and tropical regions of America where they primarily attack maize crops in autumn. In India, FAW was spread via Karnataka state. FAW has damage intensity of 9 to 62 % with a yield loss of 34% in case of severe infestation. FAW is a major pest on maize due to its early onset in the crop life cycle, voracious eating habits, large-scale aggressive behaviour, high fecundity, quick migration, wide host range, and irreversible crop damage. Cloudy weather with low temperatures and high rainfall favours a rapid increa-

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se in the FAW population. In maize, its economic threshold level is 5% of seedlings are cut or 20% of whorls of small plants are infested. At this level, an insecticide should be applied.

Alternate host plant and distribution

Maize is one of the prominent hosts of the FAW other than that it infests around 80 plant species including rice, millets, sorghum, and cotton. FAW was earlier found in America after that it was also detected in Central and Western Africa, Nigeria, Gabon, Sao Tome, Benin and Togo infestation is recorded in Berlin. In India, it has caused severe infestation in central and southern India.

Morphological identification

Eggs: Small, pale yellow, covered in a covering of scales; typically laid in clusters of 100-200 on the underside of leaves close to the plant's base. The caterpillars of young caterpillars (Instars 1-3): Light green to brown, with a dark head capsule; it forms semitransparent patches or “windows” on the undersides of leaves through feeding. Mature caterpillars (Instars 4-6): Darker, with two dark spots with dark spines on each body segment on the upper body surface, four black spots arranged in a square on the final abdominal segment, and pale white stripes down the body, as well as a pale inverted “Y” form between the eyes. Pupae: oval-shaped, shiny brown, and measuring 1.3-1.7 cm in length. Adult moths: They have wingspan of 3-4 cm, with females being marginally bigger than males. Male moths have conspicuous triangular white patches at the tip and near the center of each forewing, and both sexes have white hindwings with a dark-brown border.

Nature of damage

Larvae burrow into a bud, whorl, or other growth point, they can impair a plant's ability to grow or cut its leaves. They may tunnel into the ear of maize plants to munch on grains. The FAW digs a tunnel through the ear's husk. The mean density of 0.2 to 0.8 larvae per plant during the late whorl stage could reduce yield by 5 to 20 per cent. Older larvae defoliate large areas of maize plants, frequently leaving only the ribs and stalks, or giving the plants a ragged, ripped look.



Image source https://www.dpi.nsw.gov.au/__data/ assets/ image/0008/1236455/FAW6.jpg

Biological life cycle

The life cycle of the FAW includes an egg, six growth stages of caterpillar development (instars), a pupa, and an adult moth. The eggs are generally laid on the underside of the leaves, typically near the base of the plant, close to the junction of the leaf and the stem. After hatching, the young caterpillars feed superficially, usually on the undersides of leaves. By stages 4-6, the fall armyworm will reach the protective region of the whorl, where it does the most damage, resulting in ragged holes in the leaves.

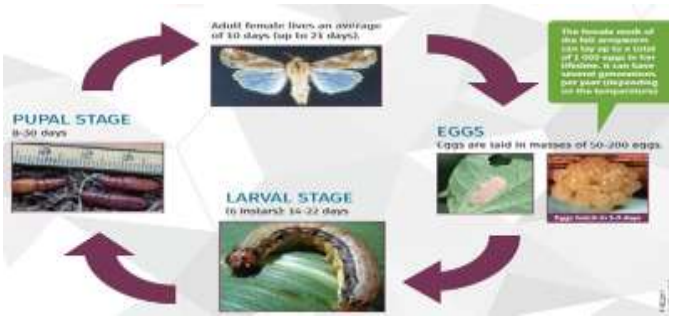


Image source https://static.vikaspedia.in/media/images_en/agriculture/crop-production/integrated-pest-managment/faw-lifecycletest.jpg

Integrated pest management strategies for fall armyworm in maize

- ✓ Hand picking and destruction of egg masses and neonate larvae in mass by crushing or drenching in kerosine water.
- ✓ Deep summer ploughing to expose pupae of FAW to predatory birds, heat etc.
- ✓ Application of dry sand into the whorl of affected maize plants soon after observation of FAW incidence in the field.
- ✓ Early, synchronized sowing of maize to reduce the availability of crop for increase of population of FAW and further outbreak.
- ✓ Application of Sand + lime in a 9:1 ratio in whorls in the first thirty days of sowing.
- ✓ Mass trapping of male moths using FAW-specific pheromone traps @ 15 acre^{-1}.
- ✓ Spread blue cloth measuring 2 m in places randomly in an acre area to attract and kill the larvae.
- ✓ Clean and weed free cultivation to destroy the alternate hosts and balanced use of fertilizers.
- ✓ Install FAW pheromone trap @ 5 numbers ac^{-1} and light trap @ 1 ha^{-1} at an early stage of crop.
- ✓ Sowing of 3-4 rows of trap crops (eg. Napier) around maize field and spray with 5% NSKE or azadirachtin 1500 ppm as soon as the trap crop shows symptom of FAW damage.
- ✓ Avoid staggered sowings.
- ✓ Control is largely achieved in the northern and central India through a winter kill by exposing larvae and pupae within the upper soil surface. Freezing temperatures cause high larval mortality.
- ✓ Dig trench around the field and fill with water and insecticide to avoid migration of FAW larvae from one to another field.
- ✓ Intercropping of maize with suitable pulse crops of particular region. (eg. Maize + pigeon pea/ black gram /green gram).
- ✓ Apply charcoal, soil, ash, local plant extract on the whorl of maize as an ITK method.
- ✓ Cultivation of maize hybrids with tight husk cover will reduce ear damage by FAW.
- ✓ Increasing plant diversity by intercropping with pulses, oilseeds and ornamental flowering plants which help in buildup of natural enemies.
- ✓ Augmentative release of egg parasitoid *Trichogramma pretiosum* or *Telenomus remus* @ 50,000 acre^{-1} at weekly intervals or based on trap catch of 3 moths trap^{-1}.
- ✓ Bio-pesticides: If infestation level is at 5% damage in seedling to early whorl stage and 10% ear damage, then use following entomopathogenic fungi and bacteria: *Bacillus thuringiensis* var. *kurstaki* formulations @ 2 g l^{-1} (or) 400 g acre^{-1}.

- ✓ *Metarhizium anisopliae, Nomuraea rileyi, Beauveria bassiana, Verticilium lecani* (1 × 10 cfu g^{-1}) @ 5 g $litre^{-1}$ whorl application. Repeat after 10 days if required.
- ✓ Seed treatment: Cyantraniliprole 19.8% + Thiamethoxam 19.8% FS @ 6 ml kg^{-1} of seed will be effective for 15-20 days.
- ✓ First Window (seedling to early whorl stage): To control FAW larvae at 5% damage to reduce hatchability of freshly laid eggs, spray 5% NSKE /Azadirachtin 1500 ppm @ 5 ml l^{-1} of water.
- ✓ Poison baiting: Poison baiting is recommended for late instar larvae of the second window. Keep the mixture of 10 kg rice bran + 2 kg jaggery with 2-3 litres of water for 24 hours to ferment. Add 100 g Thiodicarb just half an hour before application in the field. The bait should be applied into the whorl of the plants.
- ✓ Second window (mid whorl to late whorl stage): To manage 2nd and 3 instars larvae having more than 10% foliar damage the following chemicals may be used upto early tasselling stage: Spinetoram 11.7% SC or Chlorantraniliprole 18.5% SC or Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC.
- ✓ Third Window (8 weeks after emergence to tasseling and post tasseling): Insecticide management is not cost-effective at this stage. Bio-pesticides as recommended above to be applied. Hand-picking of the larvae is advisable.
- ✓ All the sprays should be directed towards whorl and either in the early hours of the day or in the evening time.

Conclusion

Fall armyworm is a major pest of maize and infests a variety of plant species causing severe reduction in yield and productivity of the crop. First reported in India in Karnataka in 2018 in maize crop. Due to its characteristic features, it has widespread to other parts of the country so rapidly. Periodic awareness training for maize growers and capacity building on early scouting, surveillance, and monitoring of FAW incidence by extension officers and input dealers are greatly essential to accomplish such freedom from FAW in other parts of the country.

References

Mallapur, C. P., Naik, A. K., Hagari, S., Prabhu, S. T. and Patil, R. K. (2018). Status of alien pest fall armyworm, Spodoptera frugiperda (JE Smith) on maize in Northern Karnataka. *Journal of Entomology and Zoology Studies*, 6(6): 432-436.

Midega, C. A., Pittchar, J. O., Pickett, J. A., Hailu, G. W. and Khan, Z. R. (2018). A climate-adapted push-pull system effectively controls fall armyworm, Spodoptera frugiperda (JE Smith), in maize in East Africa. *Crop Protection*, 105: 10-15.

Sisay, B., Tefera, T., Wakgari, M., Ayalew, G. and Mendesil, E. (2019). The efficacy of selected synthetic insecticides and botanicals against fall armyworm, Spodoptera frugiperda, in maize. *Insects*, 10(2): 45.

Deshmukh, S., Pavithra, H. B., Kalleshwaraswamy, C. M., Shivanna, B. K., Maruthi, M. S. and Mota-Sanchez, D. (2020). Field efficacy of insecticides for management of invasive fall armyworm, Spodoptera frugiperda (JE Smith)(Lepidoptera: Noctuidae) on maize in India. *Florida Entomologist*, 103(2): 221-227.

Ganiger, P. C., Yeshwanth, H. M., Muralimohan, K., Vinay, N., Kumar, A. R. V. and Chandra-shekara, K. J. C. S. (2018). Occurrence of the new invasive pest, fall armyworm, Spodoptera frugiperda (JE Smith) (Lepidoptera: Noctuidae), in the maize fields of Karnataka, India. *Current Science*, 115(4): 621-623.

Padhee, A. K., and Prasanna, B. M. (2019). The emerging threat of Fall Armyworm in India. *Indian Farming*, 69(1): 51-54.

Bio-priming with AM Fungi: A Biotic Tool in Improving Crop Productivity

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In modern agriculture, advance technologies are being deployed for breaking yield barriers and enhancing crop productivity. Devising varied seed enhancement technologies is an important domain assuring uniform field emergence, better crop stand and realisation of higher yield in various crops. Seed priming is a technique of controlled hydration (soaking in water) and drying that result in more rapid germination when the seeds are reimbibed. There are different methods of priming like hydro-priming, halopriming, thermopriming, bio-priming, etc. Bio-priming is a process of biological seed treatment that refers to a combination of seed hydration and inoculation of the seeds with beneficial microorganisms. It improves seed viability, germination, vigour indices, plant growth and subsequent protection against diseases and finally enhances crop yield. In most of the cases microbial inoculants such as plant growth-promoting rhizo-microorganisms (bacteria or fungi) are used for the purpose of bio-priming of seeds. It is an environmentally sound ecological approach using selected microorganisms which enhance plant growth by producing plant growth promoting substances or enhancing nutrient uptake or by protecting seedling/plants against soil-/seed-borne plant pathogenic organisms.

Mycorrhizal fungi, one of the commonly occurring microorganism in soil associated with more than 80% of land plants play an increasingly vital important role in plant growth promotion, plant stress tolerance induction and agricultural sustain-ability. Mycorrhizal fungi establish stable and closer mutualistic symbiosis that generate a huge hyphal network in the soil and have prominent beneficial effect in improving the associated-plants absorption of soil water and nutrients. In exchange, the host plant provides the mycorrhizal fungi with a place to live and with carbohydrates that are essential to the completion of the fungal life cycle.

Over the past decades, mycorrhizal-based commercial inoculants are sold world-wide as biofertilizers in a variety of formulations in agriculture, horticulture and forestry. Mycorrhizal fungal inoculation was basically implemented through seed sowing and seedling plantin, and both of them have shown a significant increase in seedling growth and production. Seed bio-priming with mycorrhizal fungi has been proved to be beneficial to seed germination, seedling survival and timely seedling establishment.

Mycorrhizal inoculants

Modern inoculants are available in diverse forms such as granular, powder and liquids to accom-

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modate a variety of equipment and application methods. Many inoculants are viable for up to two years or more, remain tolerant of temperatures from well below freezing up to 140° F, and are compatible with most fertilizers and pesticides.

Seed treatment is best accomplished using either powdered or liquid mycorrhizal inoculants applied so that the inoculum adheres directly to the surface of the seed. Powdered inoculants work well with hairy-textured seeds such as wheat, barley, oats or many grass seeds. Seed adhesion is important to insure inoculum proximity to the germinating seed. A liquid inoculum is often preferred for corn, beans, alfalfa and similar smooth-surfaced seeds because it will adhere well. A "sticker" or tackifier product is necessary to apply powdered inoculants to these types of seeds to keep the powder attached to the seed surface.

Steps of biopriming

- ✓ Pre-soak the seeds in water for 12 h.
- ✓ Mix the formulated product of bio-agent with the pre-soaked seeds at the rate of 10 g kg^{-1} seed.
- ✓ Put the treated seeds as a heap.
- ✓ Cover the heap with a moist jute sack to maintain high humidity.
- ✓ Incubate the seeds under high humidity for about 48 h at approximately 25-32 °C.
- ✓ Bio-agent adhered to the seed grows on the seed surface under moist condition to form a protective layer all around the seed coat.

Advantages of seed bio-priming

- ✓ Seed bio-priming is a suitable alternative to seed treatment because the microbes multiply continuously, occupy the growing root surfaces, form a biofilm around the roots and protect the plants from soil-borne plant pathogens through-out the crop-growing stages.
- ✓ Other advantages are the elicitation of systemic resistance in plants that can protect the plants from foliar pathogens during the later stages of their growth and development and induced systemic tolerance (IST) against biotic and abiotic stresses.
- ✓ Alternatively, seed bio-priming can also enhance seed's nutritional and physiological characteristics and result in better germination and adaptation under different soil conditions

Baslam *et al*. (2011) found increase in anthocyanins, total carotenoids, and totalphenolics in mycorrhizal lettuce plants. Pereira *et al.* (2016) observed improved plant nutrition of pepper by mycorrhizal inoculation in a comprehensive review study. Dhawal *et al*. (2016) showed that bio-priming of okra with *Glomus fasiculatum* and *Gigaspora* spp. had a significant effect on plant height, leaf area, chlorophyll content, root length, dry and fresh weight of root, dry weight of shoot and nutrient use efficiencies of NPK by enhancing the root colonization and uptake of nutrients (NPK). Kumar *et al*. (2017) stated that application of AMF (Glomus mosseae) in Himalayan production system can yield nutritionally-rich produce for the resource-poor farmers. Their field studies reported quality enhancement in okra-pea cropping system in terms of macro-

nutrients (N, P, K, and Ca) and micronutrients.

Summary

Symbiotic fungi arbuscular mycorrhiza *viz*., *Acaulospora* sp., *Ambispora* sp., *Gigaspora* sp., *Glomus* sp., *Pacispora* sp. and *Paraglomus* sp. have shown significant influence on plant nutrient uptake, growth and colossal capacity to resist abiotic stress, especially drought situations. However, the success of establishing symbiotic interaction was limited through bio- priming, but recent reports suggest that inclusion of some *biostimulants* has made it successful by increasing the occurrence of viable colonies and *percent* infection at early seedling growth stages.

References

Baslam, M., Garmendia, I. and Goicoechea, N., (2011). Arbuscular mycorrhizal fungi (AMF) improved growth and nutritional quality of greenhouse-grown lettuce. *Journal of Agricultural and Food Chemistry*, 59: 5504-5515.

Pereira, J. A. P., Vieira, I. J. C., Freitas, M. S. M., Prins, C. L., Martins, M. A. and Rodrigues, R. (2016). Effects of arbuscular mycorrhizal fungi on *Capsicum* spp. *The Journal of Agricultural Science*, 154: 828-849.

Dhawal, S., Sarkar, D. R., Yadav, R. S., Parihar, M. and Rakshit, A. (2016). Bio-priming with Arbuscular mycorrhizae for addressing soil fertility with special reference to phosphorus. *International Journal of Bioresource Science*, 3(2): 35-40.

Kumar, A., Choudhary, A. K. and Suri, V. K. (2017). Agronomic bio-fortification and quality enhancement in okra-pea cropping system through arbuscular mycorrhizal fungi at varying phosphorus and irrigation regimes in Himalayan acid Alfisol. *Journal of Plant Nutrition*, 40(8): 1213-1229.

Fruit Waste: A Hidden Wealth Waiting to be Unveiled in Present Era

Rahul Dongre and Bharti Choudhary

Abstract

Fruits are not only a delightful part of our diet but also a source of immense nutritional value. Fruits are highly perishable in nature hence leads to high levels of deterioration loss and waste. India alone produces 107.24 million tons of fruits and vegetables and constitute about 6.6 million ton of waste annually. However, what often goes unnoticed is the vast amount of fruit waste generated in the process of consumption and production. This fruit waste, typically consisting of peels, seeds, and discarded portions. Food waste disposal causes several worldwide problems in a variety of areas, including the social, environmental, and financial. It can be transformed into hidden wealth, benefiting both the environment and economically. Consequently, the goal of this study is to offer a critical perspective on the integrated valorisation of fruit by-products in order to address a worldwide issue by producing very valuable antioxidant extracts.

Introduction

India, the second-largest producer of fruits, accounts for 12% of the global fruit production. Fruits are not only a delightful part of our diet but also a source of immense nutritional value. Fruits are highly perishable in nature hence leads to high levels of deterioration loss and waste. India produced 107.24 million tons of fruits (Anonymous, 2022) out of them constitute about 6.6 million ton of waste annually. Fruits) are produced in large quantities in markets and cause environmental pollution due to their high biodegradability. The waste is disposed of by dumping on the outskirts of cities. Lack of control on food processing industries and agri-economy practices contributes to this waste. Food processing is a crucial sector in agriculture, reducing wastage of perishable commodities.

Various uses of fruit waste are as follows

Animals Feed: In an era where sustainable practices are gaining prominence, repurposing fruit waste as animal feed emerges as a promising solution. The disposal of fruit waste poses environmental challenges, but its conversion into nutritious feed for animals not only addresses this issue but also contributes to a more circular and sustainable food system. Fruit waste, including peels, cores, and discarded parts, is often rich in vitamins, minerals, and fiber. Utilizing these components as animal feed can enhance the nutritional profile of the feed, promoting the health and well-being of the animals. We can minimize the ecological footprint associated with landfilling and create a more sustainable waste

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management system. Farmers can benefit economically by using fruit waste as animal feed. It offers a cost-effective alternative to traditional feeds, reducing the overall expenses incurred in livestock farming. Incorporating fruit waste into animal diets diversifies the sources of nutrition. This not only aids in providing a balanced diet for the animals but also contributes to the resilience of the farming system, mitigating potential risks associated with dependence on a single type of feed.

Different Parts of Fruit Waste Used for Animal Feed

- ✓ **Peels:** Fruit peels are often rich in fiber, vitamins, and minerals. Repurposing peels as animal feed enhances the nutritional content of the feed, contributing to the overall health of the animals. Fruit waste, including jackfruit peel and axis, has been explored as a potential ingredient in nutrient-enriched cattle feeds (Akter, 2020). Grapes and apples, has been studied to enhance their quality and nutrient accessibility for poultry feed.
- ✓ **Cores:** The cores of fruits, often discarded, contain valuable nutrients. Including fruit cores in animal feed provides a sustainable way to utilize this often overlooked resource.
- ✓ **Discarded Parts:** Various parts of fruits that are typically discarded, such as seeds and stems, can be processed and incorporated into animal feed. This practice minimizes waste and maximizes the nutritional benefits for livestock.
- ✓ **Pulp and Residue:** After extracting juices or processing fruits, the remaining pulp and residue can be used as valuable components in an animal feed as it is high antioxidants source. Fruit and vegetable waste from marketplaces, with a composition of 10% crude protein and 36.6% neutral detergent fiber, has been identified as a potential feedstuff for bovine feeding (Angulo, 2012).

Nutrient-Rich Compost: Fruit peels and leftover pulp are rich in organic matter, making them excellent components for composting. Creating nutrient-dense compost from fruit waste not only diverts it from landfills but also enriches the soil, promoting healthier plant growth. This sustainable practice contributes to reducing the dependence on chemical fertilizers and fostering a more ecologically balanced environment.

In an era where sustainable practices are gaining prominence, repurposing fruit waste as animal feed emerges as a promising solution. The disposal of fruit waste poses environmental challenges, but its conversion into nutritious feed for animals not only addresses this issue but also contributes to a more circular and sustainable food system. Choy (2015) found that co-composting fruit peels with horticultural waste increased nutrient content, particularly potassium, but did not reach the required temperature for pathogen destruction. Zawadzińska (2021) demonstrated that compost enriched with fruit-vegetable waste improved tomato yield and nutritional value. Jothimani (2013) used fruit waste from palm oil industries to

produce organic manure, enhancing nutrient content.

Bioenergy Production: Certain fruit waste, such as pomace (the solid remains after extracting juice), can be utilized in bioenergy production. Through anaerobic digestion or other fermentation processes, fruit waste can be converted into biogas or biofuels. Example waste of pineapple, sweet potato, and Indian water chestnut, can be used for bioethanol production providing an alternative and cleaner energy source. This not only reduces the carbon footprint associated with waste disposal but also contributes to renewable energy initiatives. Khandaker (2020) further emphasized the potential of fruit and vegetable waste, particularly pineapple and orange, as a feedstock for bioethanol production.

Innovative Food Products: The discarded parts of fruits, often deemed as waste, can be transformed into innovative food products. Banana peels, for example, can be used to make banana peel flour, a rich source of dietary fiber. Mango pits can be processed to extract edible oil, adding value to what is commonly discarded. By exploring creative ways to use fruit waste, we can unlock new avenues for sustainable and nutritious food options. A range of studies have explored the potential of fruit waste in creating innovative food products. For instance, a study by Trishkaneva (2021) highlighted the use of waste from canned fruit and vegetable production to develop new functional food products. One of the most valuable types of secondary raw materials is the waste of vegetable raw materials obtained as a result of technological processes of processing fruits and vegetables in the production of canned products.

Medicinal Extracts and Supplements: Research has shown that certain compounds present in fruit waste, such as citrus peels, exhibit potential medicinal properties. Extracts from these discarded parts can be used to create supplements or functional foods, providing health benefits beyond traditional consumption. This not only reduces waste but also taps into the medicinal potential of these overlooked resources. Mihaylova (2018) identified nettle, bladder campion, and rose hip fruit as rich sources of bioactive compounds and microelements.

Artisanal and Craft Industries: Fruit waste can serve as a valuable resource for artisans and craftsmen. Citrus peels, for instance, can be dried and used for potpourri or in the creation of natural dyes. By incorporating fruit waste into various artistic endeavors, we not only reduce environmental impact but also contribute to the growth of sustainable artisanal industries.

Conclusion

Raising awareness among farmers, food processors, and the general public about the potential of fruit waste as animal feed is crucial. Collaborative efforts between agricultural sectors, food industries, and waste management entities can foster a holistic approach to implementing and scaling up this sustainable practice. Fruit waste is a hidden wealth waiting to be unveiled. By recognizing the potential of these discarded parts, we can turn what was once considered waste into valuable resources. From enriching the soil through composting to generating

bioenergy and creating innovative food products, the possibilities are vast. Embracing these opportunities not only benefits the environment but also opens up new avenues for sustainable practices and economic growth. It's time to rethink our approach to fruit waste and harness its hidden wealth for a brighter and more sustainable future.

References

Angulo, J., Mahecha, L., Yepes, S. A., Yepes, A. M., Bustamante, G., Jaramillo, H., Valencia, E., Villamil, T. and Gallo, J. (2012). Quantitative and nutritional characterization of fruit and vegetable waste from marketplace: a potential use as bovine feedstuff? *Journal of Environmental Management*, 95 Suppl: S203-9.

Anonymous. (2022). https://apeda.gov.in/

Choy, S. Y., Wang, K., Qi, W., Wang, B., Chen, C., and Wang, J. (2015). Co-composting of horticultural waste with fruit peels, food waste, and soybean residues. *Environmental Technology*, 36: 1448-1456.

Jothimani, P. and Rajannan, G. (2013). Empty fruit bunch- a potential organic manure for agriculture. *International Journal of Science, Environment and Technology*, 2(5): 930-937.

Khandaker, M. M., Abdullahi, U. A., Abdulrahman, M. D., Badaluddin, N. A. and Mohd, K. S. (2020). Bio-Ethanol Production from Fruit and Vegetable Waste by Using Saccharomyces cerevisiae. *Bioethanol*, DOI: http://dx.doi.org/10.5772/intechopen.94358

Akter, F. and Haque, M. A. (2020). Jackfruit Waste: A Promising Source of Food and Feed. *Annals of Bangladesh Agriculture*, 23: 91-103.

Mihaylova, D., Vrancheva, R., Petkova, N. T., Ognyanov, M. H., Desseva, I., Ivanov, I. G., Popova, M. and Popova, A. (2018). Carotenoids, tocopherols, organic acids, charbohydrate and mineral content in different medicinal plant extracts. *Zeitschrift für Naturforschung C*, 73: 439-448.

Trishkaneva, M. V. and Posokina, N. E. (2021). Technological solutions for processing of fruits and vegetables: a patent mini-review for 2009-present. *IOP Conference Series: Earth and Environmental Science*, 937.

Zawadzińska, A., Salachna, P., Nowak, J. S., Kowalczyk, W., Piechocki, R., Łopusiewicz, Ł. and Pietrak, A. (2021). Compost Based on Pulp and Paper Mill Sludge, Fruit-Vegetable Waste, Mushroom Spent Substrate and Rye Straw Improves Yield and Nutritional Value of Tomato. *Agronomy*, 12(1): 13.

Natural Farming for Sustainable Agriculture

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Natural Farming

Natural farming, popularly known as zero budget natural farming, is an innovative farming approach. It is low input based, climate resilient, and low-cost farming system because all the inputs (insect repellents, fungicides, and pesticides) are made up of natural herbs and locally available inputs, thereby reducing the use of artificial fertilizers and industrial pesticides. The important steps in natural farming are conservation of crop diversity, no tillage, watershed management, efficient water management, integrated nutrient management, integrated weed management, integrated pest management and crop diversification.

Definition

"Natural Farming is a chemical-free traditional farming method. It is considered as an agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity" -Niti Ayog

Natural farming is a system where the laws of nature are applied to agricultural practices. This method works along with the natural biodiversity of each farmed area, encouraging the complexity of living organisms, both plants, and animals that shape each particular ecosystem to thrive along with food plants. Natural Farming builds on natural or ecological processes that exist in or around farms.

Important features of Natural Farming

- ✓ Nutrient uptake from air and sunlight.
- ✓ Organic mulch for soil health.
- ✓ Bio-cultures instead of fertilizers.
- ✓ Environmental and economic benefits.
- ✓ Dependence on Indian breed Cows.
- ✓ Exclusion of exogenous fertilizers.
- ✓ Encouragement of soil Microbes and earth-worms.
- ✓ Natural weeding Practices.
- ✓ Natural pest control.
- ✓ Role of weeds as mulch.
- ✓ Emphasis on multiple cropping.

Objectives for natural farming promotion

- ✓ Reduce input cost of agricultural production.
- ✓ Restore soil health and fertility and soil's biological life.
- ✓ Maintain diversity in crop production.
- ✓ Preserve natural flora and fauna.
- ✓ Use of natural / local resource-based inputs.
- ✓ Efficient utilization of land and natural resources (light, air, water).
- ✓ Promotion of local breeds for livestock integration.
- ✓ Promote natural beneficial insects, animals and microbes in soil for nutrient recycling and biological control of pests and diseases.

Principles of Natural farming

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- ✓ Implementation of diversified cropping system-based agriculture.
- ✓ Reuse and recycle of on-farm generated biomass.
- ✓ Use of locally developed and refined practices based on plant, animal and microbial source as raw materials.
- ✓ Recycling of naturally available nutrients in fields.
- ✓ There is no need for chemical pesticides because nature has a careful balance that precludes any one species from gaining an advantage.
- ✓ Ramming the soil affects the natural climate of the soil and encourages the growth of weeds. Hence, a no-till farming system is employed.
- ✓ Farmers employ innovative techniques that are always evolving in response to cropping patterns, regional climates, altitude, soil quality, insect and pest intensity and variability, etc

Components of natural farming

Jivamrita: It is a beneficial organic bio stimulant made by fermenting well-rotted cow dung, cow urine, jaggery, and water for around 48 hours. This nutrient-rich liquid fertilizer enhances soil fertility, stimulates microbial activity, and aids plant nutrient absorption, contributing to sustainable agriculture by reducing the need for synthetic inputs.

Bijamrita: Bijamrita is a natural seed treatment solution for crops, prepared by soaking seeds in a mixture of cow dung, water, lime and cow urine. After soaking, the seeds are dried and then sown. This traditional practice is believed to enhance seed germination, protect against diseases, and promote healthy plant growth in an organic and sustainable manner.

Acchadana - Mulching: Subhash Palekar suggests the following types of mulching:

- ✓ **Soil Mulch:** Preserves topsoil during farming and refrains from tilling it. Furthermore, it helps the soil retain water and aerate. Palekar has recommended against deep ploughing.
- ✓ **Straw Mulch:** The dried biomass waste from earlier crops is hinted to by the straw particles. As Palekar indicates, this could consist of the decomposing remains of any living thing, including plants, animals, etc.

Live Mulch (symbiotic intercrops and mixed crops): To provide the necessary elements to the soil and crops, Palekar suggests that it is crucial to construct various cropping patterns of monocoty-ledons and dicotyledons cultivated in the same area

Whapasa - Moisture: Palekar disputes the wide-spread notion that plant roots require a lot of water. He challenges the over-reliance on irrigation in green revolution farming in this way. He firmly believes that water vapour is necessary for the roots. He refers to this as Whapasa, the state in which air and water molecules are present in the soil. He stresses using irrigation just at midday and promotes cutting back on its use.

Plant protection measures: Natural farming emphasizes the use of traditional, organic, and plant-based solutions for pest and disease management. Different “astras” or botanical preparations are utilized for plant protection:

- ✓ **Neemastra:** It is used to eradicate insects or larvae that consume plant foliage and drink plant sap, as well as to prevent or treat diseases. Additionally, this aids in preventing the spread of dangerous insects. Neemastra is a bioinsecticide and pest deterrent for natural farming that is incredibly simple to manufacture.
- ✓ **Agniastra:** Neem leaf pulp, tobacco powder, green chilli powder, garlic paste, and turmeric powder are combined to create a natural insecticide. All sucking pests and caterpillars, such as Leaf Roller, Stem Borer, Fruit Borer, and Pod Borer, are controlled with it.
- ✓ **Brahmastra:** This all-natural insecticide is made from neem, karanj, custard apple, and daphnia leaves, which contain certain alkaloids that deter pests. All sucking pests and concealed caterpillars found in fruit pods are managed by it.
- ✓ **Dashaparni ark:** It serves as an alternative to Agniastra, Bramhastra and Neemastra. Depending on what's available, it's made with tobacco powder, ginger paste, turmeric powder, Asafoetida, chilli pulp, garlic paste, and any ten leaves. We can utilise the leaves of several plants, such as neem, pogoamia pinnata, Annona sqamosa, Castor, Datura, Rui, Hibiscus, mango, lantana camara, and guava. Depending on the extent of the infestation, it is used to control various kinds of pests.
- ✓ **Fungicide:** It is made with cow milk and curd which is found to be very successful in controlling and managing fungal infection.



Major constrains of natural farming

- ✓ Pest and disease management limitations.
- ✓ Lower crop yields compared to conventional methods.
- ✓ Labor-intensive weed control.
- ✓ Transition period with lower yields and added costs.
- ✓ Certification requirements and costs.
- ✓ Need for knowledge and training.
- ✓ Vulnerability to weather fluctuations.
- ✓ Competition with conventional agriculture.

Conclusion

Natural farming could play a major role in sustainable agriculture. It focusses is to farm is to farm in harmony with nature, producing food that is safe and healthy for all to eat and with lower overhead cost, generates a nice profit for the farmers. Although many challenges stand in the way of implementation of natural farming in the large scale.

Natural farming, rooted in ecological balance and organic principles, offers a sustainable and environmentally friendly approach to agriculture. By prioritizing soil and human health, biodiversity, and responsible farming practices, it presents a compelling solution to meet the growing demand for pesticide-free and eco-conscious food, while also benefitting farmers and the environment

Advancing Rice Yield: C_4 Genetic Engineering Challenges and Collaborative Solutions

Hemanth S., Thippeswamy Danakumara, Aavula Naveen, Manoj S. H., Basavaraj A. Dodmani and Uday Kiran M.

Abstract

Challenge with collaborative efforts from diverse institutions and significant funding from the Bill & Melinda Gates Foundation. The study explores the genetic requirements for converting a C_3 into a C_4 plant and discusses various engineering approaches, including mutagenesis, testing C_4 mutants, DNA activation tagging, and omics techniques. While the advantages of the C_4 photosynthetic pathway are highlighted, challenges in commercializing transgenic rice underscore the complexities in bridging anatomical and genetic gaps. This comprehensive overview navigates the intricate intersection of agricultural demands, genetic engineering, and environmental adaptation, emphasizing the pivotal role of photosynthesis in ensuring future food security.

Introduction

Asia stands as the predominant contributor to the world's rice production, currently commanding a 90% share, and each hectare of rice-producing land fulfils the nutritional needs of approximately 27 individuals. However, projecting forward to 2050, the landscape reveals impending challenges arising from population expansion and the rapid encro-achment of urbanization. With this trajectory, each remaining hectare of rice cultivation must adapt to the task of nourishing a minimum of 43 people to accommodate the growing global populace.

This necessitates a compelling imperative: a mandatory surge in yield by a minimum of 50% over the next three decades, a formidable target essential to forestall the spectre of widespread food scarcity (Fig. 1). The gravity of this undertaking is accentuated by the dual pressures of sustaining a burgeoning population and the dwindling availability of arable land due to urban development. Embedded in this challenge is a critical insight from predictive models, proposing that achieving such substantial increases in yield is contingent upon advancements in the complex biological process of photosynthesis.

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These models underscore the pivotal role of manipulating and enhancing photosynthetic efficiency as the linchpin to unlocking the full potential of crop productivity. As we navigate the complex intersection of agricultural demands, population dynamics and evolving land utilization, this emphasis on improving photosynthesis emerges as a key focal point in ensuring future food security (Lin *et al*., 2019).

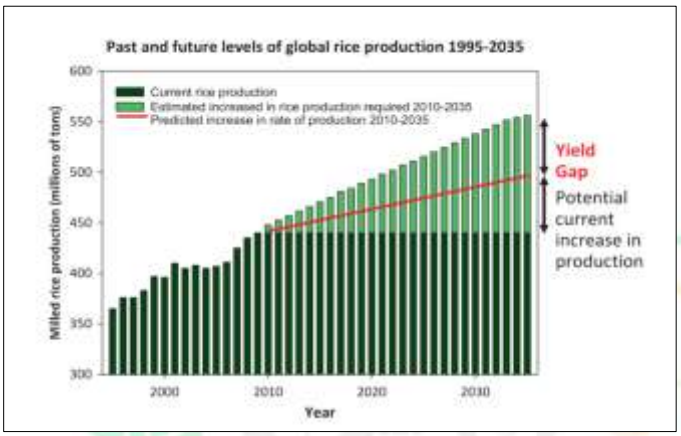


Figure 1: Rice production from 1995 to 2010 and predicted increase in the rate of production required from 2010 to 2035

Evolution of C_3 to C_4 Plants: When plants initially evolved, the issue of photorespiration did not pose a challenge due to the low levels of oxygen (O_2) and the high concentration of carbon dioxide (CO_2) in the environment. As a by-product of photosynthesis, oxygen began accumulating in the atmosphere, gradually reaching the present levels over millions of years. The current atmospheric concentration of oxygen imposes limitations on C_3 photosynthesis. Moreover, photorespiration, a process that reduces the net carbon gain and productivity of C_3 plants by as much as 25%, becomes a significant hindrance. To adapt to these challenges, certain tropical plant species, such as maize and sugarcane, have undergone modifications in leaf anatomy. They evolved a biochemical mechanism known as the "CO_2 pump" or the C_4 photosynthetic pathway (Wang *et al.*, 2017). This pathway concentrates atmospheric CO_2, effectively overcoming the limitations posed by photorespiration and enhancing overall photosynthetic efficiency (Fig. 2).

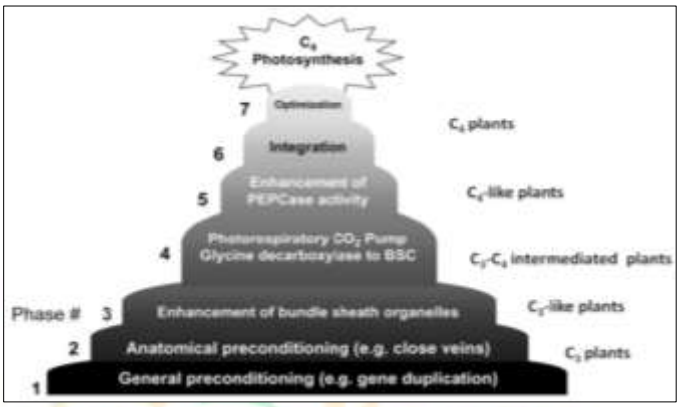


Fig. 2: Evolution of C_4 pathway

What is C4 Rice?

C_4 rice is a genetically modified rice variety that demonstrates a modified C_4 photosynthetic pathway, deviating from the conventional C_3 pathway (Fig. 3). This transformation involves manipulating the anatomy, biochemistry, and physiology of C_3 rice plants through the application of genetic engineering and bioinformatics tools (Ermakova *et al*., 2020).

The C_4 Rice Project: The C_4 Rice Project stands as a significant scientific undertaking, representing one of the 'Grand Challenges' of the 21st Century. Collaborative efforts involve researchers from seven institutions spanning five countries, working together to employ innovative scientific methodologies in the creation of high-yielding rice varieties tailored

for smallholder farmers. A notable contribution to this initiative comes from the Bill & Melinda Gates Foundation, which has granted $15 million to the International Rice Research Institute (IRRI) to support research on C_4 rice. The project is structured around four main phases (Fig. 4).

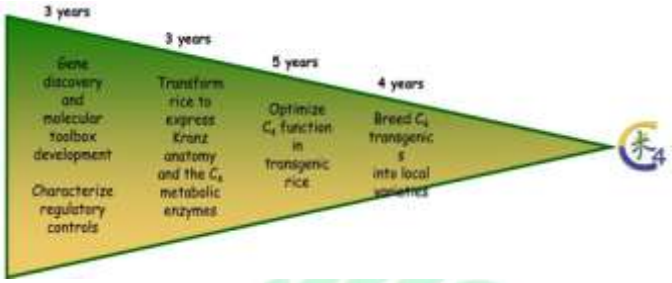


Figure 4: The Timeline for C_4 Rice

The Requirements to convert a C_3 into a C_4: A compartment dedicated to the concentration of CO_2 around Rubisco, a sufficient supply of photosynthetic energy, a reservoir of metabolites and transporters, a specialized system for decarboxylating metabolic intermediates, and maintaining the correct stoichiometry of metabolites to bundle sheath cells, typically at a ratio of 1:1, as observed in C_4 plants.

Approaches for Engineering C_4 Rice

- ✓ **Mutagenesis:** It is a technique that induces changes in the genetic material (DNA) of an organism to create variations. In the context of C_4 rice research, mutagenesis is employed to generate mutants for testing and understanding their impact on the C_4 photosynthetic pathway (Kajala *et al.*, 2011).
- ✓ **Testing C_4 Mutants:** It involves evaluating the characteristics and traits of mutants created through mutagenesis. In C_4 rice research, testing C_4 mutants helps uncover insights into the genetic factors influencing the efficiency of the C_4 photosynthetic pathway.
- ✓ **Rice DNA Activation Tagging:** DNA activetion tagging is a genetic engineering method where specific DNA elements are introduced to enhance the expression of nearby genes in rice. This technique aids in understanding gene functions and improving desired traits.
- ✓ **OMICS:** it refers to comprehensive studies analysing biological molecules on a large scale. In C_4 rice research, techniques like microarrays and transcriptome analysis under the OMICS umbrella provide insights into gene expression patterns and molecular processes.
- ✓ **Microarrays:** Tools used for analysing the expression levels of thousands of genes simultaneously. In C_4 rice research, microarrays help researchers understand the complex gene regulatory networks involved in the C_4 photosynthetic pathway.
- ✓ **Transcriptome Analysis:** It involves studying the complete set of RNA transcripts in a cell or tissue. In the context of C_4 rice research, this provides valuable information on gene expression patterns related to the C_4 photosynthetic pathway.
- ✓ **Epigenetics:** It explores changes in gene expression or phenotype that do not involve alterations to the DNA sequence. In C_4 rice research, histone modification and miRNA (microRNA) are studied as epigenetic mechani-

sms influencing gene regulation and expression.

Advantages of C_4 photosynthetic pathway: Enhance rice yield by 50%, double water-use efficiency, optimize nitrogen use efficiency, boost radiation use efficiency by 50%, exhibit a higher rate of CO_2 assimilation than C_3 plants, demonstrate minimal photorespiration in contrast to C_3 plants, and display superior adaptability to environmental stress compared to C_3 plants.

Limitations: Achieving the commercialization of transgenic rice remains challenging in the current era. The research on C_4 rice proves to be a costly and labor-intensive endeavor due to the considerable disparity in anatomy and genetics between C_3 and C_4 rice. While certain modifications in the photosynthetic apparatus have been documented in transgenic varieties, there is a notable absence of significant direct enhancements in the photosynthesis rate, with observed alterations primarily limited to changes in stomatal conductance.

Conclusion

The evolving global landscape, marked by population growth and urbanization, underscores the urgency of enhancing rice yield and resilience. The genetic transformation to C_4 rice, though promising, faces hurdles in commercialization, primarily due to the intricate anatomy and genetic disparities. Despite recorded modifications in photosynthetic processes, direct improvements in photosynthesis rates in transgenic varieties remain elusive. The collaborative efforts, fuelled by the Bill & Melinda Gates Foundation, reflect a crucial step forward, emphasizing the imperative role of advanced genetic engineering in securing future food security.

References

Bin Rahman, A. R. and Zhang, J. (2023). Trends in rice research: 2030 and beyond. *Food and Energy Security*, 12(2): e390.

Ermakova, M., Danila, F. R., Furbank, R. T. and von Caemmerer, S. (2020). On the road to C_4 rice: advances and perspectives. *The Plant Journal*, 101(4): 940-950.

Kajala, K., Covshoff, S., Karki, S., Woodfield, H., Tolley, B. J., Dionora, M. J. A., ... and Quick, W. P. (2011). Strategies for engineering a two-celled C_4 photosynthetic pathway into rice. *Journal of Experimental Botany*, 62(9): 3001-3010.

Lin, Z., Yan, J., Su, J., Liu, H., Hu, C., Li, G., ... and Lin, Y. (2019). Novel OsGRAS19 mutant, D26, positively regulates grain shape in rice (*Oryza sativa*). *Functional Plant Biology*, 46(9): 857-868.

Wang, S., Tholen, D. and Zhu, X. G. (2017). C4 photosynthesis in C_3 rice: a theoretical analysis of biochemical and anatomical factors. *Plant, Cell & Environment*, 40(1): 80-94.

Organic Farming: An Effective Master Mind

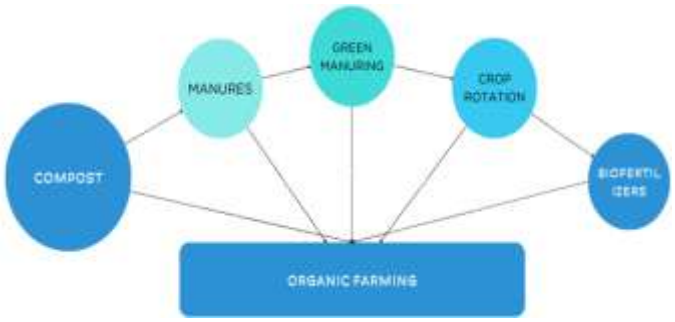
B. Subhash

Organic farming an efficient agricultural process that uses biologically processed fertilizer and controls the pest and disease which causes a drastic yield loss for most of the economical benefitting crops through the end products obtained from animal and plant waste. The main concern of opting for organic farming is to enhance or regenerate the lost soil nutritive compositions naturally by adding natural components like panchagavya, green leaves, biofertilizers etc., and to reduce the accumulation of chemical pesticides and also the synthetic fertilizers. There are 5 main types of green manuring and are as follows: compost, manures, green manuring, crop rotation & biofertilizers. Rather then adding other elements as a green manuring component these five component above mentioned acts as an effective soil enriching component. There are various types of composts which effectively enriches the soil nutritiity and productivity which have has a combination of food waste elements like fruits and vegetable scraps, crushed egg shells, paper tea bags without staples which consists of 0.5 % of N, 0.25 P_2O_5 and 0.5% K_2O which is obtained naturally without adding a singe amount of synthetic or chemical fertilizers or bio fertilizers. The next major component is manures. In these manures which contains rich concentration of Nitrogen, Phosphrous (P) & Potassium (K) as well as micronutrients such as Copper (Cu), Manganese (Mn) and Zinc (Zn). The major form of manures are present in the form of Common Farm Yard Manures (FYM) which are obtained from the animals such as Cow, Horse, Pig, Chicken, Sheep and Rabbit. The nitrogen and potassium content of the above-mentioned animals are enlisted below:

Manures	Nitrogen (%)	Potassium (%)
Cow manure	0.6%	0.5%
Horse Manure	0.7%	0.6%
Pig manure	0.8%	0.5%
Chicken manure	1.1%	0.5%
Sheep manure	0.7%	0.9%
Rabbit manure	2.4%	0.6%

The next compound in the organic manure is Green Manuring. These cropping and grazing green manures include harvesting field beans, saving a hay crop, grazing red clover or making silage from a cereal/ legume mixture. And these green manuring mixtures contains of about 2.83% of Nitrogen (N), 3.51 % Phosporous (P) and 2.76% Potassium (K). The yield which we obtain by using this green manuring has rich content of foliage and nutritious value which can be consumed by various cattle animals and few by our humans. The next major component comes under organic farming practice is Biofertilizers which plays a vital role for formation of initial nodes during its germination phases. And it acts as the base material for roots and further shoot initiations also. There are various biofertilizers which has the highest germinations percentage (%).

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The biofertilizers are classified into 3 types. i.e.,

Bacterial Biofertilizers: Rhizobium, Azospirillum, Azotobacter & Phospobacteria.

Fungal Biofertilizers: Mycorrhiza.

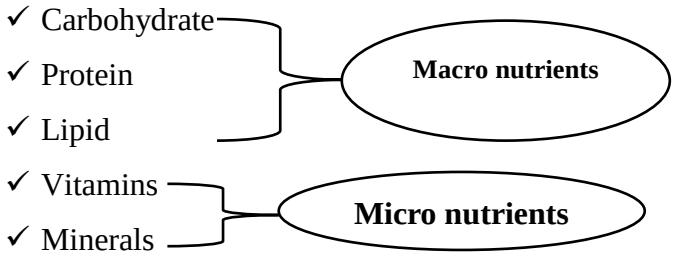
Algal Biofertilizer: Blue Green Algae (BGA) and Azolla.

Efficient Methods of Nitrogen Estimation

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Introduction

Nutrients are at the base of nutrition can be grouped into five major group:



Appropriate feed intake ensures sufficient supply of nutrient. It is therefore important to analyse the composition of some feed for proper nutrient supply to concern animal for proper growth and life maintenance.

Analysis of carbohydrate

✓ **Titration methods:** The Lane-Eynon method is an example of a tritration method of determining the concentration of reducing sugars in a sample. A burette is used to add the carbohydrate solution being analyzed to a flask containing a known amount of boiling copper sulfate solution and a methylene blue indicator. The reducing sugars in the carbohydrate solution react with the copper sulfate present in the flask. Once all the copper sulfate in solution has reacted, any further addition of reducing sugars causes the indicator to change from blue to white. The volume of sugar solution required to reach the end point is recorded. The reaction is not stoichiometric, which means that it is necessary to prepare a calibration curve by carrying out the experiment with a series of standard solutions of known carbohydrate concentration.

✓ **Gravimetric methods:** The Munson and Walker method is an example of a gravimetric method of determining the concentration of reducing sugars in a sample. Carbohydrates are oxidized in the presence of heat and an excess of copper sulfate and alkaline tartrate under carefully controlled conditions, leading to a copper oxide precipitate. Reducing sugar + Cu^{2+} + base ⟶ Oxidized sugar + CuO_2 (precipitate)

✓ **Colorimetric methods:** The Anthrone method is an example of a colorimetric method of determining the concentration of the total sugars in a sample. Sugars react with the anthrone reagent under acidic conditions to yield a blue-green color. The sample is mixed with sulfuric acid and the anthrone reagent and then boiled until the reaction is completed. The solution is then allowed to cool and its absorbance is measured at 620 nm. There is a linear relation-ship between the absorbance and the amount of sugar that was present in the original sample. This method determines both reducing and non-reducing sugars because of the presence of the strongly oxidizing sulfuric acid.

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Analysis of protein

- ✓ **Biuret method:** A violet-purplish color is produced when cupric ions (Cu^{2+}) interact with *peptide bonds* under alkaline conditions. Biuret reagent is mixed with a protein solution and then allowed to stand for 15-30 minutes before the absorbance is read at 540 nm. The major advantage of this technique is that there is no interference from materials that adsorb at lower wavelengths, and the technique is less sensitive to protein type because it utilizes absorption involving peptide bonds that are common to all proteins, rather than specific side groups. However, it has a relatively low sensitivity compared to other UV-visible methods.
- ✓ **Lowry method:** The Lowry method combines the biuret reagent with another reagent (the Folin-Ciocalteau phenol reagent) which reacts with tyrosine and tryptophan residue in proteins. This gives a bluish color which can be read somewhere between 500-750 nm depending on the sensitivity required. There is a small peak around 500 nm that can be used to determine high protein concentrations and a large peak around 750 nm that can be used to determine low protein concentrations. This method is more sensitive to low concentrations of proteins than the biuret method.
- ✓ **Turbidimetric method:** Protein molecules which are normally soluble in solution can be made to precipitate by the addition of certain chemicals, *e.g.,* trichloroacetic acid. Protein precipitation causes the solution to become turbid. Thus the concentration of protein can be determined by measuring the degree of turbidity.

Analysis of lipid

- ✓ **Soxhlet method:** Crude fat content is determined by extracting the fat from the sample using a solvent (petroleum ether), then determining the weight of the fat recovered. The sample is contained in a porous thimble that allows the solvent to completely cover the sample. The thimble is contained in an extraction apparatus that enables the solvent to be recycled over and over again. This extends the contact time between the solvent and the sample and allows it time to dissolve all of the fat contained in the sample.
- ✓ **Iodine value:** The iodine value (*IV*) gives a measure of the average degree of unsaturation of a lipid: the higherv the iodine value, the greater the number of C=C double bonds. By definition the iodine value is expressed as the grams of iodine absorbed per 100 g of lipid. One of the most commonly used methods for determining the iodine value of lipids is “Wijs method”. The lipid to be analyzed is weighed and dissolved in a suitable organic solvent, to which a known excess of iodine chloride is added.
- ✓ **Saponification number:** The saponification number is a measure of the average molecular weight of the triacylglycerols in a sample. Saponification is the process of breaking down a

neutral fat into glycerol and fatty acids by treatment with alkali. The saponification number is defined as the mg of KOH required to saponify one gram of fat. The lipid is first extracted and then dissolved in an ethanol solution which contains a known excess of KOH. The smaller the saponification number the larger the average molecular weight of the triacy-lglycerols present.

Analysis of Minerals

- ✓ **Gravimetric methods:** The element to be analyzed is precipitated from solution by adding a reagent that reacts with it to form an insoluble complex with a known chemical formula. The precipitate is separated from the solution by filtration, rinsed, dried and weighed. The amount of mineral present in the original sample is determined from a knowledge of the chemical formula of the precipitate. For example, the amount of chloride in a solution can be determined by adding excess silver ions to form an insoluble silver chloride precipitate, because it is known that Cl is 24.74% of AgCl.
- ✓ **Colorimetric methods:** Colorimetric methods are used to determine the concentration of a wide variety of different minerals. Vandate is often used as a colorimetric reagent because it changes color when it reacts with minerals. For example, the phosphorous content of a sample can be determined by adding a vandate-molybdate reagent to the sample. This forms a colored complex (yellow-orange) with the phosphorous which can be quantified by measuring the absorbance of the solution at 420nm, and comparing with a calibration curve. Different reagents are also available to colorimetrically determine the concentration of other minerals.
- ✓ **Titration methods**
  - **EDTA complexiметric titration:** EDTA is a chemical reagent that forms strong complexes with multivalent metallic ions. The disodium salt of EDTA is usually used because it is available in high purity. The calcium content of a food sample is determined by comparing the volume of EDTA required to titrate it to the end-point with a calibration curve prepared for a series of solutions of known calcium concentration.
  - **Precipitation titration:** A titrimetric method commonly used in the food industry and the *Mohr* method is used for chloride analysis. Silver nitrate is titrated into an aqueous solution containing the sample to be analyzed with a chromate indicator. The end point of the reaction is the first hint of an orange color. The volume of silver nitrate solution (of known molarity) required to reach the endpoint is determined, and thus the concentration of chloride in solution can be calculated.

Analysis of Vitamins

- ✓ **HPLC methods:** Reversed-phase HPLC is a well-suited technique for vitamin analysis. In typical regulated HPLC methods and commonly reported HPLC methods, water-soluble vitamins

are determined using an aqueous mobile phase with low-organic solvent content, whereas fat-soluble vitamins are determined using organic solvent mobile phases. Commonly used buffers for the separation of water-soluble vitamins are phosphate, formic acid, and acetic acid. Non-aqueous reversed-phase (NARP) retention is commonly used for fat-soluble vitamins so that the vitamins are soluble throughout the analysis. A typical NARP mobile phase consists of a polar solvent (acetonitrile), a solvent with lower polarity (e.g., dichloromethane) to act as a solubilizer and to control retention by adjusting the solvent strength, and a third solvent with hydrogen bonding capacity (e.g., methanol) to optimize selectivity. Based on HPLC method for the analysis of vitamins in a dry syrup (powder mixtures that require reconstitution in water before administration), a method was tested with two injections during the same analysis (injecting the extracts for water- and fat-soluble vitamins, respectively. This double-injection method can resolve the problem of inefficient analyses of multivitamin tablet samples; however, some strongly retained compounds from the first injection can interfere with the fat-soluble vitamin analysis in the second injection. For example, some fat-soluble vitamins (such as ß-carotene and acetate of vitamin A and vitamin E) were found in the extract of water-soluble vitamins. To avoid possible interferences with fat-soluble vitamin determination, an integrated and efficient dual-mode tandem solution for the simultaneous determination of water- and fat-soluble vitamins in different types of samples, such as multivitamin tablets and beverages, was developed.

References

Meat technology-information sheet, Crude fiber determination - Soxhlet method, 2006.

Thermo fisher scientific, Determination of water- and fat-soluble vitamins by HPLC, 2017.

https://people.umass.edu/~mcclemen/581Carbohydrates.html#:~:text=Thin%20layer%20chromatography%20(TLC)%2C,to%20separate%20and%20identify%20carbohydrates.

Hybridoma Technology: An Overview

Ashutosh Danve, Yash Khalasi and Elina Jose Vettom

Abstract

The technique of hybridoma technology, introduced by Kohler and Milstein in 1975, revolutionized the generation of monoclonal antibodies (mAbs), providing a continuous supply of antibodies with consistent specificity. This method involves fusing immortal myeloma cells with antibody-producing B cells, resulting in hybridomas capable of perpetual growth and mAb production. The historical context spans from Littlefield's seminal work in 1964 to the Nobel Prize-winning discovery by Kohler, Milstein, and Jerne in 1984. The fundamental principle involves the immortalization of B cells via fusion with myeloma cells, yielding hybridomas and mAbs. Operational steps encompass cell fusion, selection, and the screening of optimal cell lines. Hybridoma technology offers notable advantages, including large-scale production of specific antibodies vital for therapeutic and diagnostic purposes. However, it presents challenges such as time intensiveness, cost, and the risk of contamination. Furthermore, concerns arise from the murine origin of antibodies, potentially leading to disease transmission to humans. Despite these constraints, hybridoma technology remains pivotal in biomedical research and clinical applications, significantly contributing to disease management and diagnostics.

Introduction

A technique to generate continuous supply of monoclonal antibodies. Hybridoma is a fusion of two cells - myeloma (plasma cell tumor) cells and splenic B cells.Takes advantage of the unlimited growth capacity of myeloma cells and cellular machinery to produce antibodies of uniform antigenic specificity of B cells.

The antibodies of uniform specificity produced by a clone of a B cell against a single antigenic determinant or a hapten are called as Monoclonal Antibodies (mAbs). Monoclonal antibodies are produced by Hybridoma Technology developed by Kohler and Milstein in 1975 at Oxford University. On contrary, sum of total antibodies produced by clones of different B cells against all antigenic determinants of a multivalent antigen are called as polyclonal antibodies. Following natural infection or vaccination against a pathogen, polyclonal antibodies are produced in vivio, which are measured quantitatively by various serological tests.

History

- ✓ **1964:** Littlefield developed a way to isolate hybrid cells from 2 parent cell lines using the hypoxanthine-aminopterin-thymidine (HAT) selection media.
- ✓ **1975:** Hybridoma technology was first discover-

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ed by Georges Kohler and Cesar Milstein They were also awarded Nobel Prize along with Niels Kaj Jerne in Physiology & Medicine field during 1984.

- ✓ **1990:** Milstein produced the first Monoclonal antibodies.

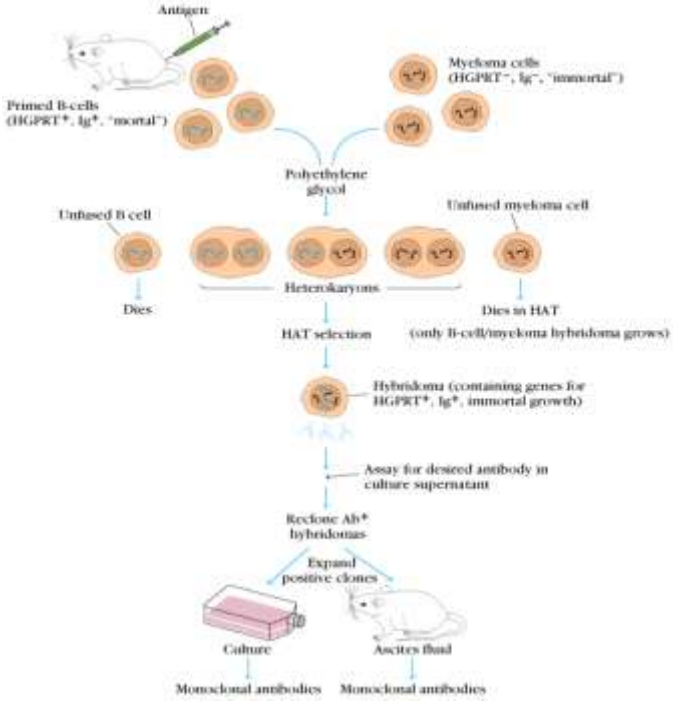
Principle: Normal B lymphocyte produced antibody of a single specificity but can't grow indefinitely. So it is necessary to immortalize B cells that produce a specific antibody. This is achieved by cell fusion of somatic cell hybridization between a normal antibody producing B cell and a myolema cell. Such fusion derived immortalized antibody producing cell lines are called hybridomas and the antibodies they produced are monoclonal antibodies.

Steps

- ✓ Fusion between myeloma cells, which are immortal, do not produce hypoxanthine-guanine phosphoribosyl transferase (HGPRT-), and spleen cells, which are HGPRT+, mortal, and secretes antibodies.
- ✓ Fusion is achieved by incubating a suspension of two cell types with a fusogenic agents like inactivated Sendai virus or polyethylene glycol (PEG).
- ✓ In the process of cell fusion, first the cell membrane and cytoplasm of the two cells become confluent keeping the two nuclei intact known as heterokaryons. Some heterokaryons become hybrid upon fusion of nuclei.
- ✓ Only a small number of cells actually fused. So in the culture mixture of unfused cells (B cell, Myeloma cells), fused with like cell (B cell - B cell, myolema - myolema) and B Cell-myeloma fusion product obtained.
- ✓ The cells are transferred into HAT medium (hypoxanthine, aminopterin and thymidine) where only fused B cell-myeloma cells are survived. This antibody secreting cells are immortal for the continuous production of monoclonal antibody in cell culture.

Basic protocol for production of monoclonal antibodies from hybrid myelomas

- ✓ Immunisation of a mouse.
- ✓ Isolation of B cells from the spleen.
- ✓ Cultivation of myeloma cells.
- ✓ Fusion of myeloma and B cells.
- ✓ Separation of cell lines.
- ✓ Screening of suitable cell lines.
- ✓ Multiplication (a) *in vitro* (b) or *in vivo*
- ✓ Harvesting



Advantages

Hybridoma Technology has many advantages some of them are mentioned. Hybridoma technology gives a large quantity of pure and specific antibodies thus an unlimited and large number of monoclonal antibodies can be produced that bind to a single epitope of an antigen. Hybridoma technology is an appropriate method in the production of monoclonal antibodies which are used in chemotherapeutics to treat cancer. Monoclonal antibodies produced by Hybridoma technology can be used for disease treatments and diagnosis purposes as well. Hybridoma technology is also useful in the differentiation between two strains of a single pathogen.

Disadvantages

Hybridoma technology also have some drawbacks such as it is a time-consuming process and an expensive method to execute and poses high risk of contamination One of the big disadvantages of this technique is that it can transfer disease from mice to humans Besides the antibodies produced in this technology are of mouse origin that's why even after purification there is no guarantee that the produced monoclonal antibodies are virus free.

References

Pandey, S. (2010). Hybridoma technology for production of monoclonal antibodies. *Hybridoma*, 1(2); 017.

Zhang, C. (2012). Hybridoma technology for the generation of monoclonal antibodies. *Antibody Methods and Protocols*, pp. 117-135.

Betsy, C. J. and Siva, C. (2023). Hybridoma Technology. In Fisheries Biotechnology and Bioinformatics (pp. 91-95).

Bartley, D. M., Rana, K. and Immink, A. J. (2000). The use of inter-specific hybrids in aquaculture and fisheries. *Reviews in Fish Biology and Fisheries*, 10: 325-337.

Mitra, S. and Tomar, P. C. (2021). Hybridoma Technology; Advancements, Clinical Significance, and Future Sspects. *Journal of Genetic Engineering and Biotechnology*, 19: 159.

Precision Aquaculture: Integrating Technology for Enhanced Production and Sustainability

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Abstract

Precision aquaculture integrates advanced technologies such as real-time monitoring, data analytics, automation, and targeted interventions to optimize production processes and minimize environmental impact in the aquaculture industry. Recent advancements in sensor technology enable precise monitoring of water quality parameters such as temperature, dissolved oxygen, pH, and nutrient levels, allowing for proactive management of aquaculture systems. Remote sensing and satellite imagery provide valuable insights into farm conditions and help detect anomalies such as algal blooms or temperature variations, facilitating timely interventions. Data analytics and artificial intelligence play a crucial role in processing large datasets generated by aquaculture operations, enabling data-driven decision-making for improved productivity and efficiency. Automation and robotics streamline tasks such as feeding, harvesting, and farm maintenance, reducing labour requirements and operational costs while ensuring consistent and precise management practices. Overall, precision aquaculture offers significant opportunities for enhancing production efficiency, environmental sustainability, and economic resilience in the aquaculture sector. Continued research and innovation are essential for addressing challenges and maximizing the potential of precision aquaculture to meet the growing demand for seafood while minimizing its environmental footprint.

Introduction

Aquaculture stands as a pivotal component in addressing the escalating global demand for seafood. With the world's population anticipated to reach 9.7 billion by 2050, accompanied by an increased preference for protein-rich diets, sustainable seafood production becomes paramount (FAO, 2020; World Bank, 2019). Precision aquaculture emerges as a transformative approach to aquaculture management, integrating cutting-edge technologies, data analytics, and tailored management practices to optimise production efficiency, minimise environmental impacts, and ensure economic sustainability (Pedersen *et al.*, 2021). Precision aquaculture enables farmers to make data-driven decisions, adapt to changing environmental conditions, and maximise resource utilisation by harnessing real-time monitoring systems, remote sensing technologies, and automated feeding systems. Precision aquaculture allows for precise monitoring of environmental parameters such as water quality, temperature, dissolved oxygen levels, and feeding behaviour. By maintaining optimal conditions for growth and health, farmers can achieve higher yields

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and improve the overall quality of their produce. Through targeted interventions and resource management strategies, precision aquaculture minimizes the ecological footprint of aquaculture operations. Precision aquaculture mitigates the risk of water pollution, habitat degradation, and eutrophication by reducing excess feed, nutrient waste, and chemical inputs. Early detection and prevention of diseases are critical for maintaining the health and welfare of farmed fish. Precision aquaculture employs advanced monitoring techniques, such as underwater cameras and sensors, to identify signs of stress or disease outbreaks. This enables farmers to implement timely interventions, such as adjusting stocking densities or administering targeted treatments, to prevent the spread of pathogens and minimize losses. By optimising production efficiency and minimising operational costs, precision aquaculture enhances the economic viability of aquaculture enterprises. Through improved feed conversion ratios, reduced mortality rates and enhanced market value, precision aquaculture offers farmers a competitive edge in the global seafood market.

Precision aquaculture represents a paradigm shift in the way aquaculture is practised, offering a holistic approach to sustainable seafood production. By leveraging technology, data analytics, and innovative management practices, precision aquaculture holds the potential to revolutionise the aquaculture industry, ensuring the long-term viability of seafood production while safeguarding the health of our oceans and ecosystems.

Precision Aquaculture

Precision aquaculture is an advanced approach to fish farming that integrates cutting-edge technologies and data-driven methodologies to optimize production efficiency, minimize environmental impact, and ensure economic sustainability. This concept encompasses four key components: real-time monitoring, data analytics, automation, and targeted interventions.

Real-time monitoring involves the continuous collection of data from various sensors and monitoring devices deployed within aquaculture systems (Pedersen *et al.*, 2021). These sensors measure critical parameters such as water quality indicators (e.g., temperature, pH, and dissolved oxygen levels), fish behaviour, feeding patterns, and environmental conditions. By capturing data in real-time, farmers can gain valuable insights into the health, performance, and behaviour of their fish populations.

Data analytics plays a pivotal role in processing and analysing the vast amounts of data generated by real-time monitoring systems (Pedersen *et al.*, 2021). Advanced analytics techniques, including machine learning algorithms and predictive modelling, are employed to identify patterns, trends, and correlations within the data. By harnessing the power of data analytics, farmers can make informed decisions, optimize production processes, and enhance overall farm productivity. Automation is another fundamental component of

precision aquaculture, enabling the automation of various farm operations and processes (Pedersen *et al*., 2021). Automated feeding systems, for example, can dispense feed at precise intervals and quantities based on predefined feeding schedules or real-time observations of fish behaviour. Similarly, automated water quality monitoring systems can adjust water parameters (e.g., aeration, filtration) in response to changing environmental conditions, ensuring optimal conditions for fish growth and health.

Targeted interventions refer to the implementation of specific actions or treatments based on insights derived from real-time monitoring and data analytics. These interventions may include adjusting feed formulations, modifying stocking densities, administering vaccines or medications, or implementing environmental management practices. By tailoring interventions to address specific challenges or opportunities identified through data analysis, farmers can optimize production outcomes and mitigate risks associated with disease outbreaks, environmental variability, or suboptimal conditions.

Technological innovations

Sensor technology: Recent advancements in technology have revolutionized the field of aquaculture, enabling precise monitoring and management of water quality parameters through the use of sensor technology. Sensors play a crucial role in providing real-time data on key water quality parameters such as temperature, dissolved oxygen (DO), pH, and salinity, allowing aquaculture operators to optimize conditions for fish growth and health. One of the notable advancements in sensor technology is the development of multi-parameter sensors capable of simultaneously measuring multiple water quality parameters with high accuracy and reliability (Nguyen *et al*., 2019). These sensors utilize advanced sensing elements and signal processing algorithms to detect and quantify various parameters in real-time, providing comprehensive insights into the aquatic environment. Optical sensors utilize light-based detection mechanisms to measure parameters such as DO and pH. Fluorescence-based DO sensors, employ fluorescent dyes that change intensity in response to variations in DO concentration, allowing for precise DO measurements (Kole *et al*., 2019). Similarly, pH sensors utilize pH-sensitive dyes or electrodes to detect changes in pH levels, enabling continuous monitoring of water acidity.

Another significant advancement is the miniaturization of sensors, enabling their integration into compact and portable monitoring devices suitable for deployment in aquaculture systems (Dhivya *et al*., 2021). These miniaturized sensors offer advantages such as ease of installation, reduced maintenance requirements, and enhanced scalability, making them ideal for use in aquaculture settings where space may be limited.

Furthermore, wireless sensor networks (WSNs) have emerged as a powerful tool for remote monitoring of water quality parameters in aquaculture ponds and facilities (Dhivya *et al*., 2021). WSNs consist of interconnected sensor nodes equip-

ped with wireless communication capabilities, allowing for seamless data transmission and real-time monitoring across large-scale aquaculture operations. This enables aquaculture operators to remotely monitor water quality conditions and respond promptly to any deviations or anomalies. In addition to traditional water quality parameters, advancements in sensor technology have also enabled the monitoring of emerging contaminants such as harmful algal blooms (HABs) and waterborne pathogens (Kole *et al.*, 2019). Advanced sensors equipped with specific detection mechanisms can identify and quantify HABs and pathogens, helping aquaculture operators implement timely interventions to mitigate risks to fish health and production.

Remote sensing and satellite imagery: Remote sensing and satellite imagery have emerged as valuable tools for monitoring farm conditions and detecting anomalies in aquaculture systems. These technologies offer a wide range of applications, including monitoring water quality, assessing habitat conditions, and detecting environmental changes over large spatial scales.

One of the key advantages of remote sensing and satellite imagery is their ability to provide comprehensive coverage of aquaculture farms and surrounding areas, enabling efficient monitoring of farm conditions without the need for extensive fieldwork (Kääb *et al.,* 2012). Satellite sensors capture images of the Earth's surface in various spectral bands, allowing for the detection of physical and biological parameters relevant to aquaculture management. Multispectral and hyperspectral sensors can be used to monitor water quality parameters such as chlorophyll concentration, turbidity, and dissolved organic matter content (Khan *et al.*, 2020). By analysing spectral signatures in satellite images, researchers and aquaculture operators can assess the health and productivity of aquatic ecosystems and identify potential sources of pollution or environmental stress. Furthermore, remote sensing technologies enable the detection of anomalies and changes in farm conditions that may indicate environmental risks or operational challenges. Changes in water temperature or surface reflectance patterns can signal the presence of algal blooms or nutrient imbalances in aquaculture ponds (Jiang *et al.*, 2019). Similarly, variations in vegetation indices derived from satellite imagery can indicate changes in habitat conditions or land use practices near aquaculture facilities.

In addition to monitoring environmental parameters, remote sensing data can be integrated with geographic information systems (GIS) and machine learning algorithms to develop predictive models for aquaculture management. These models can forecast water quality trends, identify optimal sites for aquaculture development, and support decision-making processes to optimize farm productivity and sustainability.

Data analytics and artificial intelligence (AI): Data analytics and artificial intelligence (AI) play crucial roles in processing large datasets and making

data-driven decisions in aquaculture. These technologies enable aquaculture operators to extract valuable insights from vast amounts of data collected from various sources, including sensors, satellite imagery, and manual observations. Data analytics involves the use of statistical methods, machine learning algorithms, and computational techniques to analyse and interpret data (Srivastava *et al.*, 2020). In aquaculture, data analytics can be used to identify patterns, trends, and correlations within datasets related to water quality, fish health, feeding behaviour, and environmental conditions. By applying advanced analytics techniques, aquaculture managers can gain a deeper understanding of complex relationships and optimize production processes accordingly.

Artificial intelligence, particularly machine learning algorithms, enhances data analytics capabilities by enabling computers to learn from data, identify patterns, and make predictions or decisions without explicit programming (Chen *et al*., 2018). In aquaculture, AI-powered systems can analyse historical data to develop predictive models for factors such as water quality dynamics, disease outbreaks, and fish growth rates. These models can then be used to forecast future trends, optimize feeding schedules, and mitigate risks associated with environmental variability. AI-driven decision support systems can assist aquaculture managers in making real-time, data-driven decisions to optimize production efficiency and resource utilization. AI algorithms can analyse sensor data in real-time to detect anomalies in water quality parameters or fish behaviour, triggering automated interventions such as adjusting feeding rates or activating water treatment systems (Wang *et al*., 2020).

Automation: Automation and robotics have revolutionized various aspects of aquaculture, particularly in feeding, harvesting, and farm maintenance tasks. These technologies offer increased efficiency, precision, and consistency in aquaculture operations, leading to improved productivity and reduced labour costs. In feeding operations, automated feeding systems utilize sensors and algorithms to dispense feed according to predetermined schedules or real-time data on fish behaviour and growth. These systems ensure accurate feeding quantities and timings, minimizing feed wastage and optimizing feed conversion ratios. Harvesting processes in aquaculture often require precision and speed to minimize stress on the fish and maintain product quality. Robotic systems equipped with cameras, sensors, and manipulators can automate the sorting, grading, and harvesting of fish, enhancing efficiency and reducing manual labour requirements. Additionally, automation plays a vital role in farm maintenance tasks such as water quality management, pond cleaning, and equipment maintenance. Autonomous vehicles and drones equipped with sensors and cameras can monitor water quality parameters, detect anomalies, and perform tasks such as algae removal or sediment dredging (Garcia *et al*., 2020).

Benefits of Precision Aquaculture

Precision aquaculture offers numerous potential benefits that can revolutionize the aquaculture industry, leading to improved efficiency, sustainability, and profitability. One of the primary advantages of precision aquaculture is the enhancement of production efficiency and resource utilization. By employing technologies such as real-time monitoring, data analytics, and automation, aquaculture operations can optimize feeding schedules, water quality management and environmental conditions tailored to the specific needs of the cultured species. This precision management allows for maximized growth rates, reduced feed conversion ratios, and optimized stocking densities, ultimately leading to increased yields per unit area or volume (Bergheim *et al*., 2018).

Moreover, precision aquaculture contributes to enhanced environmental sustainability by minimizing waste and pollution. By precisely controlling feeding regimes and monitoring water quality parameters, aquaculture operations can minimize excess feed input and nutrient discharge, reducing the risk of eutrophication and environmental degradation in surrounding water bodies. Additionally, advanced waste treatment technologies, such as recirculating aquaculture systems (RAS) and bio filtration, enable the efficient removal of organic matter and nitrogenous compounds from wastewater, ensuring minimal environmental impact.

Another significant benefit of precision aquaculture is the mitigation of disease outbreaks and improved health management practices. Real-time monitoring of water quality parameters and fish behaviour allows for the early detection of disease symptoms and environmental stressors, enabling prompt intervention and disease prevention measures. Furthermore, advancements in genetics and selective breeding programs can produce disease-resistant strains of cultured species, reducing the reliance on antibiotics and chemical treatments for disease control (Hansen *et al*., 2021).

Furthermore, precision aquaculture has the potential to increase the profitability and economic resilience of aquaculture operations. By optimizing production processes and reducing input costs, such as feed and energy consumption, aquaculture businesses can improve their bottom line and withstand market fluctuations and external shocks. Additionally, the implementation of precision aquaculture technologies can enhance product quality and consistency, leading to higher market value and customer satisfaction.

Challenges and opportunities

Precision aquaculture, while offering promising benefits, faces several challenges and limitations that hinder its widespread adoption and implementation. One significant challenge is the high initial investment costs associated with acquiring and deploying precision aquaculture technologies. The installation of advanced monitoring systems, sensors, automation equipment, and data analytics platforms requires substantial financial resources, which may deter small-scale or resource-constrained aquaculture operations from adopting

these technologies. Data privacy and security concerns present significant barriers to the adoption of precision aquaculture. As aquaculture operations increasingly rely on digital technologies and data-driven decision-making, there is a growing risk of data breaches, cyberattacks, and unauthorized access to sensitive information. Safeguarding proprietary data, trade secrets, and personal information from malicious actors requires robust cybersecurity measures and adherence to strict data protection regulations (Kocaman *et al*., 2021).

Integration with existing farming practices and regulatory frameworks poses another challenge for precision aquaculture. Many aquaculture operations operate within established farming systems, cultural practices, and regulatory environments that may not readily accommodate the adoption of new technologies. Integrating precision aquaculture solutions into traditional farming practices requires overcoming cultural resistance, addressing compatibility issues, and navigating complex regulatory requirements (Bergheim *et al*., 2018).

Despite these challenges, precision aquaculture offers numerous opportunities for research, innovation, and industry collaboration to overcome limitations and drive advancements in the field. Future research efforts can focus on developing cost-effective precision aquaculture technologies that are accessible to a broader range of aquaculture stakeholders. Innovation in sensor technology, data analytics algorithms, and automation systems can help reduce initial investment costs and improve the scalability of precision aquaculture solutions.

Moreover, industry collaboration and knowledge sharing initiatives can facilitate the exchange of best practices, lessons learned, and technical expertise among aquaculture practitioners, technology developers and regulatory agencies. Collaborative research projects, public-private partnerships, and technology demonstration projects can accelerate the adoption of precision aquaculture and address common challenges faced by the industry (Rosenlund *et al*., 2015).

Conclusion

Precision aquaculture holds immense promise for revolutionizing the aquaculture industry by integrating advanced technologies to enhance production efficiency, minimize environmental impact and ensure economic viability. Through real-time monitoring, data analytics, automation, and targeted interventions, precision aquaculture enables precise management of water quality, feed delivery, and fish health, leading to improved productivity and resource utilization. Recent advancements in sensor technology, remote sensing, data analytics, and automation have paved the way for precision aquaculture, offering new tools and methodologies for enhancing farm management practices. While challenges such as high initial investment costs and data privacy concerns exist, continued research, innovation, and industry collaboration are crucial for overcoming these hurdles and unlocking the full potential of precision aquaculture in ensuring sustainable seafood production and safeguarding aq-

uatic ecosystems for future generations.

References

Food and Agriculture Organization (FAO). (2020). The State of World Fisheries and Aquaculture 2020. Rome.

World Bank. (2019). Fish to 2030: Prospects for Fisheries and Aquaculture. Washington, DC.

Pedersen, L.-F., Pedersen, P. B. and Tyson, R. (2021). Precision Aquaculture: Precision Feeding in Fish Farming. In Y. Rui, Y. Wang, & H. J. Hou (Eds.), Big Data in Aquaculture (pp. 87-105). Academic Press.

Dhivya, B., Jayaraman, R. and Sangeetha, D. (2021). Smart Sensors for Aquaculture. In P. Arumugam, R. Thirumurugan and R. Palanivel (Eds.), Smart Aquaculture (pp. 139-156). Springer.

Kole, P., Ramachandran, S., Naik, B. and Bhushan, S. (2019). Optical Sensors in Aquaculture. In B. S. Chandel, P. K. Dadheech and B. Ramkumar (Eds.), Optical Sensors (pp. 357-370). Springer.

Nguyen, T. V., Wongsai, W., Truong, T. X. and Tuantranont, A. (2019). Advances in Optical Sensors for Aquaculture Applications. In T. Tuantranont, K. H. Lim and A. Tuantranont (Eds.), Optical Fiber Sensors for Aquatic Environments (pp. 23-52). Springer.

Jiang, H., Li, C. and Zhao, X. (2019). Detection of Aquaculture Algae Bloom Based on Sentinel-2A Satellite Image. *Journal of Coastal Research*, 87(SP1): 203-208.

Kääb, A., Leinss, S., Gilbert, A., Bühler, Y., Gascoin, S., Evans, S. G., ... and Malz, P. (2012). Massive collapse of two glaciers in western Tibet in 2016 after surge-like instability. *Nature Geoscience*, 5(11): 338-342.

Khan, A., Kabir, A., Rahman, M. H. and Hasan, M. (2020). Remote Sensing in Aquaculture. In M. H. Rahman, A. Rahman and M. J. Alam (Eds.), Aquaculture and the Environment (pp. 91-112). Springer.

Qiu, Y., Song, D., Chen, Y., Huang, J., Gao, F. and Liu, L. (2020). Machine Learning in Aquaculture. In M. H. Rahman, A. Rahman, & M. J. Alam (Eds.), Aquaculture and the Environment (pp. 153-168). Springer.

Chen, X., Guo, T., Li, Y. and Ye, M. (2018). Artificial Intelligence in Aquaculture. In M. H. Rahman, A. Rahman, & M. J. Alam (Eds.), Aquaculture and the Environment (pp. 113-130). Springer.

Srivastava, A., Kumar, A., Gupta, A. and Sharma, S. (2020). Big Data Analytics in Aquaculture. In M. H. Rahman, A. Rahman, & M. J. Alam (Eds.), Aquaculture and the Environment (pp. 131-152). Springer.

Wang, J., Zhang, Y., Liu, D., Zhao, X., Chen, H. and Hu, C. (2020). Artificial Intelligence Applications in Aquaculture. In M. H. Rahman, A. Rahman, & M. J. Alam (Eds.), Aquaculture and the Environment (pp. 169-184). Springer.

Garcia, L. M. T., Korsnes, K., Smistad, G., Sunde, L. M. and Kalleberg, K. T. (2020). Automation in Aquaculture: Drones and Autonomous Underwater Vehicles. In M. H. Rahman, A. Rahman, & M. J. Alam (Eds.), Aquaculture and the Environment (pp. 185-200). Springer.

Zhu, Q., Wei, Q. and Fang, J. (2019). Robotics in Aquaculture: Current Status and Future Perspectives. *Reviews in Fisheries Science & Aquaculture*, 27(3): 379-389.

Bergheim, A., Sunde, L. M., Kalleberg, K. T. and Ulvan, E. M. (2018). Automated Feeding Systems in Aquaculture. In M. H. Rahman, A. Rahman, & M. J. Alam (Eds.), Aquaculture and the Environment (pp. 153-167). Springer.

Hansen, H., Gargan, P. and Rodríguez, C. (2021). Aquaculture and Selective Breeding for Disease Resistance. In M. H. Rahman, A. Rahman, & M. J. Alam (Eds.), Aquaculture and the Environment (pp. 79-94). Springer.

Kocaman, E., Ozcinar, C. and Kucuk, S. (2021). Review on Cybersecurity in Smart Aquaculture Systems: Issues, Challenges, and Solutions. *Computers and Electronics in Agriculture*, 183: 106022.

Rosenlund, G., Skretting, A. and Naylor, R. L. (2015). Feed and fishmeal for aquaculture. In A. E. Farrell & P. L. Kantor (Eds.), Encyclopedia of Agriculture and Food Systems (Vol. 2, pp. 441-453). Academic Press.

Drones: Advanced Technology in Agriculture

Neha Negi and Bharti Gautam

India's economy is based mostly on agriculture. The majority of rural Indians still rely significantly on agriculture as their main source of income. Despite the growing importance of agriculture, the industry is still lagging behind in terms of technical development. The biggest worry is crop failure brought on by unfavourable weather and unchecked pest problems. Drone technology has gained popularity recently in the agricultural industry. Farmers can profit from using drones in a variety of ways, such as higher productivity, increased yields, and lower expenses. There are worries, too, that farmers would be hesitant to use drone technology out of concern for their jobs or a lack of understanding and training. This new technology can help farmers work more efficiently and in less time. As the business develops, the usage of drones in agriculture is only anticipated to increase, thus it is wise to learn how to use this technology responsibly.

Advantages of Drone Use in Agriculture

Drones have a wide range of applications in the agriculture sector, including crop mapping, soil analysis, irrigation, and pest control. According to recent estimates, the global market for agricultural drones is expected to develop at a compound annual growth rate of 35.9% and reach $5.7 billion by 2025.

Field and soil analyses: Agricultural drones can analyse soil and fields for effective field planning. They can be used to mount sensors that measure soil moisture, terrain, soil conditions, soil erosion, soil nutrient concentration, and soil fertility.

Crop monitoring: Crop surveillance is the monitoring of a crop's development from the time the seeds are sown until the crop is ready to be harvested. This includes timing the application of fertilizers, keeping an eye out for pest infestations, and tracking the impact of weather. By using infrared cameras to scan the field, drones can aid in efficient crop surveillance. Farmers can then act on the information they receive in real-time to improve the health of the plants there.

Crop spraying: Agri-drones can be used to spray chemicals on crops since they have reservoirs that, in comparison to conventional methods, can be quickly filled with fertilizers and insecticides. Therefore, drone technology has the potential to bring in a new era of precision farming.

Check crop health: Agriculture is a large-scale endeavor that involves acres of land. To keep track of the condition of the soil and the crop that has been planted, regular surveys are required. Manually, this could take days, and even then, human mistake is possible. The same task can be completed by drones in a few hours. Drones can use infrared mapping to collect data on the condition of the crop and the soil.

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Avoid overuse of chemicals: Reducing the usage of herbicides, insecticides, and other chemicals can be done particularly well with the use of drones. These substances do in fact aid in crop protection. But using them excessively can be harmful. Drones are able to identify even the tiniest indicators of pest infestations and provide precise information on the intensity and territory of the attack. This can assist farmers in determining the necessary dosage of chemicals to employ so that the crops are only protected, not harmed.

Prepare for weather glitches: Be ready for weather hiccups: The weather can be a farmer's best friend or worst foe. It is quite challenging to get ready for any change in patterns because these are impossible to foresee with any degree of accuracy. Future weather conditions can be predicted with the help of drones. Better forecasts are already being made using storm drones. Farmers can also use this information to better prepare themselves.

Survey and track crop growth: Crops need to be examined and tracked to make sure that the appropriate yield will be available when the crop is ready to be harvested, even when everything is going according to plan. It is also crucial for planning the future, whether it is for picking cyclical crops or figuring out the best pricing for the open market. Drones can deliver precise information on every stage of crop growth and can alert farmers to any differences before they turn into a disaster. Additionally, multispectral scans can accurately reveal minute variations between crops that are healthy and ill.

Geofencing: Drones equipped with infrared cameras can quickly identify people or animals. Therefore, drones can protect the fields from external animal damage, especially at night.

Drones and the Indian agriculture industry

A lot of drone-based agricultural projects are undergoing in India.

- ✓ On January 26, 2022, the Indian government also unveiled a certification program for agricultural drones, allowing them to carry a payload devoid of the pesticides and other liquids typically employed in drone spraying operations. When spraying these solutions, make sure to abide by all rules and regulations.
- ✓ The Indian government recently offered the Farm Machinery Training and Testing Institutes, ICAR Institutes, Krishi Vigyan Kendras, and State Agriculture Universities a 100% subsidy up to March 2023, whichever is less, to encourage the use of drones for agricultural purposes and lessen the labor burden on farmers.
- ✓ The International Crops Research Institute (ICRISAT) received permission from the Indian government to utilize drones for agricultural research on November 16, 2020. The government hopes that by taking this action, it will inspire aspiring scientists and business-people to consider low-cost drone solutions for the more than 6.6 lakh Indian villages.

Challenges of adopting drone technology in the agriculture sector

While drones offer many benefits to farmers, there are also some challenges that may be holding farmers back from adopting this technology. Here are some of the key challenges:

Fear of job loss: Many farmers are concerned that the adoption of drone technology will lead to job loss, as fewer workers will be needed to perform manual labour on the farm.

Lack of knowledge and training: Farmers may not have the knowledge or training necessary to operate drones effectively. This can make it difficult for them to adopt this technology, as they may not be confident in their ability to use it.

Cost: Drones can be expensive, and many farmers may not have the financial resources to invest in this technology.

Regulatory barriers: There may be regulatory barriers to the use of drones in agriculture, which could make it difficult for farmers to adopt this technology.

Conclusion

In the longer term, drone technology will transform the agricultural industry. Numerous Indian start-ups are also expressing interest in the sector and hoping to invest in inexpensive drones that can benefit farmers, as well as provide work possibilities for rural youngsters and improve farmers' knowledge. To sum up, the use of drone technology in agriculture has the potential to change how farmers manage their crops and increase yields.

References

Abdollahi, A., Rejeb, K., Rejeb, A., Mostafa, M. M. and Zailani, S. (2021). Wireless sensor networks in agriculture: insights from bibliometric analysis. *Suistainability*, 13(21): 12011-12023.

Aditya, S., Natu and Kulkarni, S. C. (2016). Adoption and Utilization of Drones for Advanced Precision Farming: A Review. *International Journal on Recent and Innovation Trends in Computing and Communication*, 4(5): 563-565.

Colomina, I. and Molina, P. (2014). Unmanned aerial systems for photogrammetry and remote sensing: Application of drone in agriculture. *Journal of Photogrammetry and Remote Sensing*, 92: 79-97

Rejeb, A., Abdollahi, A., Rejeb, K. and Treiblmaier, H. (2022). Drones in agriculture: A review and bibliometric analysis. *Computers and Electronics in Agriculture*, 198: 1-19.

Challenges and Perspectives on the Life of an Indian Farmer

Aditya Rathi and Shivani

The life of an Indian farmer is characterized by a multitude of challenges stemming from socio-economic, environmental, and policy-related factors. Despite being the backbone of the agrarian economy, Indian farmers face numerous hardships that significantly impact their livelihoods and well-being. This article aims to delve into the various aspects of their lives, highlighting the challenges they encounter and the perspectives for improvement.

Socio-economic Challenges

- ✓ **Debt Burden:** Indian farmers often find themselves trapped in a cycle of debt due to various reasons such as inadequate credit access, unpredictable weather conditions leading to crop failures, and high input costs. According to a study by the National Bank for Agriculture and Rural Development (NABARD), over 52% of rural households in India are indebted, with agriculture being a primary source of indebtedness (NABARD, 2019).
- ✓ **Low Income:** Despite being the primary producers of food and raw materials for various industries, Indian farmers face low and fluctuating incomes. The lack of remunerative prices for their produce and middlemen exploiting the market chain exacerbate this issue, pushing many farmers into poverty.

Environmental Challenges

- ✓ **Climate Change:** Indian farmers are particularly vulnerable to the impacts of climate change, including erratic rainfall patterns, prolonged droughts, and extreme weather events like cyclones and floods. These environmental disruptions disrupt agricultural activities, leading to crop failures and reduced yields.
- ✓ **Soil Degradation:** Intensive farming practices, coupled with inadequate soil conservation measures, have led to widespread soil degradation across India. Soil erosion, nutrient depletion, and salinization pose significant challenges to sustainable agricultural production, affecting farmers' long-term productivity.

Policy-related Challenges

- ✓ **Inadequate Support:** Despite various government schemes and initiatives aimed at supporting farmers, such as crop insurance, subsidies, and loan waivers, the implementation often falls short. The bureaucratic hurdles, lack of awareness among farmers, and delays in disbursement hinder the effectiveness of these policies in addressing farmers' needs.
- ✓ **Land Fragmentation:** The fragmented landholding pattern in India, with small and marginal farms dominating the agricultural landscape, poses challenges for mechanization, efficient resource utilization, and economies of scale. This

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fragmentation limits the farmers' ability to adopt modern farming techniques and increase productivity.

Perspectives for Improvement

- ✓ **Diversification:** Encouraging diversification beyond traditional crops to high-value and climate-resilient crops can enhance farmers' income and resilience to environmental shocks.
- ✓ **Access to Credit and Markets:** Strengthening rural credit institutions, promoting farmer producer organizations (FPOs), and establishing market linkages can improve farmers' access to credit and ensure fair prices for their produce.
- ✓ **Sustainable Agricultural Practices:** Promoting sustainable farming techniques such as organic farming, agroforestry, and precision agriculture can enhance soil health, conserve water, and mitigate the impacts of climate change.

Conclusion

The life of an Indian farmer is fraught with challenges, ranging from socio-economic hardships to environmental vulnerabilities and policy-related inadequacies. Addressing these challenges requires concerted efforts from policymakers, agricultural experts, and other stakeholders to ensure the well-being and prosperity of Indian farmers.

Reference

National Bank for Agriculture and Rural Development (NABARD). (2019). All India Rural Financial Inclusion Survey. Retrieved from (https://www.nabard.org/auth/writereaddata/tender/21092019173109AFI_report_2016-17.pdf)

Understanding Different Types of Cropping Systems

Aryan Choudhary and Shivani

Cropping systems are essential components of agriculture, determining how land is utilized, crops are grown, and resources are managed. Various types of cropping systems have evolved over time to meet the diverse needs of farmers, address environmental concerns, and optimize production. This article explores some of the prominent cropping systems along with their characteristics and benefits.

Monoculture Cropping System

In monoculture cropping, a single crop species is grown repeatedly on the same piece of land. This system simplifies management practices and allows for efficient use of machinery and inputs. However, it can lead to increased pest and disease pressure, soil degradation, and reduced biodiversity.

Polyculture Cropping System

Polyculture involves growing multiple crop species together in the same field. This system promotes biodiversity, reduces pest and disease incidence, and enhances soil fertility through complementary interactions among crops. Polyculture systems are often associated with agroecological approaches and sustainable farming practices.

Crop Rotation

Crop rotation involves alternating the types of crops grown in a specific sequence over time. This practice helps improve soil health, manage pests and diseases, and optimize nutrient utilization. By rotating crops with different nutrient requirements and growth characteristics, farmers can maintain soil fertility and reduce reliance on chemical inputs.

Agroforestry Systems

Agroforestry integrates trees and shrubs with crops or livestock in a mutually beneficial arrangement. This system provides multiple products, such as food, fuel, timber, and ecosystem services like soil conservation and biodiversity enhancement. Agroforestry contributes to climate change mitigation and resilience by sequestering carbon and enhancing ecosystem stability.

Conclusion

Different cropping systems offer unique advantages and challenges, and their selection depends on various factors, including climate, soil type, market demand, and farmer preferences. Sustainable agriculture requires careful consideration of cropping systems to ensure long-term productivity, environmental stewardship, and socio-economic viability.

References

Pretty, J. and Bharucha, Z. P. (2014). Sustainable intensification in agricultural systems. *Annals of Botany*, 114(8): 1571-1596.

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R. and Polasky, S. (2002). Agricultural susta-

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inability and intensive production practices. *Nature*, 418(6898): 671-677.

Nair, P. K. (2012). Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems*, 86(1): 1-10.

Drinkwater, L. E., Wagoner, P. and Sarrantonio, M. (1998). Legume-based cropping systems have reduced carbon and nitrogen losses. *Nature*, 396(6708): 262-265.

Vandermeer, J. and Perfecto, I. (2007). The agricultural matrix and a future paradigm for conservation. *Conservation Biology*, 21(1): 274-277.

Advancements in Nematode Research: Unveiling the Frontiers of Plant Parasitic Nematode Studies

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Abstract

In the dynamic realm of agricultural science, researchers are continually pushing boundaries to enhance our understanding of plant-parasitic nematodes. These microscopic worms, often unseen but with a colossal impact on crop health, have been the focus of ground-breaking research in recent years. In this article, we delve into the latest advancements in nematode research, shedding light on the innovative findings and technological breakthroughs that promise to revolutionize nematode management in agriculture.

Introduction

Plant-parasitic nematodes pose a persistent threat to global agriculture, impacting crop yields and food security. Recent advancements in nematode research have opened new frontiers in understanding their biology and developing innovative management strategies. Genomic insights, achieved through whole genome sequencing and comparative genomics, have unveiled the genetic makeup of nematodes, identifying key genes related to pathogenicity and resistance. Integration of omics technologies, including transcriptomics and proteomics, provides a holistic view of nematode biology, offering crucial insights into molecular mechanisms. RNA interference (RNAi) emerges as a powerful tool for nematode control, enabling targeted gene silencing to disrupt essential biological processes. Microbiome modulation, utilizing nematophagous organisms and beneficial microbes, offers ecofriendly strategies for nematode management. Advanced remote sensing and imaging technologies, such as spectral imaging and drone technology, enable non-invasive monitoring of nematode-induced stress in crops, allowing for timely interventions. Precision breeding techniques, including CRISPR-Cas9 and marker-assisted selection, empower the development of nematode-resistant crop varieties. This comprehensive review explores the multidimensional approaches in nematode research, showcasing recent breakthroughs that promise to reshape agricultural practices, fostering resilience against nematode infestations and contributing to sustainable global food production.

Genomic Insights: Decoding the Nematode Genome

Recent advancements in genomic technologies have enabled scientists to unravel the intricate genetic makeup of plant-parasitic nematodes. Under-

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standing the nematode genome provides crucial insights into their biology, behaviour, and evolution. Researchers have identified key genes associated with pathogenicity, reproduction, and resistance, opening new avenues for targeted interventions.

- ✓ **Whole Genome Sequencing (WGS):** Advances in WGS technology have allowed scientists to sequence the entire genome of plant-parasitic nematodes. This has provided a comprehensive understanding of their genetic composition, including the identification of specific genes associated with traits such as pathogenicity, reproduction, and resistance.
- ✓ **Comparative Genomics:** Comparative genomics involves comparing the genomes of different nematode species or strains to identify conserved and divergent genetic elements. This approach helps researchers unravel the evolutionary relationships and adaptability of nematodes, shedding light on their ability to overcome plant defenses.

Omics Technologies: Integrating Genomics, Transcriptomics, and Proteomics

The integration of genomics with other "omics" technologies, such as transcriptomics and proteomics, has provided a comprehensive view of nematode biology. This holistic approach allows researchers to identify specific molecular pathways involved in host interaction, virulence, and the development of resistance in plants.

- ✓ **Transcriptomics:** Transcriptomic studies involve analysing the complete set of RNA transcripts in nematodes. This helps researchers understand which genes are actively expressed during different life stages or in response to specific environmental conditions, providing insights into the molecular mechanisms underlying nematode behaviour.
- ✓ **Proteomics:** Proteomic analyses focus on identifying and quantifying the proteins produced by nematodes. This allows researchers to link gene expression to protein function, uncovering key proteins involved in processes such as host recognition, immune evasion, and nutrient acquisition.

RNA Interference (RNAi) for Nematode Control

RNA interference, a revolutionary genetic tool, has gained prominence in nematode research. Scientists are exploring the potential of using RNAi to disrupt essential nematode genes, hindering their ability to infect and reproduce. This targeted approach holds promise for developing environmentally friendly and sustainable nematode control strategies.

- ✓ **Mechanism of RNAi:** RNAi is a biological process where the introduction of specific RNA molecules interferes with the expression of targeted genes. In nematode research, scientists are designing RNA molecules that, when ingested by nematodes, trigger gene silencing, disrupting essential biological processes and hindering their ability to infect plants.
- ✓ **Delivery Systems:** Developing effective delivery systems for RNAi molecules is a key

challenge. Researchers are exploring methods such as using nanoparticles or incorporating RNAi into beneficial microbes to enhance delivery and ensure targeted gene silencing within nematode populations.

Microbiome Modulation: Harnessing Beneficial Microbes

Understanding the complex interactions between nematodes and the soil microbiome has led to innovative approaches for nematode management. Researchers are exploring the use of beneficial microbes, such as nematophagous fungi and bacteria, to suppress nematode populations naturally. This eco-friendly strategy shows potential for integrated pest management systems.

- ✓ **Nematophagous Organisms:** Certain fungi (e.g., *Arthrobotrys, Hirsutella*) and bacteria (e.g., *Bacillus, Pseudomonas*) are known to prey on nematodes. Scientists are investigating ways to enhance the abundance and activity of these nematophagous organisms in the soil to naturally control nematode populations.
- ✓ **Plant-Microbe Interactions:** Understanding the intricate interactions between plants and beneficial microbes is crucial. Some microbes can induce systemic resistance in plants, making them more resilient to nematode attacks. This area of research explores the use of plant growth-promoting rhizobacteria (PGPR) and mycorrhizal fungi for nematode management.

Remote Sensing and Imaging Technologies

Advancements in remote sensing and imaging technologies are facilitating non-invasive monitoring of nematode infestations in agricultural fields. Drones and satellite imagery are being employed to detect early signs of nematode-induced stress in crops, allowing farmers to implement timely and targeted interventions.

- ✓ **Spectral Imaging:** Spectral imaging involves capturing and analysing the electromagnetic spectrum reflected by plants. Nematode-induced stress in crops can alter this spectrum, and by employing spectral imaging techniques, researchers can detect subtle changes in plant health indicative of nematode infestations.
- ✓ **Drone Technology:** Drones equipped with high-resolution cameras and sensors can provide detailed images of agricultural fields. By flying over fields and capturing data, drones enable rapid and cost-effective monitoring of large areas, allowing farmers to identify and address nematode issues in a timely manner.

Nematode-Resistant Crop Varieties: Precision Breeding Techniques

Modern breeding techniques, including precision breeding and gene editing technologies like CRISPR-Cas9, are accelerating the development of nematode-resistant crop varieties. Researchers are identifying and manipulating genes responsible for resistance, creating crops that can withstand nematode infestations without the need for chemical interventions.

- ✓ **CRISPR-Cas9 and Precision Breeding:** CRISPR-Cas9 technology allows precise modifi-

cation of specific genes in plants. Researchers are utilizing this tool to introduce or enhance resistance genes in crop varieties, creating plants that can naturally defend against nematode attacks without the need for chemical treatments.

- ✓ **Marker-Assisted Selection:** Traditional breeding methods can be time-consuming. Marker-assisted selection involves identifying molecular markers linked to nematode resistance traits, allowing breeders to select and propagate resistant plant varieties more efficiently.

Conclusion

The recent strides in nematode research represent a significant leap forward in our ability to combat these elusive agricultural pests. From deciphering the nematode genome to harnessing the power of RNA interference and precision breeding, researchers are equipping farmers with innovative tools for sustainable nematode management. As these advancements continue to unfold, the agricultural landscape is poised to benefit from more resilient crops, reduced reliance on chemical treatments, and a renewed hope for global food security.

References

Abad, P., Gouzy, J., Aury, J. M., Castagnone-Sereno, P., Danchin, E. G., Deleury, E. and Wincker, P. (2008). Genome sequence of the metazoan plant-parasitic nematode *Meloidogyne incognita*. *Nature Biotechnology*, 26(8): 909-915.

Blanc-Mathieu, R., Perfus-Barbeoch, L., Aury, J. M., Da Rocha, M., Gouzy, J., Sallet, E. and Danchin, E. G. (2017). Hybridization and polyploidy enable genomic plasticity without sex in the most devastating plant-parasitic nematodes. *PLoS Genetics*, 13(6): e1006777.

Mahlein, A. K., Oerke, E. C., Steiner, U. and Dehne, H. W. (2012). Recent advances in sensing plant diseases for precision crop protection. *European Journal of Plant Pathology*, 133: 197-209.

Mendes, R., Kruijt, M., De Bruijn, I., Dekkers, E., Van Der Voort, M., Schneider, J. H. and Raaijmakers, J. M. (2011). Deciphering the rhizosphere microbiome for disease-suppressive bacteria. *Science*, 332(6033): 1097-1100.

Opperman, C. H., Bird, D. M., Williamson, V. M., Rokhsar, D. S., Burke, M., Cohn, J. and Windham, E. (2008). Sequence and genetic map of *Meloidogyne hapla*: A compact nematode genome for plant parasitism. *Proceedings of the National Academy of Sciences*, 105(39): 14802-14807.

Sosnowski, O., Charcosset, A. and Joets, J. (2012). BioMercator V3: an upgrade of genetic map compilation and quantitative trait loci meta-analysis algorithms. *Bioinformatics*, 28(15): 2082-2083.

Urwin, P. E., Lilley, C. J. and Atkinson, H. J. (2002). Ingestion of double-stranded RNA by preparasitic juvenile cyst nematodes leads to RNA interference. *Molecular Plant-Microbe Interactions*, 15(8): 747-752.

Tulsi (*Ocimum tenuiflorum*): Herb with Health Benefits

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Introduction

Tulsi is a wonderful plant with a long history, great cultural value, and deep meaning. A plant that is closely linked to health, spirituality, and customs. *Ocimum tenuiflorum*, the scientific name for tulsi, is a member of the Lamiaceae family. This herbaceous perennial has been prized for generations because of its amazing qualities; it originated in India. Tulsi has long had a revered status in Indian spirituality and culture. Frequently referred to as "The Queen of Herbs" or "The Incomparable One," it is highly regarded in ancient manuscripts and religions. This plant is an essential part of traditional Ayurvedic medicine since it has long been valued for its deep effects on well-being in addition to its physical qualities.We will learn about the botanical features of Tulsi, investigate its therapeutic uses, and recognise its spiritual and cultural importance as we delve further into this fascinating plant.

Botanical Description: *Ocimum*, the scientific name for tulsi, is a member of the Lamiaceae family of plants, which also includes a number of other aromatic herbs. This perennial herbaceous plant is distinguished by unique morphological traits that make it stand out.Tulsi usually grows in a compact, bushy form and reaches a height of approximately 30 to 60 centimetres (1 to 2 feet). It can, however, grow higher in favourable conditions, up to three feet (90 centimetres) or more. Its strong stems contribute to its attractive appearance. One distinctive aspect of Tulsi is its leaves. Their length ranges from roughly 1 to 2 inches (2.5 to 5 cm), making them small to medium in size. The leaf has an elliptical or oval form, with edges that are slightly serrated and a pointy tip. Upon careful inspection, the leaves display a stunning glossy texture. Tulsi leaves create a pleasant scent that combines earthy, flowery, and somewhat spicy notes when softly brushed or crushed. Its aromatic flavour adds to its appeal and makes it a popular option for a range of uses, including culinary and therapeutic. When handled, the leaves release a delightful scent that adds to this amazing plant's allure.



Medicinal properties: Tulsi is well known for its powerful therapeutic qualities and wide range of health advantages. Its therapeutic potential is highlighted by its use in different healing systems and traditional Ayurvedic medicine. Tulsi is regarded as an adaptogen in Ayurveda, meaning that it supports general balance and well-being while assisting the body in adjusting to stimuli. These are a few of the tulsi's well-known therapeutic qualities and health advantages.

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Immunomodulatory: Due to its immunomodulatory properties, tulsi supports healthy immune system function. It strengthens the body's defences against infections, allergies, and autoimmune diseases by supporting natural defence mechanisms.

Antioxidants: Antioxidants found in abundance in the plant scavenge dangerous free radicals and shield the organism from oxidative stress. This characteristic aids in the prevention of chronic diseases, lowers inflammation, and fights cellular damage.

Antimicrobial: Tulsi has antibacterial qualities; it can suppress the growth of certain bacteria, viruses, fungus, and parasites. It might help treat skin conditions, digestive problems brought on by bacteria, and respiratory infections.

Anti-inflammatory: Compounds in the plant with anti-inflammatory qualities aid to lessen inflammation and relieve related symptoms. For ailments such inflammatory bowel disease, arthritis, and skin inflammations, it might be helpful.

Respiratory Health: Tulsi is frequently used to promote respiratory wellness. It is thought to reduce cold, asthma, bronchitis, congestion and cough symptoms. Its expectorant qualities facilitate breathing by releasing mucus.

Stress and Anxiety: Because of its adaptogenic qualities, tulsi is well known for assisting the body in managing stress and anxiety. It might enhance mental clarity, encourage relaxation, and boost mental health in general. Scientific investigations have also illuminated Tulsi's medicinal properties. Research has indicated that it possesses antibacterial properties against a range of diseases, such as viruses, bacteria, and fungi. Its traditional usage in treating illnesses associated to inflammation and oxidative stress is further supported by studies that demonstrates its anti-inflammatory and antioxidant properties. Many illnesses and problems are thought to be improved by tulsi, such as respiratory issues include asthma, colds, gastrointestinal infections, skin conditions such as fungal infections, eczema, and acne inflammation and soreness in the joints.

Nutritional Values

Beyond its therapeutic benefits, tulsi is a rich source of important vitamins, minerals, and antioxidants. Let's examine this amazing plant's nutritional makeup.

Vitamins: Numerous vitamins, including as vitamins A, C, and K, are included in tulsi. Immune system, skin, and visual health are all supported by vitamin A. Strong antioxidant vitamin C strengthens the immune system and encourages the production of collagen. Bone health and blood clotting depend on vitamin K.

Minerals: Numerous minerals, including as calcium, iron, zinc, and potassium, are all found in good amounts in tulsi. Iron is necessary for the body to carry oxygen and to prevent iron-deficiency anaemia, while calcium is necessary for healthy bones and teeth. Zinc participates in a number of enzymatic processes and enhances immunological function. Potassium is essential for preserving the right fluid balance and controlling cardiac rhythm.

Antioxidant: Antioxidants, such as those found in tulsi, help shield the body from oxidative stress and the harm that free radicals bring to cells. These protective agents comprise tannins, phenols, and flavonoids. They lower inflammation, counteract dangerous free radicals, and improve general health and wellbeing.

Essential Oils: The unique flavour and perfume of Shikaka Tulsi are derived from the essential oils it contains, such as eugenol. Eugenol has analgesic, antibacterial, and anti-inflammatory properties.

Phytochemicals: In addition, tulsi is a rich source of phytochemicals such as apigenin, ursolic acid, and rosmarinic acid. These substances have demonstrated anti-inflammatory, antibacterial and anticancer effects, among other possible health advantages. It is noteworthy that the nutritional makeup of Tulsi may exhibit modest variations contingent upon variables such as plant maturity, growth conditions, and soil quality. Still, it's well acknowledged to be an excellent source of minerals, vitamins, antioxidants, and other bioactive substances. Adding Tulsi to your diet for example, by using the leaves in soups, drinks, or garnishes can improve your general health and nutritional status. However, in order to make sure you get a variety of nutrients from various sources, it's always advised to eat a varied and balanced diet.

Allergies: People who have a history of allergic reactions to plants in the Lamiaceae family, which includes oregano, mint, and basil, may be more vulnerable to Tulsi allergy reactions. When utilising or consuming tulsi, it's best to use caution and pay attention to your body's reaction if you have a history of plant allergies.

Pregnancy and Breastfeeding: The safety of Tulsi during pregnancy and breastfeeding has not been thoroughly studied. It is advised to err on the side of caution and refrain from using it during these times. Seek advice from a medical expert prior to contemplating its application in such circumstances.

Cultivation Conditions

Grow across the entirety of India. Rainy season cultivation is the main focus; winter cultivation should be avoided.

Soil: Ideal soil type is sandy loam; stay away from water logging.

Ready Method for Nursing: The best months to prepare a nursery are February through May. After combining the seeds with dry sand in a 1:5 ratio, the mixture is applied to the ground. Add a thin layer of dirt over the seeds. Sprinklers will be used to help with irrigation after two days. The seed begins to grow after eight to twelve days. The nursery is ready for the plants to be transferred to the field when four to five leaves are visible.

Land Preparation: The nursery plants are prepared for field sowing after six weeks. 1.5’ x 1.5’ plants are inserted into holes. After that, irrigation is carried out initially every three days with the aid of sprinklers, then on a regular basis after seven to ten days.

Harvesting: In appropriate sunlight, after 90 to 95 days, the first cutting is should be made. Above 15 cm above the ground is where the cut must be made. Following the initial cutting, subsequent cuttings will

occur every 70-75 days. The third cutting is to be made 70-75 days following the second cutting.

Benefits of Growing Tulsi Plant

The herb tulsi is demanding: Owing to its therapeutic qualities, tulsi is regarded as a sophist-icated herb with a highly demanding market.There are two ways to sow basil: using seeds or plants. The crop is planted in April and May. Ten kilogrammes of seed are required to cultivate one hectare, or 2.5 acres. Since the basil plant is hardy, it is not seriously affected by any severe diseases.

Tukashmiya Tulsi: Occurs in Persia and Western India. It is used to treat leprosy, acid reflux, and throat problems.

Amrita Tulsi: Located throughout India. It forms a thick bush with its dark purple foliage. It is used to treat dementia, diabetes, rheumatoid arthritis, cancer, and heart disease.

Vana Tulsi: *Ocimum gratissimum* is native to the Indian plains and Himalayas. Compared to other types, the plant is taller. It boosts immunity, reduces stress, and strengthens resilience to stomach ulcers, among other health advantages. The leaves have a rich, spicy scent that is similar to cloves.

***Ocimum sanctum* or kapoor tulsi:** It is mostly grown in the United States but has also long been farmed in India. It is easier to grow and is mostly planted in temperate climates. Tea is made from the dried leaves.

How to statrt Tulsi farming

Land Preparation: Soil that drains well is necessary for Tulsi plantations. After multiple ploughing and harrowing passes, the soil is fine-tilled and the FYM is well mixed in. Tulsi is planted on a high-quality seedbed.

Planting: The sowing period: In the third week of February, make the nursery beds ready.

Spacing: Depending upon its growth habit, prepare seed beds of 4.5 x 1.0 x 0.2 m size. Seeds should be sown at a distance of 60 cm by 60 cm.

Sowing Depth: Seeds are sown at depth of 2 cm.

Method of Sowing: Crop is transplanted in field, 6-7 week after sowing.

Seed: Use 120 grammes of seed per acre for Tulsi plantations.

Handling of seeds: Treat seeds with Mancozeb @ 5 gm kg^{-1} of seeds before to sowing to protect them against soil-borne diseases and pests.

Nursery Management and Transplanting: For a decent yield, add 15 tonnes of FYM to the soil before sowing. Plant Tulsi seeds in well-prepared beds that have ample room. Eight weeks before the monsoon arrives, seeds are sowed on beds. The seeds are planted two centimetres deep. Seeds are covered with a thin layer of soil and FYM after sowing. With a sprinkler hose, irrigation is carried out. Applying a 2% urea solution 15-20 days before to transplanting aids in producing healthy seedlings. When seedlings are 6 weeks old and have 4-5 leaves, they are transplanted in the middle of April. To ensure that seedlings can be easily uprooted and remain turgid while transplanting, water seedling beds 24 hours prior to transplanting. Apply farmyard manure (FYM) to the land as it's being prepared and thorou-

ghly mix it into the soil. Apply the recommended dosage of fertiliser as follows: 48 kilogramme of nitrogen, 24 kg of phosphorus, 24 kg of urea, 40 kg of MOP, and 150 kg of SSP acre^{-1}. When transplanting, administer a half-dose of nitrogen and a full dose of phosphate pentoxide as a basal dose. Micronutrients Mn @50 ppm conc. and Co @100 ppm conc. are applied. The remaining nitrogen dose is delivered in two segments following the first and second cutting.

Weed Control: To keep the field free of weeds, perform hoeing and weeding. Weed will hinder crop growth if it is not controlled. Initially, weeding is done four weeks after the initial planting and again a month after the first. It is best to do just one hoeing after two months after planting.

Irrigation: Apply three irrigations a month during the summer; during the wet season, none is necessary. In a year, 12-15 irrigations should be performed. After transplanting, the plants should receive their first irrigation, followed by a second irrigation during seedling establishment. Following these two mandatory irrigations, the remaining irrigations are carried out according on the season.

Plant Protection

Pest and their control

Leaf rollers: Caterpillars consume leaves, buds, and crops for sustenance. They cause leaves to roll or fold by sealing their surface. Apply 300 millilitres of Quinalphos per acre in 150 litres of water to manage leaf roller.

Tulsi lace wing: Nymphs eat leaves and excrete something that is harmful to foliage. Initially, the leaves curl, and the plant as a whole dries up. Apply an azadirachtin 10,000 ppm conc. @ 5 ml Ltr^{-1} of water to control lace wings.

Harvesting: After transplanting, plants begin to yield after three months. Harvesting is completed during the whole blooming season. When the plant is at least 15 cm above the ground, pruning should be done to encourage continued branch regeneration. Fresh leaves are used, or they can be sun-dried for later use.

Post-Harvest: The leaves are dried after harvesting. To extract basil oil, steam distillation is next carried out. It is packaged in sealed bags for transit. It is best to preserve leaves in dry areas. After processing, a number of products are manufactured from the herb, such Panch Tulsi oil, Tulsi ginger, Tulsi powder, Tulsi tea, and Tulsi capsules.

Conclusion

Tulsi is an amazing plant with a long history and a wide variety of health advantages. We have covered a lot of ground in this essay about Tulsi, including its botanical description, therapeutic uses, nutritional benefits, growing advice and safety measures.

Adapting Agriculture to Changing Climate: Strategies for Resilience

Tanya Rathore and Kirti Vardhan Pandey

Abstract

As global climate patterns continue to shift, the agricultural sector faces unprecedented challenges that necessitate innovative and adaptive strategies. This study explores the multifaceted impacts of climate change on agriculture and proposes resilient strategies to mitigate its adverse effects. Through a comprehensive review of current research, we examine the changing climate's implications for crop yields, water resources, and overall agricultural productivity. The abstract outlines key adaptation measures, including the development of climate-resistant crop varieties, improved water management practices, and the adoption of sustainable agricultural techniques. Additionally, the abstract highlights the importance of integrating technological advancements and community-based approaches to enhance the resilience of farming systems. By synthesizing existing knowledge and proposing forward-looking solutions, this study aims to contribute to the ongoing discourse on building climate-resilient agricultural systems for a sustainable future.

Introduction

In recent years, the world has witnessed unprecedented changes in climate patterns, with rising temperatures, erratic precipitation and extreme weather events becoming more frequent. These shifts pose a significant threat to global agriculture, disrupting traditional farming practices and challenging food security. As the impacts of climate change continue to unfold, there is an urgent need for the agricultural sector to adapt and build resilience to ensure sustainable food production. The Inter-governmental Panel on Climate Change (IPCC) has emphasized the importance of adapting agriculture to changing climate conditions to mitigate potential risks and secure future food supplies. This article explores the various strategies that farmers, policymakers, and researchers can employ to enhance the resilience of agricultural systems in the face of climate change.

Understanding the Climate Challenge: Before delving into adaptation strategies, it's crucial to grasp the specific climate challenges faced by agriculture. Changes in temperature, precipitation patterns, and the frequency of extreme weather events can lead to shifts in growing seasons, increased pest and disease pressure, and water scarcity. Farmers must contend with these challenges while ensuring sustainable food production to meet the needs of a growing global population.

Crop Diversification: One key strategy for building

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resilience in agriculture is crop diversification. Traditional mono-cropping practices are vulnerable to climate extremes and diseases. Farmers are encouraged to diversify their crops to spread risks and enhance adaptability. This approach not only safeguards against the impact of specific climatic conditions but also contributes to improved soil health and sustainable farming practices.

Water Management: Changing precipitation patterns and increased evaporation due to higher temperatures demand innovative water management practices. Implementing efficient irrigation systems, rainwater harvesting, and adopting drought-resistant crops are crucial steps to ensure water availability for agriculture. Smart water technologies, such as soil moisture sensors and precision irrigation, can optimize water use and mitigate the impact of water scarcity on crops.

Agroforestry: Integrating trees and shrubs into agricultural landscapes through agroforestry provides multiple benefits. Trees act as windbreaks, reduce soil erosion, and contribute to carbon sequestration. Agroforestry systems enhance biodiversity, provide shade for crops, and create microclimates that can buffer against extreme weather events, fostering a more resilient and sustainable farming environment.

Precision Agriculture and Technology: Harnessing the power of technology is essential in adapting agriculture to a changing climate. Precision agriculture utilizes data analytics, sensors, and satellite imagery to optimize farm management. Farmers can make informed decisions regarding planting times, fertilizer application, and pest control, thereby increasing efficiency and reducing environmental impact.

Harnessing Technology for Climate-Smart Agriculture: This section will explore the role of technology in climate-smart agriculture. From the use of remote sensing and drones for precision farming to the application of artificial intelligence in crop modeling, technological advancements offer innovative solutions to monitor and manage the impacts of climate change on agriculture. This section aims to showcase how integrating technology into farming practices can enhance adaptive capacity and overall resilience.

Climate-Resilient Crop Varieties: Developing and adopting climate-resilient crop varieties through breeding programs and genetic engineering is pivotal in ensuring food security. These varieties are designed to withstand temperature fluctuations, resist pests and diseases, and thrive in diverse climatic conditions. Governments and research institutions play a vital role in promoting the adoption of these resilient crop varieties among farmers.

Community-Based Adaptation: Engaging local communities in the adaptation process is critical. Building the capacity of farmers through education and training on climate-smart practices enhances their ability to cope with changing conditions. Establishing community-based early warning systems and sharing knowledge about sustainable

farming practices contribute to the overall resilience of agricultural systems.

Impact on Global Food Security: Building upon the understanding of climate change challenges, this section will delve into the potential threats to global food security. Exploring how changes in climate can disrupt agricultural production and distribution systems, it will highlight the vulnerability of communities, particularly in developing regions, to fluctuations in food availability and affordability.

Innovative Adaptation Strategies: The heart of the article will focus on cutting-edge and practical strategies for adapting agriculture to a changing climate. This will encompass a range of approaches, including the development of climate-resilient crop varieties, precision farming techniques, water management strategies, and the integration of agroforestry and sustainable land-use practices. Case studies from around the world will be examined to showcase successful adaptation initiatives.

Role of Technology and Research: Emphasizing the crucial role of technology and ongoing research, this section will explore how advancements in agricultural science, remote sensing, and data analytics can contribute to climate-smart farming practices. The integration of traditional knowledge with modern innovations will be highlighted as a key aspect of developing effective and context-specific adaptation solutions.

Policy and Institutional Support: Acknowledging the need for a supportive policy environment, the article will discuss the role of governments and international organizations in fostering climate-resilient agriculture. This includes policies that incentivize sustainable practices, financial support mechanisms for farmers, and the importance of global cooperation in addressing transboundary challenges.

Conclusion

Adapting agriculture to a changing climate is an urgent and collective responsibility. By embracing a combination of crop diversification, water management, agroforestry, technology, resilient crop varieties, and community involvement, we can build a more robust and sustainable food production system. Governments, farmers, researchers, and communities must work together to implement these strategies, ensuring that agriculture remains resilient in the face of ongoing climate challenges and secures the future of global food security.

Development of Disease Resistance through Resistant Genes

Premalatha K.

Resistance genes

Plant diseases can drasti1cally abate the crop yields as the degree of disease outbreak is getting severe around the world. Therefore, plant disease management has always been one of the main objectives of any crop improvement program. Plant disease resistance (R) genes have the ability to detect a pathogen attack and facilitate a counter attack against the pathogen. Numerous plant R-genes have been used with varying degree of success in crop improvement programs in the past and many of them are being continuously exploited. Plant pathogen interaction is a well understood mechanism which involves the activation of signals sometimes resulting in a rapid defense response against an array of plant pathogens. This response helps the host plant to avoid further infection of the disease. Induction of plant defense signalling involves the recognition of specific pathogen effectors by the products of specialized host genes called R-genes. Numerous individual plant resistance (R) genes have already been characterized and are being efficiently used in crop improvement research programs (Omondi *et al.*, 2016). Using plant resistance genes for developing disease-resistant varieties is a convenient alternative to other measures like pesticides or other chemical control methods employed to protect crops from diseases. Benefits of using the plant resistance genes in resistance breeding programs include the efficient reduction of pathogen growth, minimal damage to the host plant, zero input of pesticides from the farmers and most importantly the environment friendly nature of such crops. Efficient and sustained control of pathogens such as bacteria, fungi, oomycetes, viruses, nematodes and insects is an exigency for all agricultural systems. In spite of the continued release of new resistant cultivars, the global yield losses caused by pathogens are substantial.

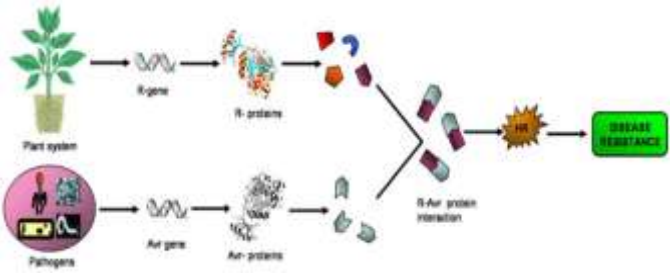
Plant pathogens not only decrease the crop yields, they also lower the crop quality by releasing toxins that affect human health. Moreover, pathogens are constantly becoming resistant to existing resistance genes and pesticides. This situation therefore demands some alternate methods of disease control. Crop improvement programs based on plant disease resistance genes are being optimized by incorporating molecular marker techniques and biotechnology. Therefore, plant resistance genes need to be studied extensively to alleviate the existing problem of pest and diseases apart from the abiotic challenges. Facing selective pressure imposed by the pathogens, plants have evolved post invasion resistance mechanisms, often

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controlled by dominant resistance genes, whose products directly or indirectly detect specific pathogen effectors and trigger effective defense responses. R protein-triggered resistance to various pathogens is normally race-specific and only effective against pathogen strains expressing the cognate effector protein (Avr protein) recognized by the R protein. This resistance is often associated with a hypersensitive response (HR), which is manifested as rapid death of the invaded cell and in some cases a few surrounding cells. The structural and functional analysis of plant resistance genes and R-gene loci is relevant for assembling various resistance sources effectively and for engineering new strategies for disease resistance in agriculture. Apart from that, it is highly desirable to understand the plant-pathogen interaction in order to achieve the said goals (Piquerez *et al.,* 2014). These aspects have been discussed in detail later in the present review which would be beneficial for researchers engaged in plant disease control-based projects. The present article also highlights the concernment of many recent investigations regarding the plant resistance genes and their dispensation in the field of plant disease management strategies.

Plant disease resistance

Plants possess two major types of disease resistance (a) basal defense and (b) R-gene mediated defense. Basal defense which can be a constituent of both non-host and host resistance, provides first line of defense to the infection by a wide range of pathogens. Often, the plant disease resistance is cultivar or accession specific which is referred as host resistance whereas non host resistance is the resistance against pathogens throughout all members of a plant species that is expressed when a plant comes into contact with a pathogen which is incapable of provoking any disease. Elicitors of basal defense can be plant cell wall derived components released by hydrolytic activity of enzymes secreted by invading pathogens, but also common features of the pathogen, referred as pathogen-associated molecular patterns (PAMPs), such as lipopoly-saccharides, chitins, glucans and flagellins. Non-pathogens as well as pathogens can trigger a basal resistance in plants due to the widespread presence of these molecular components in their cells. However, adapted microbes express a suite of effector proteins that often act to suppress these defenses. Subsequently, plants have evolved other receptors (R proteins) that detect these pathogen effectors and activate strong defences (Andolfo *et al.,* 2021).



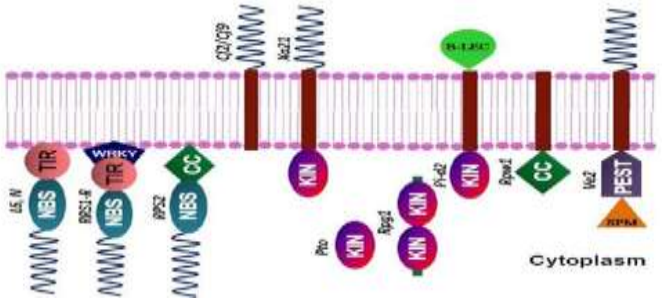
R-gene mediated pathogen resistance

Phytopathogens produce certain molecules called ‘effectors’, encoded by Avr (avirulence) genes, which are delivered directly into the plant cells during initial stage of infection. These effectors either change the physiological state of host plant in

order to benefit pathogen colonization or are used to interrupt the activation of host plant defenses. However, plants have subsequently developed a form of immunity that is based on perception of these proteins by host resistance proteins called R-gene mediated pathogen resistance. In gene-for gene relationships, a plant carrying a resistance gene resists pathogen races with the corresponding effectors. The effectors found in bacteria, virus, nematodes, fungus, oomycetes and insects cause a plant pathogen to elicit a resistance response in a host plant. The effector genes are defined by corresponding resistance genes of which a relatively large number have now been cloned. This resistance response is appended with another reaction called hypersensitive reaction (HR) which is a form of programmed cell death (Barbey *et al.*, 2019). The signaling cascade behind the HR is triggered either when an appropriate disease resistance gene recognizes an effector or by an elicitor of plant defense responses recognized by a specific receptor. Either of these signals accompanied by other factors like influx of Ca2þ ions from the extracellular space and/or anion flux results in an oxidative burst producing reactive oxygen intermediates (ROIs) and defense gene activation, finally resulting in development of local and systemic disease resistance. A well characterized example of HR elicitation through gene-for-gene interaction is provided by the tomato (*Solanum lycopersicon*) Cf-9 gene, which confers resistance to races of the fungus *Cladosporium fulvum* expressing the Avr9 gene. Treatment of leaves of Cf-9 tomato or transgenic Cf-9 tobacco (*Nicotiana tabacum*) with the Avr9 peptide induces HR and Avr9-treated Cf-9 tobacco cell cultures showed rapid production of ROS and activation of MAP (Mitogen Activated Protein) kinases and calcium-dependent protein kinases. The interaction between rice (*Oryza sativa*) and the fungal pathogen *Magnoporthe grisea* (Hebert) Barr (anamorph *Pyricularia grisea* Sacc.) causing the devastating rice blast disease is another example of well documented gene-for-gene system. *M. grisea* has the Avr-Pita gene containing the C-terminal 176 amino acids which functions as an elicitor molecule that directly binds the Pita protein of rice and triggers a signal cascade leading to resistance. Despite several studies and intense efforts with numerous sets of R and Avr proteins, the interaction between R and Avr proteins remained inexplicit and the insufficiency of verifiable R-Avr interactions led to the formulation of the 'guard hypothesis' (Mc Cabe *et al.*, 2018).

According to this model, the R proteins activate resistance when they interact with another plant protein known as guardee protein that is targeted and modified by the pathogen in order to create an appropriate environment. Resistance is initiated when the R protein detects an attack of its guardee or, in some cases when the R protein recognizes the product of the pathogen attack, which might not necessarily involve direct interaction between the R and Avr proteins. To date, the most convincing evidence for the guard hypothesis has

been found in *Arabidopsis thaliana* bacterial R-Avr systems where RIN4 (RPM1- interacting protein 4) was identified as a cellular protein that is required for the resistance to *Pseudomonas syringae* pv. tomato mediated by RPM1 and RPS2. The RIN4 (guardee) is modified in various ways, depending on the Avr that it associates with, and these modifications then serve to activate the corresponding R protein (guard). Another example is the cleavage of the *A. thaliana* kinase PBS1 (guardee) by the cysteine protease AvrPphB from *P. syringae* pv. tomato, which results in activation of RPS5 (guard) - mediated resistance. Recently, it was shown that AvrPphB, a cysteine protease, binds PBS1 and cleaves it, which triggers RPS5- mediated resistance, indicating that RPS5 might sense the integrity of PBS1.



Conclusion

Conscious breeding for disease resistance started early in this century and concentrated on major resistance genes. Soon after resistant cultivars were released farmers were confronted with the versatility of the pathogen; new forms of the pathogen neutralized the introduced resistance (the resistance was said to be "broken"). This did not stop breeders from using such non-durable resistance. On the contrary, the rapid increase of man's effort to produce resistant 35 crops based on major resistance genes was accompanied by an equally rapid increase in "broken" resistance. Even today the situation has not changed much. Screening and selection methods favouring major gene resistance are still widely used by breeders. As a result of the widespread use of such screening and selection methods QR has been used considerably less than major gene resistance, although abundantly present to most pathogens.

References

Andolfo, G., Agostino, N., Frusciante, L. and Ercolano, M, R. (2021). The tomato inter-specific NB-LRR gene arsenal and its impact on breeding strategies. *Gene*, 12(184): 1-12.

Barbey, C. R., Lee, S., Verma, S.,….and Folta, K, M. (2019). Disease Resistance Genetics and Genomics in Octoploid Strawberry. *Journal of. Genetic Genomics*, 9(3315): 1-18.

Mc Cabe, C. E., Cianzio, S. R., Rourka, J. A. and Graham, M. A. (2018). Leveraging RNA-Seq to characterize resistance to brown rot and the Rbs3 locus in soybean. *Molecular Plant Microbes Interactions*, 31(10): 1083-1094.

Omondi, C., Gichimu, B., Cheserek, J. and Gimase, J. (2016). Leveraging on germplasm acquisition for arabica coffee improvement in Kenya. *Journal of Argonomic Crop Science*, 4(1): 9-16.

Piquerez, S. J., Harvey, S. E., Beynon, J. L. and Ntoukakis, V. (2014). Improving crop disease resistance lessons from research on arabidopsis and tomato. *Frontiers in Plant Science*, 5(671): 1-13.

Artificial Ripening of Fruits: A Boon or Bane

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Introduction

The process of ripening is a crucial stage in the life cycle of fruits, determining their taste, aroma, and overall quality. Traditionally, fruits ripen naturally on the tree or vine, but in today's fast-paced world, the demand for quick and efficient ripening has led to the widespread use of artificial ripening methods. One such method involves the use of chemicals like ethylene, ethephon, and calcium carbide. While artificial ripening has its advantages, it also raises concerns about the safety of the practice and its impact on human health and the environment.

The Need for Artificial Ripening

The global demand for fresh and ripe fruits throughout the year has intensified the need for faster ripening methods. Natural ripening is often a time-consuming process, and the transportation of fully ripened fruits over long distances can result in spoilage. Artificial ripening provides a solution to this problem, allowing fruits to be harvested before reaching full maturity and then ripening them at a desired location.

Methods of Artificial Ripening

1. **Ethylene Gas:** Ethylene is a plant hormone that naturally triggers the ripening process. In artificial ripening, ethylene gas is introduced into a controlled environment where fruits are stored. This method is considered relatively safe, as it mimics the natural ripening process without leaving any harmful residues on the fruits.

✓ **Ethephon:** Ethephon is another chemical commonly used for artificial ripening. When ethephon comes into contact with the fruit, it breaks down into ethylene, promoting the release of natural ethylene gas and accelerating the ripening process. This method is widely used in the ripening of tomatoes and pineapples.

✓ **Calcium Carbide:** One of the controversial methods of artificial ripening involves the use of calcium carbide. When calcium carbide comes into contact with moisture, it releases acetylene gas, which mimics the effects of ethylene in triggering ripening. However, this method has raised serious health and safety concerns, as calcium carbide may contain impurities like arsenic and phosphorus.

Advantages of Artificial Ripening

✓ **Year-Round Availability:** Artificial ripening allows consumers to enjoy a variety of fruits throughout the year. This is particularly important in regions where certain fruits have a limited growing season. Artificial ripening extends the

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availability of these fruits, meeting consumer demand and supporting the fruit industry.

- ✓ **Reduced Losses during Transportation:** By harvesting fruits before they reach full maturity and ripening them at a later stage, the risk of spoilage during transportation is significantly reduced. This not only minimizes economic losses for farmers but also ensures a more consistent and reliable supply of fruits to consumers.
- ✓ **Improved Market Efficiency:** Artificial ripening enhances market efficiency by synchronizing the supply and demand for fruits. It enables farmers to harvest their crops at the optimal time, preventing overripening on the tree and allowing for better planning and management of fruit distribution.

Concerns and Controversies:

- ✓ **Health Risks Associated with Calcium Carbide:** The use of calcium carbide for artificial ripening has been a major source of controversy. Calcium carbide may contain impurities such as arsenic and phosphorus, which can pose serious health risks. Consumption of fruits treated with calcium carbide has been linked to various health issues, including gastric problems and long-term health hazards.
- ✓ **Residue on Fruits:** While ethylene and ethephon are considered safer alternatives, concerns persist about the residue left on artificially ripened fruits. Studies have shown that some residues may remain on the surface of the fruit, potentially affecting consumer health. Strict regulations and monitoring are necessary to ensure that residue levels are within acceptable limits.
- ✓ **Environmental Impact:** The production and use of certain chemicals for artificial ripening can have environmental consequences. Improper disposal of calcium carbide residue may lead to soil and water contamination, affecting eco-systems and agricultural practices. Ethylene, while generally safe, can contribute to air pollution if not properly controlled during the ripening process.

Regulatory Measures and Guidelines

In response to the concerns surrounding artificial ripening, many countries have implemented regulations and guidelines to ensure the safety of the process. These measures include:

- ✓ **Maximum Residue Limits (MRLs):** Governments establish MRLs to limit the amount of residues allowed on fruits. Regular monitoring and testing are conducted to ensure that artificially ripened fruits comply with these safety standards.
- ✓ **Use of Approved Chemicals:** Some countries have banned the use of certain chemicals, such as calcium carbide, for artificial ripening. Only approved and safe substances, like ethylene and ethephon, are allowed for use in the ripening process.
- ✓ **Training and Certification:** Farmers and handlers involved in the artificial ripening process are often required to undergo training and certifica-

tion programs. These programs educate them about safe practices and the proper use of ripening agents.

- ✓ **Public Awareness Campaigns:** Governments and non-governmental organizations conduct public awareness campaigns to inform consumers about the risks associated with artificially ripened fruits. This encourages informed choices and promotes a demand for safer and naturally ripened produce.

Conclusion

Artificial ripening of fruits has become a common practice to meet the growing demand for fresh produce. While it offers several advantages, concerns about health risks, chemical residues, and environmental impact cannot be ignored. Striking a balance between the benefits and risks requires strict regulatory measures, responsible agricultural practices, and ongoing research into safer ripening methods.

Consumers play a crucial role in promoting the adoption of safer practices by making informed choices and supporting initiatives that prioritize health and environmental sustainability. As technology advances and new methods of artificial ripening are developed, it is essential to prioritize the well-being of both consumers and the environment to ensure a sustainable and healthy future for the fruit industry.

References

Chowdhury, F., Billal, A. and Ashraf-ur, T. (2008). Artificial Ripening: What we are eating. *Journal of Medicine*, 9. 10.3329/jom.v9i1.1425.

Siddiqui, Md. Wasim and Dhua, R. S. (2010). Eating artiically ripened fruits is harmful. *Current Science*, 99(12).

Ripening- an important process in fruit development, Prof. S. N. Naik, Centre for Rural Development & Technology, IIT Delhi.

Rahman, A., Chowdhury, F. R. and Alam. (2008). Artiicial Ripening: What we are eating. *Journal of Medicine*, 9(1): 42-44

Mursalat, M. Rony, Hasan, A., Abul, R., Islam, Md. and Khan, M. S. (2013). A Critical Analysis of Artificial Fruit Ripening: Scientific, Legislative and Socio-Economic Aspects. 04: 6-12.

Mani, A., Paramanik, B. and Murmu, D. (2021). Artificial Ripening in Fruit Crops - A Boon or Bane.

Cultivation of Grain Amaranth (*Amaranthus hypochondriacus* L.)

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Introduction

The International Year of Nutrient Millets (IYM) was declared by the United Nations in 2023 to raise awareness about the nutritional benefits of millets and promote their consumption worldwide. Millets are a group of small-seeded grasses that are rich in essential nutrients such as iron, calcium, and magnesium.



They are also gluten-free and have a low glycemic index, making them suitable for people with gluten intolerance and diabetes. The IYM aims to highlight the potential of millets in addressing malnutrition and promoting sustainable agriculture. Through various events and campaigns, the IYM seeks to create a global movement for the consum-ption and production of millets, contributing to the achievement of the Sustainable Development Goals. Taking into consideration these points, the present article is written to informed farmers about cultiv-ation practices and Nutritive values of amaranth crop.

Amaranth is one of the important grain as well as vegetable crop in India as well as in many other countries of the world. But very little research work is available on grain amaranth in Agronomy in our country. The grain amaranth has 16% protein, 62% carbohydrates, 8.0% lipids and 3% minerals. The grain amaranth has high quality of protein.They contain essential amino acid such as lysine 5%, methionine 4.0% that are lacking in other cereals (Raiger *et al.*, 2009). Besides this it also has higher amount of folic acid which helps in increasing the blood haemoglobin level. The tender leaves are used as vegetables and are rich in vitamin-A, calcium and iron content.

Grain Amaranth is called as pseudocereal as it is not a member of Gramineae family but it has grain like seeds. In India, it is called under different common name like Rajgara in Gujarat (king of seeds), Ramdana in Bihar (seed sent by god), Anardana in Uttar Pradesh, Chuka in Bengal, Kalaghesa in Central India, Rajgiri (Karnataka), Rajgira and Shravanimath (Marathi), Chaulal and Chau (Uttarakhand), etc. (Solanki *et al.*, 2021). In India, Amaranth is cultivated both in hills as well as plains covering states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Tripura, Jharkhand, Chattishgardh, Maharashtra, Gujarat, Orissa, Karnataka, Kerala and Tamilnadu. It is cultivated as both pure as well as mixed crop during *kharif* and *rabi* season. The exact information



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about grain amaranth area, productionand productivity of national level is lacking.

Cultivation Practices

Selection of site

Soil: Grain Amaranth is adaptable to different types of soil such as sandy, loamy, alkaline and saline soil. It require soil pH of 6.0-7.5. It requires soil temperature range from 18-24^{0}C for optimal growth. (Gelinas and Seguin, 2008). The crop can be grown all year round and can be produced in any type of soil. It requires 40-50% less moisture than maize and it survives betterthan most cereal crops under dry and hot conditions because it has extensive root system and use of C_4 photosynthesis mechanism (Stallknecht *et al*., 1993)

Climate: Grain Amaranth grows in wide range of climatic conditions. It grows best under hot and humid climate. It grows well in optimum temperature rangeof 30-35^{0}C, although it tolerates drought, low fertility and adverse climatic condition. Grain amaranth drought tolerance is due to its C_4 metabolism as well as deep and extensive root system which is efficient in use of sunlight and nutrients under dry and high temperature condition. It has ability to go dormant under extreme drought condition. It requires wet condition during germination and early establishment. Itcan be grown well in areas where the annual rainfall is 390 mm-550 mm.

Field Preparation: Grain amaranth being a small seeded crop requires a fine seed bed for proper seed soil contact and good germination. For this purpose, soil is turned with a mould board plough prior to once of rains. This is followed by two to three ploughing sand plankings on receipt of soaking rains. At the time of sowing, the field must have fine grain structure, adequate moisture and should be free from weeds.

Improved Varieties

Phule Kartiki: This variety of amaranth was released by MPKV, Rahuri in 2010. It matures within 110 to 120 days after sowing. This variety have good popping ability and contain 13.80% protein. The inflorescences are yellowish green colour, straight, smooth and intermediate, seed colour is pale yellow. The average grain yield of this variety in *rabi* season is 1400-1500 kg ha^{-1}. Beside this Suvarna, Annapurna and G.A-1 Varieties are also used for cultivation of amaranth crop.

Sowing

Sowing time: The crop is generally sown either in *rabi* or *kharif* season. In hills, it isgrown in *kharif* season but in plain it is cultivated in *rabi* season and is sown in the month of October-November.

Crop Spacing: Sowing the seeds 2 cm deep in rows with spacing of 45 cm and 10-15 cm distance between plants have been observed to give good yields.

Seed rate: A seed rate of 1.5 kg ha^{-1} is enough for obtaining desired plant stand. If the rains are delayed in *kharif* and irrigation is not available in time during *rabi* season, dry sowing can also be done. The seeds will germinate after downpour or as and when irrigation is given. For obtaining desired plant stand for effective germination, the seeds of amaranth is

mixed with sand at rate of 1 gram seed per 100 gram of sand plant population density has a significant effect on grain yield with highest yields achieved at the lowest populations.

Intercultivation: Gap filling was done immediately after emergence. Thinning was done at 20 days after sowing. To keep the crop weed free, hand weeding was done twice to remove weeds in plot at 25 and 40 DAS.

Fertilizer requirement: There is only limited information available on the fertilizer requirement of grain amaranths but nitrogen is reported as a primary limiting factor in grainamaranth production (Pospisil *et al*., 2006). The crop gives a good response up to application of fertilizer dose of 60:40:20 kg NPK ha^{-1} (Raiger *et al.*, 2009). The fertilizer was applied in two splits as per the treatment. Basal dose consisted of half dose of nitrogen and full dose of phosphorous and potassium through urea, single super phosphate and muriate of potash respectively and remaining half dose of nitrogen was applied 30 days after sowing through urea. High Nitrogen application reduces grain yield and promotes excessive vegetative growth and making the plants more susceptible to lodging.

Weed Control: Weeds compete with the crop for space, light, nutrients and moisture and can cause considerable loss if not controlled in time. The period between 20 to 50 days after sowing (DAS) has been observed to be critical for crop-weed competition ingrain amaranth. Therefore, two hand weedings at 25 and 40 DAS or pre-emergent application of Oxyflurofen @ 50 g ha^{-1} with one hand weeding at five weeks after sowing are recommended for effective weed control.

Irrigation: Grain amaranth is mostly grown as rainfed crop in the hills during *kharif* season. However, in plains, when grown during *rabi* season, it has been found to respond favourably to application of irrigations. Depending upon these conditions about 3-4 irrigations are sufficient for getting good yield in amaranth.

Suitable intercrop systems: Amaranth is usually grown in crop mixtures. Intercropping amaranth with French bean, rice bean, ragi, groundnut and pigeonpea have been found profitable. Simply mixing seeds of different crops and broadcasting may not given desired results. However, to obtain maximum advantage from the mixed crop and to facilitate separate harvesting of component crops, the crops should be sown in different lines and in appropriate row ratios. In hills, intercropping French bean and amaranth in 2:1 ratio and applying fertilizer doze recommended for French bean only (N:P:K @ 20:40:20 kg ha^{-1}) resulted in highest B:C ratio (2.57).

Plant Protection: There is no report of serious problem for pests and diseases in this crop. However, leaf head blight, white rust, damping off, mycoplasma and viral diseases may affect this crop. Among insect pests, leaf webber, caterpillars, aphids, blister beetle, flea beetle, bugs, stem weevil and stem borer have been reported to affect this crop. Use of certified seeds, disease resistant varieties and spray-

ing of insecticide sand fungicides are recommended for management of insect pests and diseases.

Harvesting: Grain amaranth has a short growing period. The grain amaranth can be harvested at 110-120 days. After harvesting of crop bundles were kept in threshing yard. After complete drying it was threshed, winnowed and cleaned and the seed was collected.



Yield: The average productivity of grain amaranth is estimated around 14-16 q ha^{-1}. There is an ample scope for increasing the yield of grain amaranth in India through efficient agronomic management of the crop.

Conclusion

By adopting improved technologies and varieties as described above, the yield of grain amaranth in hills and plains can be substantially increased. It will not only increase economic condition of the farmers dwelling in the hills and plains, but will also enhance the availability of nutritious food to check malnutrition in human being. There is a lot of scope for increasing the yields of grain amaranth in India by using efficient agronomic management practices of the crop.

References

Gelinas, B. and Sequin, P. (2008). Evaluation of management practices for grain amaranth Production in Eastern Canada. *Agronomy Journal*, 100: 344-351.

Pospisil, A., Pospisil, M., Varga, B. and Svecnjak, Z. (2006). Grain yield and protein concentration of two amaranth species (*Amaranthus spp.*) as influenced by the nitrogen fertilization, *European Journal of Agronomy*, 25(3): 250-253.

Raiger, H. L., Phogat, B. S., Dua, R. P. and Sharma, S. K. (2009). Improved varieties and cultivation practices of grain amaranth. *Intensive Agriculture*, 8-17.

Solanki, R. S., Bhut, N. M., Joshi, D. P., Prajapati, C. D. and Kumar, R. (2021). Grain Amaranth (*Amaranthus hypochondriacus* L.): A new millennium crop of pseudo-cereals. *Agri. Articles*, 01(05): 39-47.

Stallknecht, G. F. and Schulz-Schaeffer, J. R. (1993). Amaranth rediscovered. (In. J. Janick and J.E. Simonceds). New Crops. Wiley, New York. 211-218.

Conventional vs Organic Farming: Future of Food Security

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Abstract

Organic Agriculture is often perceived as most sustainable as conventional farming. We review the literature on this topic from a global perspective. In terms of environmental and climate change effects, organic farming is polluting than conventional farming when measured per unit of land but not when measured per unit of output. Organic farming which currently accounts for only 1% of global agricultural land, is lower yielding on average. Due to higher knowledge requirements, observed yield gaps might further increase if a larger number of farmers would switch to organic practices. Widespread upscaling of organic agriculture would causes additional losses of natural habitats and also entail output price increases, making less affordable for poor consumers in developing countries. Organic farming is not the paradigm for sustainable agriculture and food security, but smart combinations of organic and conventional methods could contribute towards sustainable productivity increases in global agriculture. High yielding varieties and breeds, synthetic inputs, mechanization, better plant protection and health care systems and good management practices have boosted crop yields and livestock productivity.

Introduction

Global food production has grown considerably in the past few decades. The daily average calorie consumption of the world has likewise risen considerably from 2550 kcal person^{-1} day^{-1} in 1981 to 2800 kcal person^{-1} day^{-1} in 2003 (FAOSTAT, 2005). In simple terms, the existing global food production would be sufficient to provide everyone with the minimum calorie needs if the available food could be distributed according to need (Von Braun *et al.*, 2003). However, a recent report on food insecurity in the world showed that there are still 848 million undernourished people in the world of whom 830 million live in developing countries and most of them in rural areas (FAO, 2008). India is home to 231 million undernourished people (175 million concentrated in rural areas), which is more than the number of malnourished in Sub-Saharan Africa (FAO, 2008). India, home to one sixth of the world's population, has achieved self-sufficiency in food grain production because of the intro duction of high-yielding crop varieties, the use of chemical fertilizers and extension of irrigation facilities, which is commonly referred to as the green revolution. Despite the green revolution, India has not been able to achieve the next quantum leap in the production potential of domestically important crops like rice, wheat and pulses for the past two decades.

Conventional Farming

✓ The prevailing agricultural system, variously

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called "conventional farming," "modern agriculture," or "industrial farming," has delivered tremendous gains in productivity and efficiency. Food production worldwide has risen in the past 50 years; the World Bank estimates that between 70 percent and 90 percent of the recent increases in food production are the result of conventional agriculture rather than more significant acreage under cultivation. U.S. consumers have come to expect abundant and inexpensive food.

- ✓ Conventional agriculture is dependent on large investments in mechanized equipment powered mostly by fossil fuels. This has made agriculture efficient, but has had an impact on the environment. Cotton Harvest by Kimberly Vardeman is licensed under CC BY 4.0.
- ✓ Conventional farming systems vary from farm to farm and from country to country. However, they share many characteristics such as rapid technological innovation, large capital investments in equipment and technology, large-scale farms, single crops (monocultures); uniform high-yield hybrid crops, dependency on agribusiness, mechanization of farm work, and extensive use of pesticides, fertilizers, and herbicides. In the case of livestock, most production comes from systems where animals are highly concentrated and confined.
- ✓ However, most farmers that use conventional methods still focus heavily on soil health and improving upon their natural resources.
- ✓ For instance, one of the biggest environmental successes of commodity-crop production in the U.S. has been the adoption of no-till farming practices, a type of production that eschews tillage and focuses on soil fertility. No-till farmers plant their cash crops into previously planted cover crops. However, because they aren't using tillage, weed control becomes an issue forcing many no-till farmers to depend upon chemical herbicides.

Organic Farming

- ✓ Organic farming is a method of agricultural production that emphasizes sustainable practices, avoiding synthetic chemicals like pesticides and fertilizers. It promotes soil health, biodiversity, and animal welfare, relying on techniques like crop rotation, composting, and natural pest control. Organic farming aims to produce food in harmony with nature while minimizing environmental impact.
- ✓ Organic farming can contribute positively to food security by promoting sustainable agricultural practices that enhance soil fertility, biodiversity, and resilience to climate change.
- ✓ It reduces reliance on synthetic inputs, conserves water and minimizes environmental degradation.
- ✓ Additionally, organic farming methods often prioritize local production and diverse crop varieties, which can increase access to nutritious foods and support local economies, thereby improving food security at both local and global levels.

Conventional farming typically relies on syn-

thetic fertilizers, pesticides, and genetically modified organisms (GMOs), while organic farming emphasizes natural methods like composting, crop rotation, and biological pest control. The main difference lies in their approach to soil and crop management, with conventional focusing on high yields and efficiency through technology, and organic prioritizing soil health, biodiversity, and sustainability. Below table explains the differences of conventional and organic farming.

Table 1: Difference between Conventional and Organic Farming

Conventional	Organic
It is based on economical orientation	It is based on ecological orientation
GMOs are used	GMOs are not used here
Synthetic fertilizers are used	Synthetic fertilizers are not used
Weeds are controlled through herbicides	Manually weeds are removed here
Pesticides and fungicides are used to control pest and diseases	Pest and diseases are controlled biologically
Produce obtained will have chemical residues accumulated in it	Produce is free from chemical residues
Air, Water and soil pollution is common	No such problem are observed here
Produce is carcinogenic and causes several health problems	No such problems are observed here
Low input : output ratio with pollution	Optimum input: output ratio with no pollution
Soil fertility is maintained for shorter period	Soil fertility is maintained on long term basis
Intensive irrigation is required	Irrigation requirements are reduced

Ecological Concerns

- ✓ Decline in soil productivity can be due to wind and water erosion of exposed topsoil, soil compaction, loss of soil organic matter, water holding capacity, and biological activity; and salinization (increased salinity) of soils in highly-irrigated farming areas.
- ✓ Agricultural practices have been found to contribute to non-point source water pollutants that include salts, fertilizers (nitrates and phosphorus, especially), pesticides, and herbicides. Pesticides from every chemical class have been detected in groundwater and are commonly found in groundwater beneath agricultural areas. Eutrophication and “dead zones” due to nutrient runoff affect many rivers, lakes, and oceans.
- ✓ Other environmental ills include over 400 insects and mite pests and more than 70 fungal pathogens that have become resistant to one or more pesticides. Pesticides have also placed stresses on pollinators and other beneficial insect species. This, along with habitat loss due to converting wildlands into agricultural fields, has affected entire ecosystems.
- ✓ Agriculture’s link to global climate change is just beginning to be appreciated. Destruction of tropical forests and other native vegetation for agricultural production has a role in elevated levels of carbon dioxide and other greenhouse gases. Recent studies have found that soils may be large reservoirs of carbon.

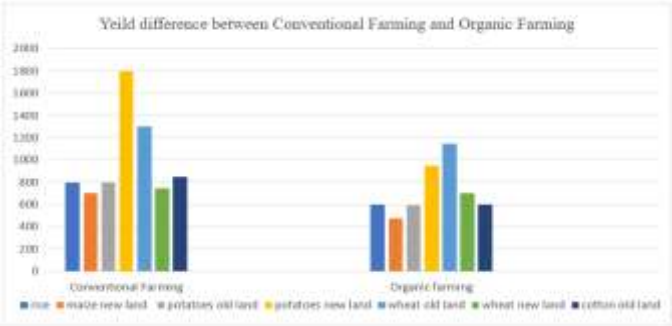
Economic and Social Concerns

- ✓ Economically, the U.S. agricultural sector includes a history of increasingly large federal expenditures. Also observed is a widening disparity among the income of farmers and the escalating concentration of agribusiness industries involved with manufacture, processing, and distribution of farm products into fewer and

fewer hands. Market competition is limited and farmers have little control over prices of their goods, and they continue to receive a smaller and smaller portion of consumer dollars spent on agricultural products.

- ✓ Economic pressures have led to a tremendous loss to the number of farms, particularly small farms, and farmers during the past few decades. More than 155,000 farms were lost from 1987 to 1997. Economically, it is very difficult for potential farmers to enter the business today because of the high cost of doing business. Productive farmland also has been swallowed up by urban and suburban sprawl since 1970, over 30 million acres have been lost to development.

Which is a More Profitable Farming System?



The profitability of organic farming versus conventional farming can vary depending on several factors such as location, crop types, market demand, input costs, and government subsidies. Organic farming often commands higher prices for products due to consumer demand for organic produce, but it can also have higher production costs. Conventional farming may have lower input costs but can face challenges such as price volatility and potential environmental externalities. Ultimately, the profitability of each method depends on the specific circumstances of the farm and market conditions. Graph of Yield of some mentioned crops are taken to consideration and explained the budget of their farming style.

Conclusion

Both organic farming and conventional farming play vital roles in ensuring food security for the future. Organic farming offers benefits such as reduced chemical usage and environmental sustainability, while conventional farming provides higher yields and efficiency. The future of food security lies in a balanced approach that integrates the strengths of both methods, prioritizing sustainability, environmental stewardship, and nutritional quality to meet the demands of a growing global population. Collaboration, innovation, and informed decision-making will be key in shaping a resilient and sustainable food system for generations to come.

References

Acs, S., Berentsen, P. B. M. and Huirne, R. B. M. (2005). Modelling conventional and organic farming: a literature review. *NJAS: Wageningen Journal of Life Sciences*, 53(1): 1.

Mondelaers, K., Aertsens, J. and Van Huylenbroeck, G. (2009). A meta-analysis of the differences in environmental impacts between organic and conventional farming. *British Food Journal*, 111(10): 1098-1119

Patil, S., Reidsma, P., Shah, P., Purushothaman, S. and Wolf, J. (2014). Comparing conventional

and organic agriculture in Karnataka, India: Where and when can organic farming be sustaiable?. *Land Use Policy*, 37: 40-51.

Wood, R., Lenzen, M., Dey, C. and Lundie, S. (2006). A comparative study of some environmental impacts of conventional and organic farming in Australia. *Agricultural Systems*, 89(2-3): 324-348

Success Story of Sukhdev Singh: The Way Forward for Sustainable Agriculture

Lalita Bhayal, Divya Bhayal and Aakash

Mr. S. Sukhdev Singh, a resilient farmer hailing from the quaint village of Bhullar Bet in Kapurthala district, Punjab, India, embodies the epitome of agricultural success. Despite his modest beginnings and limited formal education up to matriculation, Mr. Singh's journey in agriculture commenced at a tender age, inheriting land that was initially barren and saline, devoid of irrigation facilities, and yielding minimal returns.

Determined to transform his inherited land, Mr. Singh embarked on a transformative journey under the land reclamation program. Through the strategic application of gypsum, he witnessed a remarkable enhancement in soil fertility, laying the foundation for his remarkable agricultural evolution. Transitioning from the conventional paddy-wheat cropping system, he diversified his crops to include sugarcane, potato, mustard, berseem, and maize, capitalizing on the improved soil conditions.

Through unwavering dedication and relentless perseverance, Mr. Singh's agricultural endeavors began yielding substantial returns. Today, he oversees the cultivation of 74 acres of land, cultivating a diverse range of crops, and serving as a beacon of inspiration for others. His remarkable transformation from rags to riches exemplifies the quintessential success story of a visionary farmer.

Guided by the expertise of extension centers such as Punjab Agricultural University, Ludhiana, and Farm Advisory Service Center (FASC), Kapurthala, Mr. Singh honed his agricultural acumen. Leveraging his profound knowledge of agriculture and allied sectors, he embraced the cultivation of improved crop varieties, significantly enhancing his productivity and yield.

Embracing innovation and sustainability, Mr. Singh adopted advanced agricultural practices such as underground pipeline irrigation systems to mitigate water loss through evaporation. Furthermore, he strategically stores his agricultural produce, including basmati and maize, in storage structures to capitalize on favorable market conditions, ensuring economic stability.

A forward-thinking farmer, Mr. Singh harnesses technology to his advantage, utilizing smartphones and the internet to access real-time market rates, weather forecasts, and cutting-edge agricultural technologies. His altruistic spirit extends

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to sharing this valuable information with fellow farmers, fostering a culture of mutual growth and prosperity.

Moreover, Mr. Singh's commitment to agricultural experimentation and collaboration with scientists has led to groundbreaking discoveries. His innovative approach, such as implementing alternate wetting and drying techniques for wheat cultivation, has significantly enhanced germination, tillering, and overall productivity.

Committed to sustainable agricultural practices, Mr. Singh adheres to district administration directives, employing techniques such as Happy Seeder for wheat and oats fodder cultivation, thus eliminating the need for paddy straw burning. By integrating environmental stewardship with agricultural productivity, he exemplifies the essence of sustainable farming.

He has an uncanny flair for growing diverse crops such as wheat, rice, basmati, oats, turmeric and marigold. This cropping pattern fetches him a gross annual income per acre of Rs. 30,000/- from wheat, Rs. 40,000/- from rice, Rs. 27,000/- from basmati, Rs. 40,000/- from maize, Rs. 20, 000/- from oats, Rs. 2,40,000/- from turmeric and Rs. 30,000/- from marigold cultivation. He also maintains a dairy enterprise comprising 9 milch animals. Four buffaloes and five H.F. Cows produce about 126 quintals of milk per annum. After sparing milk for domestic consumption, the surplus milk is sold to dairy units, which fetches him an annual income Rs. 3,78,000/-. Mr. Singh has been bestowed with Dalip Singh Dhaliwal Memorial Award for crop diversification by PAU Ludhiana in 2017. He is a successful amalgamation of modern farming using agrotechnologies, economic prosperity and human values combined with simplicity, thriftiness and knowledge.

Success Story of Abhishek Jain: The 'Lemon King' of Rajasthan

Divya Bhayal, Aakash and Lalita Bhayal

Abhishek Jain, originally from the Bhilwara district in Rajasthan, has transformed the traditional farming landscape into a thriving enterprise, earning himself the title of the 'Lemon King' of his city. His journey is a testament to determination, resilience, and a passion for modern agricultural practices.

Abhishek, a commerce graduate, initially pursued a career in the corporate world by establishing his own company. However, fate took a different turn with the untimely demise of his father. This event prompted Abhishek to make a pivotal decision: to close his company and return to his roots in farming.

Challenges Faced

In the beginning, Abhishek faced numerous challenges due to a lack of guidance and information. Undeterred, he took bold steps like replacing his guava orchard with pomegranate trees. Despite initial setbacks, he persevered and found a turning point when the internet connected him to valuable resources, particularly through WhatsApp groups where farmers shared insights and information.

Diversification of Land

Currently managing 6 acres of land, Abhishek has strategically allocated his resources, dedicating four acres to lemon cultivation, one and a half acres to guava, and the remaining half acre to a cowshed. The diversification doesn't end there, he has ventured into food processing, particularly pickles, contributing significantly to his overall profits.

Establishing Own Company, 'Pickle Junction'

In 2016, he started making the pickle commercially, selling between 500-700 kg, every year. A 900 gm bottle is priced at Rs 200, with additional nominal charges for packing and shipping.



"Lemons have changed my life. My average income from 1.75 acres of lemons is Rs 6 lakh, with nearly Rs 1-1.5 lakh as expenditure," he beams.

The inception of 'Pickle Junction,' Abhishek's brand, shows his entrepreneurial spirit. Not confined to local markets, Abhishek has embraced the digital era, selling his pickles on Amazon, reaching a wider audience, and expanding his business horizons. Approximately 20 percent of his lemon crop finds its

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way into delectable pickles, while the rest graces the traditional markets.

Abhishek's orchard shows his meticulous planning, featuring a mix of lemon varieties, including a perennial type and the locally renowned ‘Kagzi’ lemon, known for its thin peel. In the guava domain, his farm hosts varieties like ‘Barafkhana’ and several others, showcasing a commitment to bio-diversity and quality

Abhishek Jain's journey is not merely a tale of agricultural success but a narrative of adaptation, learning, and community building. As the ‘Lemon King,’ he stands as an inspiration for aspiring farmers, proving that innovation, coupled with shared knowledge, can transform challenges into opportunities and cultivate a prosperous future in the heartlands of India.

Climate Change and Food Security: A Looming Catastrophe for Global Agriculture

Rishabh S. Gaur and Biswajit Mallick

Abstract

Climate change is a real and present worry in today's globe, affecting many aspects of the earth, including agriculture. This essay critically investigates the substantial impact of climate change on global food security, revealing the deep links between climatic shifts and agricultural disturbances. As temperatures rise, harsh weather events intensify, and precipitation patterns shift, agricultural systems' stability faces unprecedented challenges. The project investigates the far-reaching effects of climate change on agriculture yields, water supplies, and the livelihoods of vulnerable communities.

Introduction

Climate change is one of the most urgent issues of our day, affecting many aspects of our globe, including agriculture. The complex web of interactions between climate, weather patterns, and food production has been altered, with serious implications for global food security. As temperatures increase, harsh weather events become more often, and precipitation patterns change, agricultural systems' stability is jeopardized. This article investigates climate change's multidimensional influence on food security, focusing on agricultural yields, water resources, and the lives of vulnerable communities.

What is climate change?

It refers to a shift in the condition of the climate that may be detected (e.g., using statistical tests) by changes in the mean and/or variability of its attributes and lasts for a long time, generally decades or longer. It refers to any long-term climate change, whether caused by natural variability or human activities. Climate change is closely tied to global warming, greenhouse gas emissions, and other human activities. Climate change has harmed human health, the economy, and concerns food security.

What is food security?

It refers to a shift in the condition of the climate that may be detected (e.g., using statistical tests) by changes in the mean and/or variability of its attributes and lasts for a long time, generally decades or longer. It refers to any long-term climate change, whether caused by natural variability or human activities. Climate change is closely tied to global warming, greenhouse gas emissions, and other human activities. Climate change has harmed human health, the economy, and concerns food security.

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Effects of Climate Change causing Global Disasters: According to a recent IPCC estimate, if temperatures rise by 1.5°Cover pre-industrial levels this century, an extra 122 million people may face severe poverty by 2030, primarily owing to rising food prices and poor health. Between 2006 and 2016, agriculture accounted for 26% of overall damage and loss from climate-related disasters in developing nations. Currently, one-third of our food production is lost or squandered. This costs up to USD 2.6 trillion year, including USD 700 billion in environmental costs and USD 900 billion in social costs. Climate change is predicted to place extra strain on water systems, increasing competition for water, impacting regional water, energy, fisheries, and food security, as well as public health.

Impact of climate change on food security: Climate change is already reducing food security and nutrition. Climate change effects all four elements of food security, namely availability, access, use, and stability. Global food security improved considerably in the twentieth century, despite the fact that the world's population grew from 2 to 6 billion. While some may believe that large-scale producers provide the majority of global food security, research since AR5 has shown that small and medium-sized food producers in Asia, Africa, and Latin America play an important role in global food security and nutrition, despite being highly vulnerable to the effects of climate change.

Mechanisms for Climate Change Impacts on Food Security: Climate change is increasing the number of people facing food insecurity by increasing the frequency and intensity of climatic impact drivers (CIDs) such as excessive heat, drought, and flooding. Increasing CO_2 concentrations benefits food and forage crops but reduces nutrient concentrations in food crops. CIDs increase the number of persons who face food insecurity. Countries that face CIDs such as excessive heat, severe drought, or floods, as well as those whose populations rely heavily on rainfed agriculture or livestock for their livelihoods and food supplies, have seen an increase in food insecurity as a result of climate change effects.

Impact on food Availability: Climate change has damaged all food production systems (crops, livestock, marine, fish, mixed, and aquaculture), and it is likely to have a greater influence in the future. Changes in land quality, precipitation, temperature, and the availability of gases in the atmosphere have a significant impact on crops. Crops in temperate places may improve productivity as temperatures rise, but other climate change-related problems such as drought, unexpected rainfall, heat waves, and coastal storms cause far more damage than production. The loss of work productivity caused by climate change-related heat stress is becoming more prevalent. Climate change reduces agricultural labor productivity by increasing the intensity and frequency of heat stress episodes, making individuals who conduct manual labor in high humidity and ambient temperatures the most vulnerable.

Impacts on food access: Increased extreme occurre-

nces (e.g., droughts, floods, and tropical storms) caused by climate change are important causes of recent increases in food poverty and severe food crises in some countries. The shift in global agricultural patterns would affect the balance of food demand and supply. With demand exceeding supply, the price of food is bound to rise. Extreme weather events limit physical and economic access to food, raise food prices, and exacerbate underlying causes of food insecurity and malnutrition, such as a lack of various healthful foods and safe water.

Case study on Desert locust; Climate as compounding effect on food security: Desert locust swarms infected Eastern Africa around the end of 2019, causing significant crop and pasture damage and putting food security and lives at risk. The FAO estimates that approximately 200,000 acres of crop and pastureland were devastated, leaving 2 million people in the region extremely food insecure. Two tropical cyclones formed desert lakes in a normally dry region of Saudi Arabia, facilitating the desert locust infestation. Moist soils, high temperatures, and plenty of flora created an ideal setting for desert locust reproduction and migration to Yemen and Somalia, where the pest went unchecked owing to warfare and spread to neighboring nations. A number of political and socioeconomic flaws, such as armed conflict, limited financial resources, and a lack of early response, exacerbated the impact of the present invasion, making it the most destructive in 70 years.

Impacts on food utilization: Food usage refers to how the body consumes food most efficiently, which includes food preparation, food quality, and intra-household distribution. Climate change affects food use in a variety of ways, including food safety, dietary diversity, and quality. Climate change has raised food safety threats, such as foodborne zoonotic animal illnesses and marine toxins derived from HABs and mycotoxins. Weather unpredictability and severe events have lowered the availability and accessibility of different foods for sale and purchase in rural markets, limiting access to inexpensive, diversified foods for both rural small-scale farmers and net consumers.

Impacts on food stability: Climate change has already altered the beginning and length of the growing season, as well as increasing rainfall unpredictability in some areas, affecting food intake, nutritional status, and income for low- and small-scale farmers. To date, evidence shows that climate change has a detrimental influence on food supply stability in the medium to long term, undermining food security. The increasing frequency and severity of severe weather events caused by climate change are key factors reducing food stability, since they lower availability, increase local price volatility, impair livelihoods for food producers, and disrupt food transportation.

Reaching Sustainable Development Goal 2: Current forecasts show that the UN SDG2 (Zero Hunger) by 2030 will most likely not be met, with climatic impacts on one of numerous determinants of food security and nutrition impeding progress, notably in Africa, Small Island States, and South

Integrated Policies.

Strategies to cope up with the food insecurity

Risk reduction: One cannot reverse the actions that have produced climate change, but one can certainly prevent it from worsening. Risk reduction often refers to initiatives to decrease and avoid the release of greenhouse gasses.

Risk management: It refers to mitigating the consequences of climate change. Improve the irrigation facility. Agriculture makes use of scientific equipment, improved seeds, and fertilizers, among other things. Improve agricultural research into drought-tolerant crops.

Risk coping: Disaster preparation techniques. Diversifying to include climatically appropriate crop and animal types, as well as modifying land use and cropping patterns. Public policies that prioritize vulnerable and marginalized people. Individual, governmental, and global attempts to mitigate the effects of climate change.

Conclusion

The effects of climate change on food security are evident and diverse. The implications are far-reaching, affecting crop production and increasing water scarcity, as well as risking vulnerable populations' livelihoods. Urgent and coordinated efforts are required at the local, national, and international levels to address the underlying causes of climate change and establish agricultural adaptation methods.

References

Portner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., Begum, R. A., Betts, R., Kerr, R. B., Biesbroek, R. and Birkmann, J. (2022). Climate change 2022: Impacts, adaptation and vulnerability (p. 3056). Geneva, Switzerland: IPCC.

Boliko, M. C. (2019). FAO and the situation of food security and nutrition in the world. *Journal of Nutritional Science and Vitaminology*, 65 (Supplement), pp. S4-S8.

Nakai, J. (2018). Food and Agriculture Organization of the United Nations and the sustainable development goals. *Sustainable Development*, 22: 1-450.

Joint, F. A. O. (2011). Food and Agriculture Organization of the United Nations. Caramel Colours. Combined Compendium of Food Additive Specification, Monograph, 11: 1817-7077.

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M. and Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *Science*, 327(5967): 812-818.

Dasgupta, S. and Robinson, E. J. (2022). Attributing changes in food insecurity to a changing climate. *Scientific Reports*, 12(1): 1-11.

Kuriachen, P., Aiswarya, S. and Aditya, K. S. (2021). Climate Change and Food Security: Two Parallel Concerns. *Climate Change and Resilient Food Systems: Issues, Challenges, and Way Forward*, pp. 399-414.

Addressing Farmer Suicides in India: Unravelling Causes, Consequences and Role of Agricultural Extension

Rishabh S. Gaur and Biswajit Mallick

Abstract

The study dives into the disturbing occurrence of farmer suicides in India, seeking to understand the complex reasons and socioeconomic ramifications of this long-standing epidemic. As India maintains its rural and agricultural character in the twenty-first century, the negative consequences of causes such as land rights loss, growing indebtedness, and nutritional degradation have pushed the agrarian problem to the forefront. In tackling these difficulties, emphasize the critical role of agricultural extension in reducing farmer suicides. The proposed measures include awareness and education, financial counselling, technology adoption, mental health assistance, government policy lobbying, livelihood diversification, community development, market connections, and post-suicide support.

Introduction

Even in the twenty-first century, India remains a rural and agricultural country in terms of people's means of subsistence. (Reddy and Mishra, 2010). The negative consequences of losing land rights owing to debt and deteriorating nutrition for the poorest majority of communities, as well as a rise in farmer suicide cases worldwide, have made the agricultural crisis more visible in recent years. Patnaik (2003); Behere *et al*. (2021). The key symptoms of this agricultural crisis include farmer suicides, farmer demonstrations, the destruction of farming sectors, and many farmers' relocation away from agriculture. In India, farmer suicide is defined as the purposeful taking of one's own life by someone who relies on farming for a living.

Suicides in India: The NCRB gathers statistics on suicides from police records. The "Accidental deaths and suicides in India" report released by the National Crime Reports Bureau (NCRB), Ministry of Home Affairs, Government of India, was used as a secondary source. For non-census years, the suicide rate was computed using predicted population, but for the census year 2011, the population from the Census 2011 Report was utilized. A total of 1,64,033 suicides were recorded in the country in 2021, up 7.2% from 2020, while the suicide rate climbed by 6.2% in 2021 compared to 2020.

Suicides rates in Farming in India: Up till 2021, both farmers and agricultural labourers are included in the data on farming-related suicides that have been compiled. According to the research, 10,881 people

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working in the farming industry (including 5,318 farmers/cultivators and 5,563 agricultural labourers) committed suicide in 2021, accounting for 6.6% of the country's total suicide victims (1,64,033). Out of 5,318 farmer/cultivator suicides, 5,107 were men and 211 were women. Out of the 5,563 suicides committed by agricultural labourers in 2021, 5,121 were male and 442 were female.

Causes of Farmers Suicides in India: There are numerous reasons why Indian farmers commit suicide. They might be societal and financial factors which are as follows:

- ✓ **Environmental catastrophes:** A favourable climate is critical for agricultural output. The natural environment has deteriorated over time due to deforestation and other human-caused problems. They become insolvent as a result of recurrent losses, and the frustration leads them to commit suicide.
- ✓ **Poor income:** Rural farmers typically incur excessive debt. Farmers are in debt due to poor earnings, forcing them to deal with a variety of social and financial challenges.
- ✓ **High Input Costs:** The cost of production is increasing because to the requirement for funds for digging, soil care, insecticides, pesticides, cutting, transportation, and product sales. Furthermore, hybrid seeds, which are extremely expensive and out of reach for small-scale and poor farmers, are required for high-quality and abundant production. Farmers are driven to commit suicide as production expenses rise.
- ✓ **Sources of credit:** Loans for agricultural uses include digging wells, building pipelines, and purchasing seeds, beehives, tractors, and other farm equipment. However, there are several difficulties and challenges when a bank makes such a large loan to farmers. So traditional financing sources such as savkar and money lenders assist them and grant loans quickly, but they demand extremely high interest rates despite accepting all of these issues.
- ✓ **Social and psychological factors:** Farmers in India sometimes face social stigma and a lack of community support, exacerbating their sentiments of isolation and despondency. Many farmers avoid getting help when they suffer from depression, anxiety, or other mental health issues due to the stigma associated with them.
- ✓ **Lack of Government Support:** Farmers in India frequently lack access to necessary infrastructure, such as irrigation and storage facilities, which may help them raise yields and gain higher prices for their goods. Furthermore, government regulations and subsidies are frequently insufficient or poorly administered, forcing farmers to suffer the brunt of market swings.
- ✓ **Loss of Livelihoods:** When farmers commit suicide, their families lose their primary source of income, which can lead to severe financial troubles. The loss of the family patriarch by suicide at a young age disrupted the whole family and had far-reaching ramifications. This lack of resources may lead to a vicious cycle of poverty

that is difficult to break.

- ✓ **Rural-urban migration:** Farmer suicides have spurred migration, as individuals from rural regions seek jobs and better economic opportunities in cities. This shift has put a pressure on urban infrastructure, contributing to the growth of slums and other informal communities.
- ✓ **Economic Losses:** Farmers' suicides have caused financial losses in the agricultural business, which is a vital driver of India's economy. When farmers commit suicide, their property is generally left fallow, resulting in a decline in agricultural productivity, which can jeopardize food security and lead to price increases.
- ✓ **Social Disruption:** Suicide among farmers frequently disrupts the social fabric of rural communities. The loss of a family member can cause social isolation and stigma among remaining family members, affecting their mental health and well-being. Following a spontaneous and secret act of suicide by the family leader or a young member of the family, other family members had serious psychological consequences.

Durkheimian theory and Farmer Suicides: Anomic suicide is a sort of suicide committed by a person following a sudden and unexpected event in their life. The majority of farmers committed suicide due to unexpected circumstances, such as agricultural loss caused by natural catastrophes or a lack of help from the bureaucracy and government. Durkheim believed that a person's estrangement from society leads to egoistic suicides. Alienation comprises destroying social bonds, isolating oneself from others, decreasing social relationships, and so on. As previously said, a farmer who has lost everything would see himself as a failure and think that he is no longer a useful part of his family or society. This sentiment stems partly from how society has behaved to farmers. Using Emile Durkheim's study and applying it to the context of farmer suicides in India, we may infer that the majority of farmer suicides belong to one of Durkheim's two forms of suicide: anomic or egoistic.

Role of Agricultural Extension in mitigating Farmers suicides: Agricultural extension plays a critical role in reducing hardship and farmer suicides in India by providing farmers with assistance, information, and resources. Here are some of the techniques we may use to decrease farmer suicides:

- ✓ **Awareness and Education:** Agricultural extension services may help farmers learn about sustainable agricultural techniques, climate-resilient agriculture, and effective input management. This instruction can help farmers adjust to environmental changes and mitigate the effects of natural catastrophes on their crops.
- ✓ **Financial Counselling and Assistance:** Extension services may assist farmers manage their loans and negotiate financial issues. They can also help people get access to official loans with acceptable interest rates, decreasing their reliance on informal lenders and money lenders.

- ✓ **Technology Adoption:** Agricultural extension may teach farmers about contemporary agricultural techniques such as effective irrigation, precision farming, and crop diversity. This can help to improve yields, reduce production costs, and increase overall farm profitability.
- ✓ **Mental Health Support:** Agricultural extension staff can increase awareness of mental health concerns and lessen the stigma associated with seeking treatment. Providing counselling services or allowing access to mental health specialists might help address the social and psychological problems that contribute to farmer suicides.
- ✓ **Government Support and Policy Advocacy:** Agricultural extension services can lobby for more effective government policies and farmer support systems. This involves guaranteeing timely subsidy implementation, strengthening infrastructure, and closing gaps in current support systems.
- ✓ **Livelihood Diversification:** Extension services can assist farmers in exploring alternate livelihood possibilities, promoting diversification beyond conventional agriculture. This can help to alleviate the effects of agricultural losses while also providing additional income.
- ✓ **Community Building and Support:** Agricultural extension specialists can help farmers form a support network by facilitating community-building efforts. This can help prevent social isolation by providing a venue for farmers to share their experiences, difficulties, and solutions.
- ✓ **Market Linkages:** Extension services can help farmers build stronger market links and secure fair pricing for their goods. This can help to improve economic stability and lessen the economic losses caused by farmer suicides.
- ✓ **Post-Suicide Support:** In the terrible occurrence of a farmer's suicide, extension services can help impacted family members. This may involve counselling, financial aid, and assisting the family in exploring new livelihood possibilities.

Conclusion

The suffering and suicides among Indian farmers require prompt attention and extensive remedies. Agricultural extension may be a good change agent by raising awareness, giving financial support, embracing technology, and emphasizing mental health. Collaboration among stakeholders, effective legislative lobbying, and community building are all necessary components of a comprehensive approach to ensuring the well-being and prosperity of people who support the country's agricultural backbone.

References

Kale, N. M., Mankar, D. M. and Wakhande, P. P. (2014). Consequences of Farmers Suicide and Suggestions perceived from victim's households to prevent suicides in Vidarbha Region. *Global Journal of Science Frontier Research: Agriculture and Veterinary*, 14 (10): 42-46.

Ade, V. V. (2021). Trends and causes of farmers suicide in Maharashtra State, India. *International Journal of Scientific Research in Science, Engineering and Technology*, 8(1): 248-261.

Behere, P. B., Chowdhury, D., Behere, A. P. and Yadav, R. (2021). Psychosocial aspects of suicide in largest industry of farmers in Vidarbha Region of Maharashtra. *Industrial Psychiatry Journal*, 30(Suppl 1): S10.

Kumar, R., Islam, M. S. and Sarathlal, P. S. (2022). Agrarian Crisis and Agricultural Policy Interventions in India. *IJFANS International Journal of Food and Nutritional Sciences*, 11(8): 2045-2058.

National Crime Reports Bureau, ADSI Report Annual - 2021 Government of India, Page 196-208.

National Crime Reports Bureau, ADSI Report Annual - 2021 Government of India, Page-239.

Sustainable Agriculture in Climate Change: The Vital Role of Extension Services

Rishabh S. Gaur and Vicky Yadav

Abstract

As the world grapples with the growing effects of climate change, the need to face and mitigate its repercussions has never been more urgent. This article investigates a wide range of climate change mitigation strategies and innovations, focusing on both global and local actions. Climate change mitigation talks encompass a wide range of solutions, including governmental frameworks and technological breakthroughs. By examining the current landscape of climate change mitigation strategies, this essay aims to shed light on the joint effort to reduce greenhouse gas emissions, protect ecosystems, and build a sustainable future.

Introduction

Climate change, induced by human activities such as fossil fuel consumption and deforestation, is a serious threat to the planet's natural balance. There is a need to tackle the complex issues surrounding climate change, which provides the door for an inquiry into mitigation methods. The use of sustainable farming practices is an important aspect of climate change mitigation. Agricultural extension services play a crucial role in spreading knowledge about conservation tillage, cover cropping, crop rotation, and organic farming. Extension professionals encourage these approaches to enhance soil health, preserve water, and minimize greenhouse gas emissions, lowering agriculture's environmental impact.

Increasing Issues of Global Warming: Currently, the global mean temperature is rising by 1.1 degrees Celsius. Oceans are warming, and sea levels are rising by 3.7 mm, or nearly 0.1 inch every year. According to the research, two or more climate change-related events are occurring concurrently or back-to-back. If emissions continue to grow, the seas and land, two critical sinks, will be significantly degraded in their ability to absorb atmospheric CO_2.

Net Zero CO_2 Emission: Human activity adds as much CO_2 to the atmosphere as it eliminates. Reaching and sustaining net zero CO_2 emissions on a global scale helps to mitigate CO_2-induced warming. Overall, human-caused warming is governed not just by CO_2 emissions, but also by the contributions of other anthropogenic climate forcing agents, such as aerosols and other greenhouse gases. To avoid total human-caused warming, emissions of

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other GHGs, notably CH_4, must be drastically reduced. To reach net zero GHG emissions, residual CH_4, N_2O, and F-gas emissions must be offset by net negative CO_2 emissions.

Roles of Carbon Dioxide Removal (CDR) in mitigation strategies: With growing global GHG levels and a desire to attain net zero CO_2, CDR alone cannot support all solutions. It supports…(i) Reduce net CO_2 or GHG emission levels in the near term; (ii) counterbalance residual emissions from sectors such as CO_2 from industrial activities and long-distance transport (e.g., aviation, shipping), or methane and nitrous oxide from agriculture, in order to help reach net zero CO_2 or GHG emissions in the mid-term; (iii) achieve and sustain net-negative CO_2 or GHG emissions in the long term, by deploying CDR at levels exceeding annual residual gross CO_2 or GHG emissions.

What is Carbon capture and storage (CCS)?

When CO_2 is harvested directly from the atmosphere (DACCS) or from biomass (BECCS), CCS serves as the storage component for these CDR approaches. CO_2 collection and subsurface injection is an established method for gas processing and increased oil recovery.

Energy Management: Reduced fossil fuel usage and use of CCS; low- or no-carbon energy systems; and increased energy efficiency. Alternative fuels include hydrogen and sustainable biofuels. An empirical analysis of the effects of environmental regulation and innovation on carbon emissions in OECD countries from 1999 to 2014 discovered that a 1% increase in environmentally friendly patents reduced carbon emissions by 0.017%, while a 1% increase in environmental tax revenue per capita reduced carbon emissions by 0.03% (Hashmi and Alam 2019).

Societal Aspects of Mitigation: Social justice increases the ability and incentive to reduce climate change. Policies that increase women's political access and participation, as well as those of racialized and marginalized groups, contribute to the democratic drive for climate action. Mitigation policies that include and communicate with individuals' values are more successful. Improvements in consumer preferences, along with structural improvements and governmental action, make low-carbon solutions more viable.

Socio-cultural and lifestyle changes can accelerate climate change mitigation: Individual consumption and transportation decisions have the greatest potential for reducing carbon footprints. Prioritizing car-free mobility by walking and cycling, as well as the use of electric vehicles, might save 2 tCO_2eq. Other effective mitigation techniques include minimizing air travel, using fewer appliances, and switching to plant-based diets.

Role of Agricultural Extension in the mitigating the effects of Climate Change

Precision Agriculture and Technology Adoption: It offers significant potential for reducing resource consumption and increasing efficiency, due to cutting-edge technologies like as remote sensing, GPS, and data analytics. Agricultural extension

services play an essential role in introducing farmers to new technologies, educating them, and assisting them in implementing precision agriculture approaches.

Climate-Resilient Farming Practices: Agricultural extension services are critical for creating and promoting climate-resilient farming practices. This involves training farmers on conservation agriculture, crop diversification, and water management techniques. Extension personnel provides practical advice on soil conservation practices such as cover cropping and agroforestry, which increase soil health and water retention while mitigating the effects of droughts and floods.

Capacity Building and Training: To effectively deal with new challenges, farmers' skill sets must adapt in reaction to climate change. Agricultural extension services offer training programs to assist farmers implement climate-friendly practices. These courses address topics such as efficient water consumption, pest and disease management in changing climates, and the use of stress-tolerant crop varieties.

Promotion of Climate-Resilient Crop Varieties: Identifying and promoting climate-resilient crop varieties is a critical component of agricultural climate change mitigation efforts. Agricultural extension agents collaborate with research institutes to teach farmers about drought-tolerant, heat-resistant, and pest-resistant crop varieties. Extension services contribute to food security and sustainability in the face of climate change by diversifying crop portfolios and encouraging the use of durable cultivars.

Early Warning Systems and Risk Reduction: Agricultural extension services contribute significantly to the development and implementation of early warning systems for extreme weather occurrences. Farmers can take preventive steps like altering planting schedules or securing animals if they are provided with timely information and risk assessments. Extension staff also work in community disaster risk reduction, supporting methods to reduce the impact of climate-related catastrophes on agriculture.

Community Engagement and Knowledge Sharing: Effective communication and community participation are essential components of agricultural extension programs. Extension officers promote knowledge sharing in farming communities by promoting the exchange of experiences and best practices. Farmers that use participatory methodologies become active participants in climate change adaptation initiatives, establishing a feeling of communal responsibility for sustainable agriculture.

Conclusion

Effective communication and community participation are essential components of agricultural extension programs. Extension officers promote knowledge sharing in farming communities by promoting the exchange of experiences and best practices. Farmers that use participatory methodologies become active participants in climate change adaptation initiatives, establishing a feeling of com-

munal responsibility for sustainable agriculture.

References

Hashmi, R. M. and Alam, K. (2019). The impact of environmental innovation and technological innovation on economic growth: A panel data analysis of 24 OECD countries. *Journal of Cleaner Production*, 208: 346-356.

Intergovernmental Panel on Climate Change. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

United Nations Framework Convention on Climate Change. (2020). Synthesis report on the aggregate effect of the intended nationally determined contributions. URL: https://unfccc.int/sites/default/files/resource/synthesis_report_on_the_aggregate_effect_of_intended_nationally_determined_contributions_in_relation_to_the_temperature_goal_of_the_paris_agreement.pdf

World Meteorological Organization. (2020). The state of the climate in 2019. *Bulletin of the American Meteorological Society*, 101(8): 1-429.

Artificial Intelligence in Agriculture: Role, Challenges and Benefits

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Abstract

The world population is projected to reach 9.1 billion by 2050, which would necessitate increasing global food production by about 70% between 2005-07 and 2050. The major challenge faced by developing countries in today's world is to feed the ever-increasing population within a limited land area and resources. In the field of agriculture, Artificial Intelligence (AI) applications and solutions have been developed to help farmers with precise and regulated farming by providing them with the appropriate guidance on water management, crop rotation, timely harvesting, crop type, optimal planting, pest attacks, and nutrition management. For the agriculture sector, artificial intelligence is a true game changer.AI makes it possible to make better decisions at every stage of the agricultural supply chain, from supply chain optimization to crop monitoring and management. Ultimately, by addressing urgent issues like food security, sustainability, and climate change, these innovations can guarantee a more resilient and effective agricultural system that can feed the world's expanding population.

Introduction

Agriculture is being rapidly transformed by artificial intelligence (AI) by addressing the dynamic issues of productivity, sustainability, and food security. By 2050, there will be more than nine billion people on the planet, which means that 70% more agricultural output will be needed to meet demand (Eli-Chukwu, 2019). The use of artificial intelligence (AI) in agriculture has long been regarded as one of the most practical ways to address challenges of food insufficiency (Zha, 2020) disease infestation, and poor soil management (Ryan *et al.*, 2023). Artificial intelligence (AI) in agriculture gives farmers access to real-time crop insights, enabling them to determine which areas require pesticide treatment, fertilization, or irrigation. According to a report by the World Economic Forum, integrating AI into agriculture could result in a 60% drop in pesticide usage and a 50% drop in water usage. Farmers can now use artificial intelligence (AI) to access sophisticated data and analytics tools that will enhance farming practices, increase productivity, and minimize waste in the production of food and biofuel while minimizing adverse environmental effects (Javaid *et al.*, 2022). According to Markets and Markets, the market for artificial intelligence in agriculture is anticipated to expand from USD 1.7 billion in 2023 to USD 4.7 billion by 2028. AI and ML techniques can optimize the utilization of resources through the analysis of agricultural data

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(Marwaha *et al.,* 2023) to solve difficult agricultural problems and assist farmers in minimizing their losses (Meshram *et al.,* 2021). Precision agriculture will be strengthened by digital/smart farming, which will incorporate cutting-edge digital technologies like artificial intelligence (Neha *et al.,* 2022). AI-powered crop monitoring systems use sensors, drones, and satellites to evaluate crop health, find pests and diseases, and identify nutrient deficiencies.Variable rate technology (VRT) uses AI-derived prescription maps to modify the application of inputs such as fertilizers and water to maximize yield. Automated farm equipment like driverless tractors, smart irrigation, fertilization systems, IoT-powered agricultural drones, smart spraying, vertical farming software, and AI-based greenhouse robots for harvesting reduce labor requirements and increase efficiency by automating processes like planting and harvesting.The synergy between precision agriculture and AI provides data-driven insights and automation tools to farmers, enabling them to maximize farming productivity and guarantee sustainable agricultural practices.

The role of artificial intelligence in Modern Agriculture

Artificial intelligence (AI) is critical in modern agriculture, revolutionizing conventional farming methods and boosting productivity, sustainability, and efficiency. AI may be useful to farmers in a variety of ways, including:

- ✓ **AI-based weather forecasting:** Due to climate change farmers find it difficult to ascertain when is the ideal time to sow seeds. Use of weather forecasting to analyze weather conditions with the help of artificial intelligence, assess weather patterns, and determine the best time to sow seeds.
- ✓ **Robotic AI:** Robotic AI transforms farming methods by accurately and efficiently automating tasks like planting, harvesting, and weeding. These AI-guided autonomous robots can navigate fields, recognize crops, and carry out other tasks with little human assistance, saving labor costs and boosting output.
- ✓ **AI-based pest detection:** AI algorithmsprocess these images to identify signs of pest infestation like broken leaves or particular patterns linked to particular pests. Using labeled datasets, machine learning models and convolutional neural networks in particular are trained to identify these patterns and differentiate between healthy and infested plants.
- ✓ **Drones for monitoring crop health:** Drones are equipped with high-resolution cameras, thermal sensors and multispectral or hyperspectral imaging capabilities to capture detailed aerial imagery. NDVI is a widely used metric to assess the health and vigor of vegetation that is obtained from satellite or drone imagery.
- ✓ **Crop breeding and genomics:** AI-powered crop breeding has the power to completely transform the agricultural industry. Artificial intelligence (AI) in plant breeding comprises using computational methods and AI algorithms to analyze

substantial amounts of plant genetic, phenotypic, and environmental data (Sampath *et al.,* 2023). Genomic selection is made possible byArtificial intelligence (AI) algorithms that can identify which plants are likely to have desired traits, like disease resistance or higher yield, by analyzing the DNA of those plants.When combined with crop simulation software, AI models can forecast crop performance and simulate plant growth in a variety of environmental conditions.

- ✓ **Precision Farming:** AI-driven decision support systems assist farmers in making well-informed choices about when and how much to water when to plant, how much fertilizer to apply, and how to manage pests using real-time data. AI easily interfaces with automated irrigation systems and GPS-guided tractors, enabling focused and coordinated actions in precision farming.
- ✓ **Soil health monitoring and management:** AI-powered remote sensing techniques, such as satellite imagery analysis and drone-based sensors detect changes in soil conditions, erosion, vegetation cover, and land use practices, based on this, AI predictive models assist farmers and land managers in making informed decisions about crop selection, irrigation scheduling, fertilizer application, and erosion control.AI techniques, such as machine learning and neural networks, process soil sensor data to create detailed soil maps and classifications. These maps delineate soil types, properties, and spatial variability, aiding in land use planning, precision agriculture, and soil conservation efforts.
- ✓ **Livestock monitoring and management:** AI-powered systems can examine a variety of data points, including behavior, heart rate, and temperature, to identify symptoms of disease or distress in animals and predict reproductive cycles and ideal periods for feeding and breeding. Facial recognition technology can be used to track an animal's growth rate, identify individual members of a herd, observe feeding habits, and spot any behavioral anomalies. AI systemssuch as RFID tags, GPS trackers, and wearable devices monitor livestock movements, grazing patterns, and overall activities.
- ✓ **Supply chain optimization:** In agriculture, supply chain optimization refers to the strategic management and coordination of all activities of agricultural production from farm to fork.It takes into account several factors, including information technology integration, storage facilities, transportation logistics, and inventory management. By utilizing technology such as blockchain, data analytics, and IoT sensors farmers, distributors, and retailers gain real-time insights into crop conditions, demand swings, and market trends empowering them to make well-informed decisions and quickly adapt to changes. Therefore, supply chain optimization is crucial to improving agriculture's sustainability, profitability, and productivity throughout the whole food production and distribution system.
- ✓ **Market forecasting and Price Optimization:**

AI can predict future market trends and consumer behavior based on historical data by using machine learning algorithms. Artificial intelligence (AI) can forecast demand for goods and services based on variables like marketing campaigns, economic indicators, and seasonality. AI systems can segment customers according to their purchasing patterns, inclinations, and readiness to pay by analyzing customer data. AI technologies enable companies to optimize pricing strategies, make data-driven decisions, and maintain competitiveness in ever-changing markets.

- ✓ **Food Safety and Traceability:** AI plays a vital role in ensuring food safety and traceability through improving quality control with image recognition and sensor technology, using predictive analytics to foresee risks like contamination, and enabling accurate product tracking across the supply chain with the help of technologies like RFID and blockchain. It enhances supply chain efficiency, identifies food fraud, and supports regulatory compliance, all of which help consumers receive safer, better-quality food while preserving faith in the food sector.

Agriculture-related AI startups

- ✓ **Farm-wise:** Farm-wise creates autonomous robots with artificial intelligence (AI) and computer vision technologies to assist farmers with chores like weeding and crop health monitoring. With the least amount of herbicide usage, their robots can accurately locate and eradicate weeds.
- ✓ **Blue River Technology:** Blue River Technology is a start-up company founded in 2011 with headquarters in California. It uses robotics, AI, and computer vision to create next-generation agricultural equipment. Their "See & Spray" technology uses computer vision to pinpoint and identify specific plants, making it possible to apply herbicide more precisely and use fewer chemicals.
- ✓ **Prospera:** It is an Israeli startup that was established in 2014. This business innovates clever farming solutions. It creates cloud-based solutions that gather all field data, including aerial photos, soil and water data, etc. and integrate this information with a field device. This device is known as the Prospera device, and it concludes this data.
- ✓ **Taranis:** Taranis provides farmers with insights into crop health, pest infestations, and other possible issues through an AI-driven platform that integrates satellite imagery, weather data, and machine learning algorithms. This aids farmers in making informed decisions based on data to maximize crop yield and minimize losses.
- ✓ **Gamaya:** Gamaya creates artificial intelligence (AI) algorithms and hyperspectral imaging technology to monitor crop health and identify early indicators of disease, stress, or nutrient deficiencies. They offer farmers useful information on how to enhance crop management

techniques and boost output through their platform.

- ✓ **FarmBot:** Farmbot is an open-source CNC precision farming device and software that can be used by anyone at home to grow crops. The entire "Farmbot" product line is offered for $4000, and it uses an open-source software system in conjunction with a physical bot to allow anyone to perform full farming tasks on their own, from seed planting to weed detection. It also offers a web application that we can use to manage farming from anywhere at any time using a computer or smartphone.
- ✓ **Fasal:** The Indian start-up Fasal is working in the field where holdings per farmer in the poorer region are low as compared to the rich region. It is useful for automated monitoring since it needs fewer, smaller, and less bandwidth to collect all of the agriculture data. It gives farmers access to real-time data and insights using inexpensive sensors and AI. This will provide farmers with up-to-date, useful information about their farm's daily operations.

Benefits and Challenges of AI in Agriculture

Benefits

- ✓ **AI facilitates improved decision-making:** Artificial intelligence (AI) algorithms can evaluate past data to forecast crop yields, disease outbreaks, and the best times to plant, assisting farmers in making better plans and reducing risks. It also assesses crop quality, monitors weather, makesfertilizer recommendationsand also determines soil and crop health.
- ✓ **Crop Monitoring:** Artificial intelligence-enabled drones and satellites can efficiently monitor vast tracts of farmland, identifying problems such as pests, diseases, and nutrient deficiencies at an early stage.
- ✓ **Labor Savings:** With AI and automation, farmers can complete tasks without hiring more workers and some examples include autonomous tractors, intelligent spraying, intelligent fertiliz-ation, and irrigation systems, vertical farming software, and AI-powered harvesting robots.
- ✓ **Environmental Sustainability:** AI-driven insights can minimize soil erosion, optimize water use, and cut down on chemical inputs to assist farmers in implementing sustainable practices.

Challenges

- ✓ **Quality and Data Accessibility:** AI models need a lot of high-quality data. It can be difficult to obtain such data, particularly for small-scale farmers in isolated areas.
- ✓ **Insufficient familiarity with new techno-logies:** Some farmers found it difficult to adopt AI technologies because they frequently involve complex algorithms and call for technical expertise for implementation and maintenance.
- ✓ **Privacy and Security:** Data security and privacy are issues that are brought up by gathering and sharing agricultural data for AI analysis. Farmers may be hesitant to share sensitive information about their operations.

- ✓ **Ethical Considerations:** AI-driven decision-making brings up moral issues like data ownership, algorithmic bias, and the effects on traditional farming methods and rural communities.

AI's future in agriculture

In the upcoming years, artificial intelligence (AI) will undoubtedly play a bigger part in agriculture and food sustainability. Modern technology combined with data-driven insights will allow AI in agriculture to fundamentally change conventional farming methods. The market for artificial intelligence (AI) in agriculture is anticipated to grow rapidly, and it is projected to reach $10.83 billion by 2025 from $2.35 billion in 2020 at a Compound Annual Growth Rate (CAGR) of 35.6%. To assist farmers in increasing their productivity and profitability from agriculture, several start-ups in this field have started applying AI-based technologies in India. Artificial intelligence (AI) has revolutionized every aspect of agriculture, ranging from market forecasting and supply chain management to food processing and distribution. Concerns about data accessibility, technology infrastructure, and ownership and privacy ethics must all be addressed to successfully implement AI in agriculture.

Conclusion

AI integration in agriculture offers a viable route to resilient, effective, and sustainable food production systems. AI helps farmers reduce risks related to pest outbreaks and weather variability, allocate resources optimally, make data-driven decisions, and provide accurate yield forecasts. The intelligent application of AI in agriculture would contribute to addressing global food security issues and create a more sustainable future for future generations.

References

Eli-Chukwu, N. C. (2019). Applications of artificial intelligence in agriculture: A review. *Engineering, Technology & Applied Science Research*, 9(4).

Javaid, M., Haleem, A., Khan, H., Ibrahim and Suman, R. (2022). Understanding the potential applications of Artificial Intelligence in Agriculture Sector. *Advanced Agrochem.* 2. 10.1016/j.aac.2022.10.001

Mark, R., Gohar, I. and Bedir, T. (2023). An interdisciplinary approach to artificial intelligence in agriculture. *NJAS: Impact in Agricultural and Life Sciences*, 95(1): 2168568.

Marwaha, S., Deb, C. K., Haque, M. A., Naha, S. and Maji, A. K. (2023). Application of Artificial Intelligence and Machine Learning in Agriculture. In Translating Physiological Tools to Augment Crop Breeding (pp. 441-457). Singapore: Springer Nature Singapore.

Meshram, V., Patil, K., Meshram, V., Hanchate, D. and Ramkteke, S. D. (2021). Machine learning in agriculture domain: A state-of-art survey. *Artificial Intelligence in the Life Sciences*, 1: 100010.

https://iiss.icar.gov.in/eMagazine/v5i2/7.pdf

Neha, Gupta, P., Nadeem, Dayam, Abuzar and Elahi, A. (2023). Artificial Intelligence in Agriculture (February 2, 2023). Proceedings of the International Conference on Innovative Computing & Communication (ICICC) 2022, Available at SSRN: https://ssrn.com/abstract=4345592 or http://dx.doi.org/10.2139/ssrn.4345592

Sampath, L., Santhosh, V., Himakara Datta, M. and Arun, T. What is Artificial Intelligence in Plant Breeding?

Zha, J. (2020, December). Artificial intelligence in agriculture.In Journal of Physics: Conference Series, 1693(1): 012058. IOP Publishing.

https://intellias.com/artificial-intelligence-in-agriculture/#:~:text=Application%20of%20AI%20in%20agriculture,production%20while%20minimizing%20resource%20usage.

https://www.jiva.ag/blog/how-artificial-intelligence-can-be-used-in-agriculture

https://www.wipro.com/holmes/towards-future-farming-how-artificial-intelligence-is-transforming-the-agriculture-industry/

https://www.javatpoint.com/artificial-intelligence-in-agriculture

https://vikaspedia.in/agriculture/ict-applications-in-agriculture/artificial-intelligence-in-agriculture

https://smarttek.solutions/blog/ai-in-agriculture/

https://www.aiplusinfo.com/blog/role-of-artificial-intelligence-in-agriculture/

https://sageuniversity.edu.in/blogs/role-of-artificial-intelligence-in-agriculture

Biofertigation: A Sustainable Solution for Field Crops

Dhanshree Bharat Jadhav and Sayan Kumar Barik

Abstract

The article paper aims to discuss and evaluate the importance of Biofertigation as a sustainable practice for field crops within the field of agriculture. With the increased use of chemical and synthetic fertilisers worldwide, soil pollution and water pollution have increased especially within the last few decades. As a consequence of the events, the soil health status along with its fertility attributes has been reduced by a far margin. Moreover, the impact has also been observed through poor qualitative and quantitative traits of the field crop without efficient management during the period of cultivation. Hence, from the perspective of sustainability, bio-fertigation plays a major role in agriculture, especially in future. Biofertigation mainly involves the efficient use of bio-fertilisers along with an irrigation system (mainly micro-irrigation) to meet the requirements of the crop plants during their growth stages. Within the article, the importance of the practice along with the elements and key factors that are necessary for implementing the process has been discussed briefly. Other than that, various case studies related to implementing biofertigation in field crops and the challenges that are restraining its potential utility among field crops worldwide have also been discussed within the article.

Introduction

Biofertigation can be addressed as an agricultural practice that involves applying organic or biofertilizers through irrigated systems directly towards the root zones of the crops (Liu *et al*., 2023). Biofertigation plays an excellent role in not only enhancing soil fertility but also in promoting the growth rates of plants.

Biofertigation is also taken as one of the sustainable practices which do not involve any kind of use of chemical substances. As per the reports published byArcas-Pilz *et al*. (2021), unnecessary use of chemical substances during agricultural procedures has significantly deteriorated the soil's status over the last three decades. Excess application of chemical fertilisers has caused enhanced soil acidification and reduction in the organic as well as humus content present within the soil. Other than that, the chemical components are also responsible for altering the pH of the soil in a frequent manner which all effects adversely over the growth and development of the crops (Tian *et al*., 2022). As a consequence, sustainable practicesas required to be prioritised in the upcoming years to avoid soil pollution as well as minimising the emission of greenhouse gases (GHGs). Hence, a brief discussion has been provided within the article on the potentiality of biofertigation as an alternative sustai-

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nable practice in agriculture in the near future.

Factors of biofertigation practice that glorify sustainability for field crops: The process of Biofertigation provides ample positive sides for both crop plants as well as farmers under a sustainable agricultural practice approach. The advantages of the process have been discussed below:

- ✓ **Enhanced nutrient distribution and nutrition use efficiency:** In general, the process of biofertigation is generally followed with the help of the micro-irrigation process. Micro-irrigation not only enhances the water use efficiency but also allows the liquid substance to drip slowly towards the root zone, either above or buried below the surface area (Malliga *et al.,* 2023). This approach also helps in the better distribution of fertilisers. In a similar pattern, as biofertigation is applied on root-specific areas it also enhances the nutrient use efficiency.
- ✓ **Minimising the chemical impacts on soil:** The practice of biofertigation does not involve any kind of use of chemicalsor synthetic elements. As a consequence, it also reduces the probability of contamination of the soil and water as the process only relies upon bio-based fertilisers. Hence, it is considered one of the priorchoices for the farmers under sustainable aspect.
- ✓ **Enhancement of soil health:** Organic materials play a major role in developing the soil status within any crop field. Enhanced amount of organic content within the soil eventually increases the structure of the soil, water holding or retention capacity along with efficient microbial activity (Raimi *et al.*, 2021). Each of the factors is responsible for nourishing the soil health.
- ✓ **Budget-friendly process for a longer period of farming:** Although the initial investment required to follow the biofertigation process is comparatively higher than the traditional approach of farming. Moreover, the requirement for organic fertilisers is also higher as it is required to be more efficient and specific-site directed. Still, to obtain longer-term benefits and achieve sustainability, biofertigation is an absolute choice of practice that helps to enhance the productivity and yield attributes for field crops as well as minimise the dependency on the use of chemical and synthetic fertilisers.

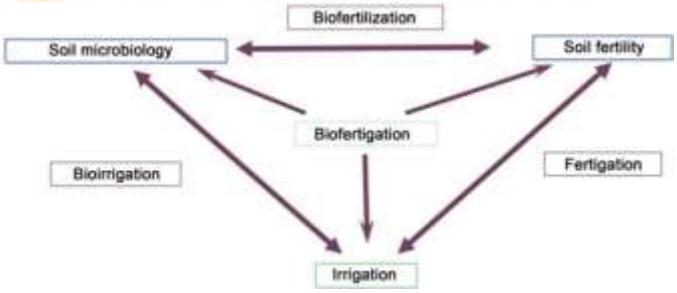


Fig. 1: Segments of biofertigation practice (Source: Richa, 2023)

Key factors in implementing the biofertigation

There are certain factors that are needed to be considered while implementing the process of biofertigation. These are:

- ✓ **Preparation of the solution and dilution rate:** Preparing the solution used for biofertigation is one of the most important factors while implementing the process. The solution needed

to be prepared at an efficient dilution rate to obtain the best outcomes over the crop plants (Barros *et al*., 2021).

- ✓ **Setting up the micro-irrigation facilities along with injection equipment:** As biofertigation is mostly applied through a micro-irrigation system, hence, the establishment of the micro-irrigation facilities (such as sprinklers) is required to be admitted first. Drip irrigation or Trickle type of irrigation system is highly preferred. Other than that, venturi injectors or fertigation pumps are required to be installed to control the water flow in the process.
- ✓ **Frequency and timing of application:** To enhance the efficiency of the process, the application of the fertilisers and their frequency of application is required to be assessed based on the crop-growth stage (critical growth stages require more frequent application than other stages) (Richa, 2023).
- ✓ **Recording the outputs and monitoring for re-adjustments:** Recording the information of the crop plants is one of the necessary factorsin biofertigation. Depending upon the plant output, the control rate of the bio-fertiliser application needs to be remodified to enhance the precision of the delivery.

Elements used as bio-fertilisers in biofertigation

There are multiple types of biofertilizers available which is used in the process of bio-fertigation. These are:

- ✓ **Extractions of the seaweed:** Obtained from various species present within marine algae. These types of biofertilizers play a major role in improving stress resistance among crop plants.
- ✓ **Microbial inoculants:** Bacterial biofertilizers such as Rhizobium, and Azospirilium; Fungal biofertilizers such as mycorrhiza; Algal biofertilizers such as Azolla and Blue-green algae.
- ✓ **Fish emulsion:** Obtained from the by-products of the fish. It is specifically enriched in N, P and other trace elements.
- ✓ **Tea composts**
- ✓ **General organic sources:** Such as organic extracts from plant residues and animal manures.

Case studies: Various studies have been conducted by researchers throughout the globe over the impact of bio-fertigation on the field crops in agriculture, like:

A research has been conducted by Kiran *et al*. (2022) on Maize at the College of Agriculture, PJTSAU, Rajendranagar, Hyderabad to discuss the impact of bio-fertigation on its qualitative traits. The treatments, comprising of two fertility levels *viz.*, 75% and 100% recommended dose (RD) of N&K as the first factor and biofertigation of MC (microbial consortium) as the second factor. The result of the experiment suggests that bio-fertigation with MC at 100% RD is more efficient and has produced better qualitative traits on the maize crops, including higher cob girth, number of cobs, and grain weight. Cob length and cob weight.

In a similar pattern, Carvalho *et al*. (2018)

conducted research aiming to evaluate the distribution as well as the diversity of Arbascukar mycorrhizal fungi (AMF) and Nitrogen-fixing bacteria (NFB) before and after the biofertigation practices with the help of wastewater and manure from the cattle slaughterhouse in the irrigation of B. *brizantha* cv Marandu in Cerrado soil to increase leaf biomass productivity. The result of the experiment suggests that the productivity of the leaf biomass is comparatively higher with the process of bio-fertigation.

Challenges of biofertigation

- ✓ In general, bio-fertilisers contain lower amounts of nutrient content than chemical or synthetic fertilisers. As a consequence, the amount of fertiliser dose required for a specific crop from the perspective of bio-fertiliser is much higher than the chemical fertilisers.
- ✓ One of the major challenges in biofertigation is maintaining the shelf life of the micro-organisms that are used as bio-fertilisers. Hence, a proper preservation facility is required to keep the micro-organisms alive for a longer period.
- ✓ The initial cost of the process is considerably much higher than the traditional practices and requires various infrastructural facilities to efficient application of biofertigation practices.
- ✓ Lack of awareness among the farmers regarding the process of biofertigation along with lack of efficient knowledge for efficient application of the process has limited its utility within the field crops in the field of agriculture.

Conclusion

Biofertigation and its importance as a sustainable practice for field crops in agriculture have been discussed briefly within the report. Biofertigation mainly focuses on the dosage rate of the biofertilizers along with water and its frequency of application on the field crops through a micro-irrigation system directly towards the root areas. Hence, it not only enhances the water use efficiency through minimising the wastage of water but also enhances the nutrient uptake efficiency for the plants through uniform distribution of the bio-fertilizers. These are the key factors that justify the potential sustainability of the practice which is highly recommended and required to avoid soil and water pollution. In conclusion, it can be stated that the prospect of biofertigation is promising. However, the lack of awareness among the farmers along with initial cost factors are the key factors that are restraining the process to its full potential utility throughout the globe.

References

Malliga, P., Geetha, N. and Jenifer, G. (2023). Bio-fertigation of Different Industrial Waste. In Biorefinery for Water and Wastewater Treatment (pp. 337-357). Cham: Springer International Publishing.

Raimi, A., Roopnarain, A. and Adeleke, R. (2021). Biofertilizer production in Africa: Current status, factors impeding adoption and strategies for success. *Scientific African*, 11: e00694.

Arcas-Pilz, V., Rufí-Salís, M., Parada, F., Gabarrell, X. and Villalba, G. (2021). Assessing the environmental behavior of alternative fertigation methods in soilless systems: The case of *Phaseolus vulgaris* with struvite and rhizobia inoculation. *Science of The Total Environment*, 770: 144744.

Barros, D. L., Coelho, E. F., de Andrade, T. P., Fernandes, R. D. M., de Oliveira, B. R., Lima, L. W. F. and da S. Sales, M. L. (2021). Emitters uneveness used in fertigation with biofertilizer. *Irrigation Science*, 39: 751-758.

Carvalho, J. J. D., Luz, J. M. R. D., Henrique, J., Silva, J. G. D., Silva, J. E. C. D. and Santos, E. A. D. (2018). Biofertigation of forage with effluents of green line of a cattle slaughter-house: Microbial diversity and leaf dry mass productivity. *Journal of Agricultural Science* 10(5): 353.

Kiran, A. S., Kumar, K. A., Devi, M. U., Naik, B. B. and Triveni, S. (2022). Effect of Biofertigation and Chemical Fertilizers on Yield Attributes and Yield of *Rabi* Maize (*Zea mays* L.). *International Journal of Economic Plants*, 9(May, 2): 152-157.

Tian, M., Zheng, Y., Sun, X. and Zheng, H. (2022). A research on promoting chemical fertiliser reduction for sustainable agriculture purposes: Evolutionary game analyses involving government, farners and consumers. *Ecological Indicators*, 144: 109433.

Liu, X., Zhang, Y., Jiang, Z., Yue, X., Liang, J., Yang, Q., ... and Li, N. (2023). Micro-moistening irrigation combined with bio-organic fertilizer: An adaptive irrigation and fertilization strategy to improve soil environment, edible Rose yield and nutritional quality. *Industrial Crops and Products*, 196: 116487.

Richa. (2023). Liquid Bio-Fertilizers: Prospects and Challenges. Metabolomics, Proteomes and Gene Editing Approaches in Biofertilizer Industry, 77-99.

Bacterial Bioagent for Sustainable Management of Plant Disease

Swarna Kurmi, Jayant Bhatt, A. K. Jain and Sanjay Kharte

A number of pathogens, including bacteria, viruses, nematodes, and fungi, can cause significant damage to agricultural plants. Plant pathogen-induced diseases in plants account for 27-42% of global food production losses, indicating a significant threat to food production. It has been believed that biological control can effectively replace use of chemicals in the management of plant diseases. Among these are biological control for augmentation, classical, and conservation purposes. Numerous naturally occurring bio-control agents target plant pathogens with vigor and suppress plant disease through diverse mechanisms of action. The term "bio-control agents" refers to a group of beneficial characteristics that include antagonistic potential, rhizosphere competence, antibiotic production, lytic enzyme production, and nutrition and niche computation. The complex network of relationships that exists within the kingdom of plants is mostly shaped by bacterial biological agents, which also influence the dynamics of plant wellness and disease. Bacteria can be both protagonists and antagonists; certain species can cause devastating diseases, while others might be formidable partners in the fight against pathogens. Bacterial biological agents offer a fascinating look into the complex interactions between microorganisms and plants, revealing the mechanisms underlying pathogenicity and defense. Because they can cause diseases that lead to considerable crop losses, plant-pathogenic bacteria represent serious challenges to agricultural productivity. On the other hand, some bacteria serve as biological control agents, which help develop environmentally benign and long-lasting methods of managing disease. These helpful bacteria, also known as biopesticides, work to protect plants by either directly inhibit the growth of pathogens or by outcompeting or opposing pathogenic micro-organisms. They can also do this by causing plants to develop a tolerance to certain substances. By utilizing these bacterial companions to their full capacity, ecologically friendly alternatives to lessen the need for chemical pesticides and promote a more resilient and balanced agricultural ecology can be developed. Due to the ease with which they can be cultured, most biocontrol research has focused on a limited number of bacterial (*Bacillus, Burkholderia, Lysobacter, Pantoea, Pseudomonas* and *Streptomyces*).

Types of interactions in biological control

As viewed by the plant, a multitude specific and non-specific interaction combines to produce biological control, which is a net beneficial outcome.

Mutualism: A relationship in which two or more species benefit from one another is known as mutualism. Sometimes, like in the case of plants and

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mycorrhizal fungus, it is an unavoidable lifetime relationship involving intimate physical and biochemical contact. They are typically facultative and opportunistic, though. For example, bacteria Rhizobium.

Protocooperation: Protocooperation is a type of mutualism, although the participating species do not solely rely on one another to survive. Numerous microorganisms that have been identified and categorized as BCAs can be regarded as facultative mutualists that engage in protocooperation.

Commensalism: A symbiotic relationship in which one living creature gains while the other is neither hurt nor benefited is known as commensalism. The majority of microorganisms linked to plants are thought to be commensals.

Neutralism: The biological interactions known as neutralism occur when the population density of one species has no bearing at all on the other. On the other hand, hostility between organisms has a detrimental effect on one or both of them.

Interaction	Species		Interaction
Mutualism	+	+	Obligatory
Protocooperation	+	+	Non obligatory
Commensalism	+	0	One benefited other unaffected
Neutralism	0	0	No effect on either population

Application Methods of Bio-control Agents

Seedling Dip: Sheath blight on rice can be controlled by using *P. fluorescence* strain mixes by immersing the rice seedlings at 20 g l^{-1} for two hours (Nandakumar *et al.,* 2001). Similar to this, immersing tulip bulbs in Pseudomonas suspension prevents *P. ultimum*-induced tulip root rot (Weststeijn, 1990).

Seed Treatment: By safeguarding plants from phythopathogens, bacterial cultures applied to seeds can increase plant productivity and output.

Bio-agent	Pathogen	Reference
P. Fluorescens strain	*Magnaporthe oryzae* and *Rhizoctonia solani*	David De Vleesschauwer, 2008
P. fluorescens	*Macrophomina phaseolina*	
P. *alkaligenes*	*Fusarium* spp.	IK Widnyana *et al.*, 2017
Pseudomonas spp	*Rhizoctonia solani*	R. Rabindra *et al.*, 1996
Bacillus subtilis, B. pumilus	Tomato mosaic virus	Murply *et al.*, 2000

Seed Bio-Priming: Bioprimming is the process of treating seeds with bio-control materials and then letting them sit in warm, humid conditions until just before the radicals appear. In the Tarai region of Uttaranchal, seed biopriming is successfully applied to tomato, brinjal, soybean, and chickpea. Mishra and Associates, 2001. In bioprimed seeds of chickpea and rajma in pots and fields, three rhizosphere-competent microbial strains *P. fluorescens* OKC, *Trichoderma asperellum* T42, and *Rhizobium* sp. RH4 individually and in combination demonstrated higher germination percentages and better plant growth in both crops when compared to nonbioprimed control plants.

Foliar Spray Application: Bean rust can be prevented by applying B. subtilis to bean leaves; in field conditions, *P. fluorescence* applied foliarly can reduce rust and leaf spot; and Poinsettia stem rot caused by *Rhizoctonia* can be controlled by applying *P. cepacia*. *P. fluorescent* strain Pf1 (1 kg ha^{-1}) can be efficiently managed by foliar spraying a powder formulation based on talc to control rice blast (*P.*

oryzae).

Soil Application: Both harmful and helpful microorganisms are present in soil; adding PGPR strains to the soil will boost the population.

Bio-agent	Pathogen	Reference
Pseudomonas suspensions	*Pythium ultimum*	Weststeijn (1990)
P. cepacia strain N24	*Sclerotinia sclerotiorum*	Hebber *et al.*, 1991
P. aureofaciens	*Gaemannomyces graminis*	Mazzola *et al.*, 1992

Applying to the Infection Site: Application of antagonistic fungi and bacteria, such as *Trichoderma harzianum* and *Pseudomonas fluorescens* (Heydari and Misaghi, 2003), application of antagonists directly to the infection court at a high population level to swamp the pathogen (inundate application), and application of antagonists to fruit for storage protection, such as *Pseudomonas fluorescens* (Janisiewicz and Korsten, 2002). These kinds of treatments are the most widely employed techniques that have effectively controlled a number of fungal plant diseases. To further enhance biological control over insect pests, biological control agents were employed.

Bio-agent	Pathogen	Reference
Pseudomonas fluorescens F113	*Pythium* spp.	Shanahan *et al.* (1992)
Agrobacterium radiobacter	*Agrobacterium tumefaciens*	Kerr (1980)
Burkholderia cepacia	*R. solani* and *Pyricularia oryzae*	Homma *et al.* (1989)
B. subtilis BBG100	*Pythium aphanidermatum*	Leclere *et al.* (2005)

Factor affecting the use of biological control

Plant diseases can be effectively controlled by microbial bio-control agents when certain critical criteria are taken into account. These elements include biotic and abiotic factors, application method formulation of the bio-control microorganisms, and time of administration. The sluggish application and commercial use of biological control agents can be attributed mostly to their inconsistent field performance in various environmental circumstances.

References

Gamliel, A. and Katan, J. (1993). Suppression of major and minor pathogens by *fluorescent pseudomonads* in solarized and non-solarized soils. *Phytopathology*, 83: 68-75.

Meena, B., Marimuthu, T., Vidhyasekaran, P. and Velazhahan, R. (2001). Biological control of root rot of groundnut with antagonistic *Pseudomonas fluorescens* strains. *Journal of Plant Disease Protection*, 108: 369-381.

Mishra, S. and Singh, H. B. (2012). Glimpses of Phytopathology for Sustainable Agriculture, AB Publication Mayur Vihar, New Delhi, India, pp 37-55

Rabindran, R. and Vidhyasekaran, P. (1996). Development of a formulation of *Pseudomonas fluorescens* PfALR2 for management of rice sheath blight. *Crop Protection*, 15: 715-721.

Tsegaye, Z., Ssefa, F., Tefera, G., Alemu, T., Gizaw, B. and Abatenh, E. (2018). Concept, Principle and Application of Biological Control and their Role in Sustainable Plant Diseases Management Strategies. *International Journal of Research Studies in Biosciences (IJRSB)*, 6(4): 18-34.

Pal, K. K. and B. McSpadden Gardener (2006). Biological Control of Plant Pathogens. The Plant Health Instructor DOI: 10.1094/PHI-A-2006-1117-02.

Weller, D. M., Raaijmakers, J. M., McSpadden, Gardener, B. B. and Thomashow, L. S. (2002). Microbial populations responsible for specific soil suppressiveness to plant pathogens. *Annual Review in Phyto-pathology*, 40: 309-348.

Free Trade Agreement for Indian Agricultural Commodities

Aditi Sharma, Ajay Baldaniya and Souradip Bose

Introduction

The Indian agricultural sector is much diversified and self-reliant after. Around 15% (2015-16) of India's total GDP generates from agricultural sector, and about 60 % of its total population depend on agriculture for employment. India's total agricultural production was 280 million tonnes in 2015-16 as compare to 52 million tonnes in 1950-51. It is the outcome of the Green Revolution and ongoing government investment in the nation's agricultural infrastructure development. Further-more, with an ever-increasing population load (1320 million according to recently released figures) and rising need for jobs and food, both India and requires a thriving agricultural sector with a fast rate of increase in the share of agricultural exports in global trade. A free trade agreement is a deal that reduces barriers to import and export between two or more nations. Free trade agreements for agricultural products are increasing exports, creating jobs, supporting the "make in India" movement, and reducing government expenditures. But it also creates an opening for foreign countries, like China, to flood the Indian market with lower-priced goods, which would hurt the trade balance and the Made in India initiative. As of January 1, 2010, the Association of Southeast Asian Nations (ASEAN) and India have a free trade agreement (AIFTA), which will significantly alter India's economic ties with participating nations. With the exception of Singapore, India and the nations of Southeast Asia were not major trading partners until the early 2000s. This is primarily because, since the mid-1980s, all of the larger Southeast Asian nations have followed an export-led growth strategy driven by foreign direct investment (FDI), whereas India's trade and investment policies have remained relatively conservative.

What is Trade Agreement?

Trade agreement is an agreement between two or more countries for specific terms of trade, commerce, transit or investment.

Trade Agreements Types

Depending on the conditions and concessions agreed upon by the participating entities, there are several sorts of trade agreements.

What is free trade agreement (FTA)?

A free trade agreement is a deal that reduces barriers to import and export between two or more nations. A free trade policy allows products, such as

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agricultural commodities, and services to be bought and sold across international borders with little to no interference from the government in the form of taxes, quotas, subsidies, or restrictions. Trade protectionism and economic isolationism are antithetical to the concept of free trade. A negative list of goods and services is maintained by the negotiating nations on which the terms of FTA are not applicable. India has bilateral agreements with the following countries and blocs: Afghanistan, ASEAN (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam), Bhutan, Chile, Japan, Malaysia, Nepal, Singapore, Sri Lanka, South Korea, Mauritius, United Arab Emirate, and Australia.



Fig. 1: Types of Trade agreement

Table 1: Five yearly Compound Annual Growth rate (CAGR) of Indian Agricultural Import & Export

Period	Agricultural Export (%)	Agricultural Import (%)
1991-1995	21.78	48.96
1996-2000	5.55	28.51
2001-2005	9.77	17.21
2006-2010	16.07	29.00
2011-2015	31.71	22.04

Source: Ministry of Agriculture, Government of India, New Delhi

Main Features of Tariff Reduction Commitments

- ✓ AIFTA provides for a phased reduction of import duties on Indian and ASEAN member countries' agricultural and non-agricultural goods between January 2010 and January 2016. These duties will come down from their 2007 applied most favoured nation (MFN) tariff levels.
- ✓ India, Indonesia, Malaysia, Singapore, Thailand and Brunei Darussalam have to eliminate tariffs by 2013 for the products listed under Normal Track-1 (NT-1) and by 2016 for Normal Track-2 (NT-2) products. The deadlines for bilateral duty elimination for India and the Philippines are 2018 and 2019, respectively.
- ✓ Apart from a Sensitive Track, there is a list of Special Products, for which tariffs will be reduced at a much lower pace than the Normal Track and Sensitive Track. There is also an Exclusion List of products for which no tariff reduction commitments have been made.

Key benefits offered by FTA for Indian Agricultural Sector

Export: Reduction or elimination of tariffs will boost the export of qualified agricultural commodities.

Make in India: It will Nurture agriculture to make 'Make in India' a reality.

Product Standards: FTA improves the ability of domestic exporters to participate in the development of product standards in the FTA partner nation.

Intellectual Property right of farmer (IPR): Protection of IPR of farmer, breeder in plant varieties

etc.

Investors: Fair treatment for both domestic and foreign investors is provided by FTAs.

Access to advanced technology: Domestic farmers, FPO acquire access to advanced technologies from their international partners.

Government subsidies: It will reduce government subsidies in the agricultural sector, such as food, fuel, and fertiliser subsidies (3F).

Conclusion

India's economy is among the fastest-growing in the world, and free trade agreements (FTAs) have greatly increased trade between the two nations. FTAs have to provide the anticipated material advantages. Consequently, all parties involved in an FTA must conduct a thorough evaluation of the products, services, and investment flows associated with the agreement. It has been determined that ASEAN nations will have considerably easier access to the Indian market for a number of semi-processed or processed agricultural goods. This could have a negative impact on the domestic agricultural sector by lowering the cost of local crops due to decreased demand for local agricultural products and increasing imports of near substitutes.

Role of Different Type of Pheromone in Integrated Pest Management

Diksha Devi, Robin and Sharanappa C. H.

Introduction

Chemical pesticides play a major role in agricultural insect pest management. Nevertheless, there are issues related to pesticide use, including contamination of harvested agricultural produce, resistance development in pests, and environmental pollution. Pheromone trapping can offer instruments for tracking the movements and activities of target insects, giving data that will support the control of insect pests. Pheromones can effectively reduce insect pest populations over the long term, something that conventional insecticides are unable to do at low pest population densities. They also have no negative effects on natural enemies (Witzgall *et al.*, 2010). Pheromones have the potential to support integrated pest management (IPM) tactics through altering insect behavior, primarily through adult pest capture. Pheromones have been effectively used in a wide variety of contexts. Among the attributes sought in a trapping system is low cost, sensitivity and specificity for the target pest species, and user convenience. According to the majority of research, farmers create their own adaptable traps that are just as successful as other commercially available traps, can be deployed in small spaces, and stay hidden (Mullen and Dowdy, 2001). Integrated pest management (IPM) programs have historically prohibited the use of insecticides; however, the new IPM approach, which incorporates established action thresholds, pest monitoring and identification, prevention and treatment, permits the use of minimal amounts of low-risk pesticides.

Role of Pheromones in integrated pest management

Pheromones are used in integrated pest management for three main purposes. The most significant use is in population monitoring to ascertain if insects are present or missing in a certain location, or whether there are sufficient insects to justify an expensive treatment. The cornerstone of integrated pest management is this monitoring role. Monitoring is often used to manage stored grain pests in warehouses or distribution centers, reduce urban pests like cockroaches, and monitor the national expansion of specific big pests like the gypsy moth. Pheromones can also be used to mass trap insects in order to eradicate a significant portion of the population's food and breeding sources.

Using pheromones for mass insect trapping is a second important way to eliminate a lot of insects

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from the population that they are feeding and growing. Significant drops in the density of insect populations eventually contribute to the preservation of resources for human consumption, like food and fiber. The third main way that pheromones are used is to prevent insect populations from mating. The most successful application of this has been with agriculturally significant moth pests. In this scenario, crop fields are sprayed with synthetic pheromone, and the resulting fake scent plumes draw males away from females that are ready to mate. As a result, there is less mating, which lowers the pests' population density.

Types of sex pheromone

Sex Pheromones: Sex pheromones act as a signal to attract potential mates over long distances (e.g. moths). Sensitive chemoreceptive sensilla in insects facilitate the detection of very low concentrations of sex pheromones in the environment. Release of sex pheromones may be governed by factors such as time of day, weather, and the availability of host plants. Furthermore, both the immature and adult stages of insects can sequester chemicals from host plants and use them as precursors for sex pheromones.

Table 1: Example of different sex and alarm pheromone

Sex pheromone		Alarm pheromone	
Insect	**compound**	**Insect**	**compound**
Honeybee	9-Keto-2-decenoic acid	Honeybee	Heptan-2-one
Fall army worm	cis-9-Tetradecen-l -ol	Claviger	Tridecan-2-one
Male butterfly	Cetyl acetate	Snouted termite	or-Pinene
Cabbage looper	cis-7-Dodecen-1-01	Leaf cutter ants	Citral

Alarm Pheromones: Aphids are among the insects that emit alarm pheromones in reaction to natural adversaries attacking them. Alarm pheromones act as a catalyst for conspecific dispersal and avoidance behavior. However, some social insects-such as leaf-cutting ants and bees in the genus *Apis* may react violently to warning pheromones.

Aggregation Pheromones: These can be defined as intraspecific signals that facilitate group formation and mating at a food source. (For example, aggregation pheromones released by some species of bark beetles (Scolytidae: Coleoptera) result in the recruitment of other individuals of either sex to the feeding site.

Oviposition-Deterring: These compounds help females of certain insect species avoid egg deposition on hosts that have already been utilized by conspecifics and thus reduce intraspecific competition. Females of numerous species of fruit flies (Diptera: Tephritidae), e.g. Mediterranean fruit fly, *Ceratitis capitata* Wiedemann, deposit an oviposition-deterring fruit-marking pheromone during ovipositor dragging after egglaying. Similarly pepper weevil, *Anthonomus eugenii* Cano (Coleoptera: Curculionidae) females deposit an oviposition plug that deters egg-laying.

Trail Pheromones: Social insects (e.g. ants and termites) use trail pheromones to mark feeding or nest sites to guide members of their colony

Mode of action of pheromones

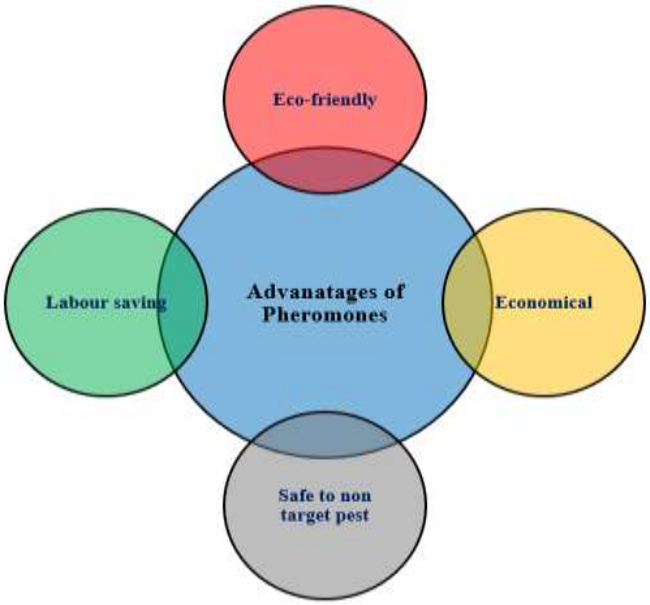
Detection and Monitoring: Insect pheromones are primarily used to draw insects into traps so that their temporal dispersion may be measured and detected.

Males are often responders to pheromones generated by females. Because of this, trap baits are made to accurately mimic the chemical component ratio and emission rate of calling females. Over the years, numerous designs of trap baits have been tested. Another essential component of using traps effectively for insect population monitoring is trap design. The size and design of traps vary according to how the target insects behave. Making decisions about the application of pesticides or other control methods can be greatly aided by the information obtained from trap captures. For instance, trap captures may suggest that pheromone treatment has to be applied again or that the pheromone's impact on mating disruption has diminished. Success requires close observation and expertise in analyzing the information gathered.

Mass trapping: Depending on how the target insects behave, traps come in a variety of sizes and designs. Making decisions about the application of pesticides or other control methods can be greatly aided by the information obtained from trap captures. For instance, trap captures may suggest that pheromone treatment has to be applied again or that the pheromone's impact on mating disruption has diminished. Success requires close observation and expertise in analyzing the information gathered. In order to lower the pest population, mass trapping captures a relatively large percentage of the insect before it mates or oviposit. Male trapping is crucial for Lepidopteron insects before mating, and single-mate insects have the best chance of success.

Mating disruption: Mating disruption is when a synthetic sex pheromone is released into the atmosphere for the goal of disrupting chemical communication between organisms and mating behaviors that result from said communication. By impacting mating, the reproduction of offspring is reduced. In camouflage type of mating disruption, High volumes of pheromone in the atmosphere makes males unable to locate plumes emitted by a female.

Lure and kill technique: This method of mass trapping, also known as attracticide, attract and kill, attractionannihilation or male annihilation, involves luring a moth with a synthetic pheromone so that it gets trapped in the trap and then exposed to a combination of insecticides and pheromones.



Trap design and placement

Trap design, placement and density can affect the number of pests captured (Jacquelyn *et al*., 2008). The most common trap employs a sticky surface to retain the attracted insect. The suitability of sticky

traps is dependent upon the population levels of the target species. One benefit of a little trap is that it can be used in places where a larger wing trap might not be desired. The narrower apertures caused by the trap being folded may have contributed to the lesser quantity of insects per centimeter (Mullen and Dowdy, 2001). Brockerhoff *et al*. (2006) used traps baited with pheromones and kairomones. The study tested the efficacy of different lures for established or newly established exotic species, and the effects of trap placement and proximity of host trees on trap catch in order to improve trap efficiency. The lure type used had highly significant effects on trap catch.

Conclusion

India's efforts to become self-sufficient in its agricultural production have been incredibly successful. In large part, new agricultural technologies have made this possible. Pheromones and other behavior-modifying semiochemicals are already a standard component of many pest management plans, and they are anticipated to be crucial in the development of advanced crop protection techniques in the future. Insect pheromone-related technologies for monitoring endemic pest populations, detecting invasive species, mass trapping for population suppression and mating disruption have had a relatively recent history of development in IPM compared to biological control and insecticide technologies. These will help provide a sustainable and environmentally friendly replacement to the broad-spectrum insecticides, either as monitoring or management tools of critical IPM programs.

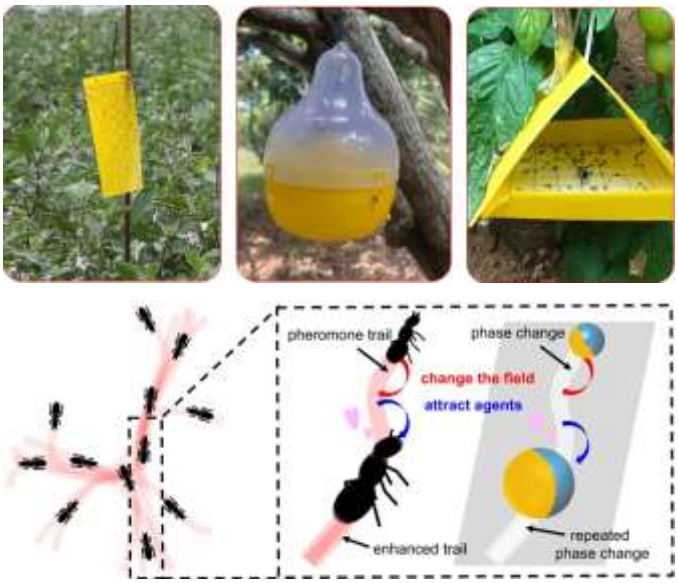


Fig.1: Mechanism of Trail pheromones



Fig. 2: Mechanism of mating disruption by camouflage

References

Mullen, M. A. and Dowdy, A. K. (2001). A pheromone-baited trap for monitoring the Indian meal moth, Plodia interpunctella (Hübner)(Lepidoptera: Pyralidae). *Journal of Stored Products Research*, 37(3): 231-235.

Brockerhoff, E. G., Jones, D. C., Kimberley, M. O., Suckling, D. M. and Donaldson, T. (2006). Nationwide survey for invasive wood-boring and bark beetles (Coleoptera) using traps baited with pheromones and kairomones. *Forest Ecology and Management*, 228(1-3): 234-240.

Blackmer, J. L., Byers, J. A. and Rodriguez-Saona, C. (2008). Evaluation of color traps for monitoring *Lygus* spp.: design, placement, height, time of day, and non-target effects. *Crop Protection*, 27(2): 171-181.

Witzgall, P., Kirsch, P. and Cork, A. (2010). Sex pheromones and their impact on pest management. *Journal of Chemical Ecology*, 36: 80-100.

Birds: Friends or Foes in Agriculture

Parimala B. and Annapurneshwari H.

Introduction

The warm-blooded, egg-laying vertebrate animals known as birds are identified by their feathers, wings, beaks, and usually their ability to fly. Approximately 1400 of the 10,000 bird species worldwide are located in Southern Asia, with 1295 of those species being found in India due to the country's subtropical climate (Johnson *et al*., 2011). Approximately 500 different bird species might be found in the Western Ghats in Karnataka. Parimala and Asiya Nuzhat (2018) investigated the population situation and diversity of avifaunal species at Tumkur district's Kaggaladu Bird Sanctuary. In the research region, a total of 48 species were discovered, representing 18 families and 12 orders. It has been determined that 63 bird species from 19 families are responsible for causing damage to various crops. However, it was only reported that 2.1% of all bird species seriously harmed crops. Birds are noticeable elements of ecosystems both visually and auditory. Asiya Nuzhat and Parimala (2018) discovered that there are 71 species known to exist, organized into 30 families and 14 orders. Passeriformes was the order in which the most species were spotted during the survey, followed by Charadriiformes and Ciconiiformes.

In ecosystems, birds are highly significant. All four categories of ecosystem services: provisioning, regulating, cultural, and supporting-are supported by birds. Through a variety of resources and procedures, ecosystem services serve humans both directly and indirectly. Because of their behavior and the services that their products offer, bird populations indirectly and directly contribute to human health. They act as bio-indicators, pollinators, seed dispersers, predators, scavengers, and eco-system engineers (Wenny *et al*., 2011). They are a significant class of vertebrates that are found in many global ecosystems and habitats, and they play a vital role in the food chain. In addition to being an integral component of the food web and the cycling of nutrients, birds are significant to human life on a cultural, social, and scientific level as well as being a source of food. One of the most significant species groups for the preservation of biodiversity is known to be birds. They safeguard the plant community by keeping pests and other rodents at bay, pollinate the plants, encourage greater plant survival through seed dissemination, keep the environment clean by acting as scavengers, and supply nutrients to the surrounding area. The agricultural ecology found in India's heavily farmed field areas is home to numero-

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us fish, dairy, honey bee, and poultry farms scattered throughout farmlands. These farms give birds, fish, animal feed, bees, nectar, and fruit trees or fruits extra food sources. Therefore, granivorous, frugi-vorous, nectarivorous, insectivorous, carnivo-rous, and omnivorous species are included in the category of agricultural birds.

Why birds are unique?

From the standpoint of ecosystem services, most birds are highly unique due to their unique characteristics. Due to their high mass-specific metabolic rates and thus high metabolic needs, the majority of birds are very mobile. Due to these traits, birds are able to react to unpredictable or sporadic resources in ways that other vertebrates are typically unable to. They can also depart places when resources are insufficient due to their mobility. Birds connect ecosystem processes and fluxes that are separated by significant distances and timeframes because many species migrate. Because of their mobility, they can also depart places where there are insufficient resources. Since many species migrate, birds connect ecological fluxes and processes that are separated by significant distances and periods of time.

Birds as friends of agriculture

Pollination services: They aid in the cross-pollin-ation of several woodland plants and agricultural crops. A crucial part of pollinating wild flowers is played by hummingbirds. A variety of birds, including sunbirds from the tropics, honeycreepers from Hawaii, honeyeaters from Australia, brush-tongued parrots from New Guinea, and spider-hunters, are essential for the pollination of verbenas, shrimp plants, bee balm, honey suckles, fuchsias, hibiscus, and bromeliads. Approximately 5% of food and medicinal plants benefit from the pollination of these birds. The lack of pollinating birds has caused 31 Hawaiian bellflower species to become extinct, underscoring the need of pollinating aves.

Soil fertility: Uric acid is abundant in bird feces. This contributes nitrogen to the soil and is easily converted to ammonia, which plants can use as fertile manure. It's possible that nearby birds contribute less to the excrement. However, adding poultry excrement to the soil significantly increases fertility.

Pest control: For food, both for themselves and their offspring, birds depend on insects and their larvae. Because of the ideal growing conditions, the population of insect's increases significantly during the agricultural season. Birds protect crops from pest attacks and restrict the proliferation of pests. Verma (2006) discovered that, in addition to wasps, house sparrows, common myna, red-vented bulbul, pycnonotus cafer, and three other bird species are significant in lowering *Catopsilla* sp. larvae in *Cassia angustifolia*, a therapeutic crop. In addition to direct predation, it has been discovered that insectivorous birds contribute significantly to the biological management of insect pests via spreading disease. Certain bird species spread the NPV that infects *Helicoverpa armigera* to the pest's healthy larvae (Vyas *et al*., 1988).

Rodent control: Birds like eagles keep an eye on

these rodents and carry away for consumption. Thus, they keep the rodent growth under control, which in turn helps the farmers. In addition to this, birds are essential to the spread of forest tree and wild plant seeds. Few studies have been conducted to assess the beneficial impact that insectivorous and predatory birds play in reducing the number of nuisance insects and rodents that affect crops, despite the fact that this role is well known. These studies have only examined the case of insectivorous birds.

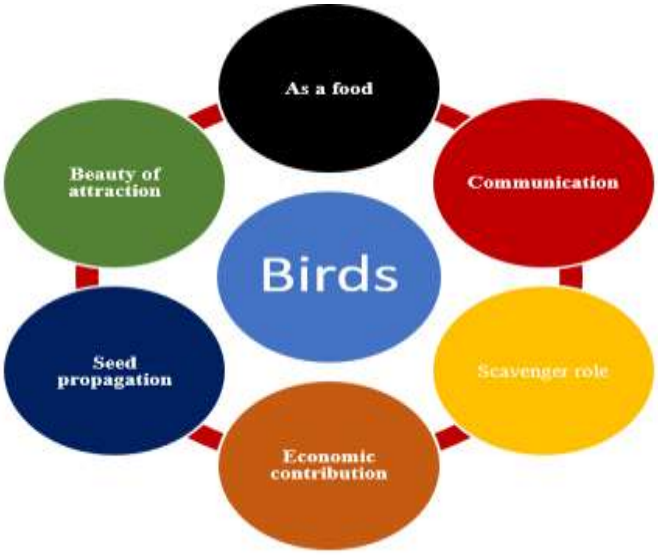


Fig. 1: Importance of birds to human

Role in seed dispersing agent: Bird foraging and seed dispersion play an important role in the ecosystem. Seed dispersal is critical to the ecosystem for maintaining bio-diversity, species distribution, population dynamics, and ecological balance in the ecosystem. Birds disseminate the seeds of many tree and plant species that are of immediate use to humans, whether for medicine, food, timber, or other purposes. These services are mainly observed in frugivorous bird species, which include nearly 48 families (1/3 of all living bird species) that feed exclusively on fruits (Mahendiran and Azeez, 2008). Birds help in the propagation of plant species by acting as seed dispersers. The process of seed dispersal regulates the dynamics of long-term plant communities and the regeneration of vegetation in ecosystems altered by humans Seeds can adhere to the feathers of birds through structures on the seed. Birds carry seeds, such as those of the mistletoe owl, by carrying them on their beaks after feeding.



Birds as foes in agriculture: From the time of planting to the time of harvesting, birds can cause harm to crops and financial loss to farmers. Bird damage persists in grain stores, shelling yards, and market locations following crop harvest. Sometimes the damage is so bad that farmers have to resowing the fields that are impacted during the sprouting stage.

Types of damage caused by birds: Birds can cause crop losses by feeding on grains, fruits and sown seeds, pulling up of seedlings, trampling of seedlings, breaking branches when roosting, nipping buds, fouling nursery stock and lawns, damage irrigation pipes and serve as vectors of plant pathogens like bacteria which aggravates the disease potentiality. When birds have eaten seeds or pulled out seedlings they are taken away from the field. Fruits injured by birds lose marketability. Thus, once attack of a bird to a seed or a fruit produces 100 % loss of it. Cereals more vulnerable to bird attack especially at dough stage. Damage to the crops of

smaller grains such as pearl millet and sorghum was more serious as compared to that in large size grains (e.g., Maize). The fact that just about 2% (or 5 out of 1000) of India's bird species have been discovered to harm agricultural and horticultural crops is highly interesting. Numerous researchers from around the world have calculated the potential damage that a variety of species could do to different crops. The removal or eating of plant stems, shoots, buds, foliage, fruits, and seeds is the main direct cause of damage. Loss to crops varies temporally and spatially depending on the crop type, phenology and location and also on the behaviour and population dynamics of birds.



References

Johnson, R. J., Jedlicka, J. A., Quinn, J. E. and Brandle, J. R. (2011). Global perspectives on birds in agricultural landscapes. *Integrating Agriculture, Conservation and Ecotourism: Examples from the Field*, 55-140.

Wenny, D. G., Devault, T. L., Johnson, M. D., Kelly, D., Sekercioglu, C. H., Tomback, D. F. and Whelan, C. J. (2011). The need to quantify ecosystem services provided by birds. *The Auk*, 128(1): 1-14.

Mahendiran, M. and Azeez, P. A. (2018). Ecosystem services of birds: a review of market and non-market values. *Entomology Ornithology Herpetology*, 7(209): 2161-0983.

Parimala, B. and Asiya Nuzhat, F. B. (2018). Avifaunal Diversity and Status of Kaggaladu Bird Sanctuary of Tumkur District, Karnataka. *International Journal for Research in Applied Science and Engineering Technology*, 6(10): 1747-1750

Parimala, B. and Asiya Nuzhat, F. B. (2018). Avifaunal Diversity and status of Bhimasandra Pond, Tumakuru District, Karnataka, India. *International Journal of Innovative Research in Science, Engineering and Technology*, 7(4): 4313-4320

Verma A. (2006). Preliminary observations on the ecology of Harriers (*Circus* sp.) roosting at Hessarghata, North Bangalore in Karnataka, South India with special reference to Eurasian Marsh Harriers (*Circus aeruginosus*). *Indian Forester*, 132: 337-344.

Vya, R. J., Frenzel, M. and Schweiger, O. (1988). Bird communities in agricultural landscapes: What are the current drivers of temporal trends. *Ecological Indicators*, 65: 113-121.

Importance of Dragon Fruit in Human Nutrition

Oksana Mandal, Ganesh Kumar Choupdar and Ajay Baldaniya

Introduction

The climbing vine cactus *Hylocereus undatus*, which is native to the tropical forests of Mexico, Central America, and South America, produces the fruit known as 'dragon fruit' or 'Red pitaya'. Pitaya, Moon lovers, Night blooming Cereus, Strawberry Pear, Belle of the Night, and Conderella plant are some of its other names. It is epiphytic thrives on soil rich in organic materials. More than a century ago, the French brought dragon fruit to Vietnam. The reason it is called Thanh Long (Green Dragon) is that the majority of the fruits have oval shapes and brilliant red skin. Possessing green foliaceous bracts or scales that mimic a dragon's skin. Pitaya plants can go through four to six fruiting cycles in a single year. The dragon fruit is shaped like a circle, an ellipse, or a pear and has varieties with bright pink and yellow skin (Hitendraprasad *et al*., 2020). According to Ritarwan K and Nerdy N's research, both the peel and flesh of the fruit are high in polyphenols and antioxidants (Sonawane, 2017). In the customs of certain ancient tribes, the leaves and flowers of *H. undatus* were conventionally employed for their diuretic, hypoglycemic, and cicatrizing properties.

The three different commercially available varieties are *Hylocereus megalanthus* (Yellow pitaya), which has white flesh and yellow-skinned fruit with edible black seeds all over, *Hylocereus polyrhizus* (Red pitaya), which has red skin and red-skinned fruit, and *Hylocereus undatus* (Red pitaya), which has white flesh and red-skinned fruit. For farmers in Vietnam, this fruit has emerged as their most lucrative harvest. Pitaya is planted in 63/65 cities/provinces in Vietnam, which has the greatest pitaya cultivation area in Asia (Hoat *et al*., 2018). According to Sofowora *et al*. (2013), dragon fruit is regarded as a medicinal plant that is utilized in Asian folk medicine, where traditional healers employ herbal remedies to both prevent and treat illnesses. The peels and pulp are high in water content, high in fiber, and packed with nutrients, including a plethora of vitamins, minerals, and antioxidants. This article summarizes what is now known about the nutritional makeup and health advantages of dragon fruit.

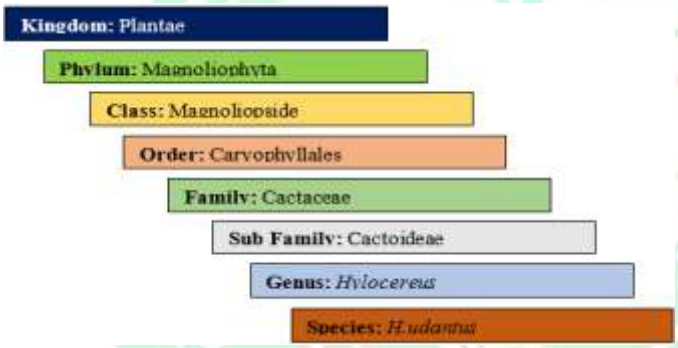
Nutritional profile of dragon fruit

The genus *Hylocereus* contains a number of species, although only a small number- *Hylocereus undatus*, *Hylocereus polyrhizus*, and *Hylocereus canariensis* are cultivated due to their economic and

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dietary significance (Muniz *et al*., 2019). The nutritional qualities of dragon fruit juice derived from various species and crops exhibit significant variability, as demonstrated by the analysis conducted. Accordingly, depending on the species and place of origin, 100 g of fresh dragon fruit pulp contains over 80% moisture, 0.4 to 2.2 g of protein, 8.5 to 13.0 g of carbs, and 6.0 g of total sugar. The discovery that the vitamin C concentrations found in Ramli and Rahmat (2014) investigations. It is said that the dragon fruit is a magical fruit with extraordinary nutritional and therapeutic qualities.

Taxonomic classification



Its effectiveness in lowering blood sugar levels in people with Type 2 diabetes is often known. Dried dragon fruit is therefore a part of the diets of people with diabetes. Fruit is believed to help with nutritional absorption, immune system enhancement, bone and tooth strength, heart muscle, blood and tissue development, pulmonary disorders, fast healing from wounds and injuries, and as a mild laxative because of its high fiber content. Some hypotheses suggest that dragon fruit can reduce cholesterol, regulate blood sugar, prevent colon cancer, enhance bone and renal health, improve brain function, increase visual acuity and contain substances that are beneficial to the skin. Fruit pulp is rich in antioxidants and Vitamin C. It also contains proteins, B vitamins, carotenoids, polyunsaturated fats, and minerals like salt, calcium, and iron. Research indicates that apple pulp has a vitamin C content of up to 6000 mg/100 g (Sonawane, 2017). Pectin-rich dragon fruit is another well-known benefit. A research states that between 14.96 and 20.14% of the dried peels were present. It could be applied to business needs.

Dragon fruit can be a significant source of pectin in fruit processing; a research found that 7.5% of the pectin was extracted during the microwave-assisted extraction procedure. The tiny, black seeds of the dragon fruit are covered in either pink or white flesh. The seeds include fatty acids such as palmitoleic acid, linolenic acid, and linoleic acid, oleic acid, myristic acid, bicis-vaccenic acid, stearic acid, and palmitic acid. Research has been conducted to determine the composition of the oil extracted from these dragon fruit seeds. It has been demonstrated that the polysaccharides and mixed oligosaccharides found in dragon fruit flesh promote the growth of lactobacilli and bifidobacteria. Gram-positive lactic acid-producing bacteria, such as lactobacilli and bifidobacteria, comprise a significant amount of the microflora in the human digestive tract. Probiotics, a type of gastrointestinal micro-biota, help stop the spread of gastrointestinal illnesses (Xu *et al*., 2016). It is believed that the stem of the dragon fruit plant has medicinal properties. Eating the juvenile stem of the dragon fruit-which

has higher ascorbic acid content than the fruit itself may have protected people from some disease-causing variables, per certain research.

Future perspective

The production of dragon fruit is a major global enterprise, but further research is needed to better understand the fruit's nutritional value and bromatological consistency so that the food and pharmaceutical industries may make greater use of it. This crop can be grown organically using locally produced organic manures and composts because of its very low nitrogen requirements when compared to many other fruit crops. Additional research is required to comprehend the adaptation mechanisms underlying the dragon fruit's salinity tolerance and to identify genotypes that can thrive in the more adverse conditions brought on by global climate change.

Conclusion

The increasing popularity of dragon fruit in India can be attributed to its nutritional content and health benefits. It is claimed that eating this fruit will provide exceptional nutritional value as well as possible solutions for a variety of health issues. The dragon fruit has several beneficial effects on human health because of its nutritional and medicinal qualities, but most notably in terms of managing and controlling oxidative stress. The dragon fruit, due to its ecological characteristics, benefits to human health, and the commercial value has become a cost-effective product for the global economy. It is clear that dragon fruit has significant nutritional and therapeutic value. It is enhanced with important minerals like calcium, iron, and phosphorus, as well as key nutrients like vitamin C, vitamins B_1, B_2, and B_3. It also has a remarkable fiber level.



References

Sofowora, A., Ogunbodede, E. and Onayade, A. (2013). The role and place of medicinal plants in the strategies for disease prevention. *African Journal of Traditional, Complementary and Alternative Medicines,* 10(5): 210-229.

Hoat, T. X., Quan, V. M., Hien, N. T. T., Ngoc, N. T. B., Minh, H. and Thanh, N. V. L. (2018, April). Dragon fruit production in Vietnam: achievements and challenges. In *Dragon Fruit Regional Network Initiation Workshop* (pp. 23-24). FFTC Taipei.

Muniz, J. P. D. O., Bomfim, I. G. A., Corrêa, M. C. D. M. and Freitas, B. M. (2019). Floral biology, pollination requirements and behavior of floral visitors in two species of pitaya. *Revista Ciência Agronômica*, 50: 640-649.

Ramli, N. S. and Rahmat, A. (2014). Variability in nutritional composition and phytochemical properties of red pitaya (*Hylocereus polyrhizus*) from Malaysia and Australia. *International Food Research Journal*, 21: 1689-1697.

Hitendraprasad, P. P., Hegde, K. and Shabaraya, A. R. (2020). *Hylocereus undatus* (Dragon Fruit): A Brief Review. *International Journal of Pharmaceutical Sciences Review and Research*, 60(1): 55-7.

Sonawane, M. S. (2017). Nutritive and medicinal value of dragon fruit. *Asian Journal of Horticulture*, 12(2): 267-271.

Xu, L., Zhang, Y. and Wang, L. (2016). Structure characteristics of a water-soluble polysaccharide purified from dragon fruit (*Hylocereus undatus*) pulp. *Carbohydrate Polymers*, 146: 224-230.

Novel Technology for Preservation of Food and Food Products: An Overview

Ganesh Kumar Choupdar, Arushi Bisht, Mansi Rana and Sajeel Ahamad

Introduction

Food has always been essential for human survival. People consume both plant and animal-based foods, such as poultry, eggs, fish, and sea-foods. Pal (2014) suggests that humans consume food for development, health, enjoyment, and satisfaction, in addition to meeting nutritional requirements. Animal and animal-derived foods are particularly perishable. Unsanitary manufacturing, handling, and packaging circumstances can lead to microbial deterioration in certain foods, particularly dairy products. Approximately one-third of collected food is lost due to spoilage. After being collected or killed, every food deteriorates to some extent. Loss of nutritional value, changes in color and organo-leptic properties, and above all a potential compro-mise to safety are some symptoms of the deterioration. The food sector faces a problem in regulating this degradation and preserving food safety, all the while ensuring that food is as accessible, nourishing, and convenient as it can be. Therefore, food preservation is crucial to preventing the significant financial losses brought on by deteriorating changes caused by microbiological, chemical, and physical processes.

Preserving food involves establishing unfavorable conditions that hinder the growth of germs. The sensory and nutritional quality of food is altered by a single parameter used in conventional preservation procedures. Research on food preservation is becoming more and more interested in a number of new and developing methods. These range from food preservation techniques that are still in their infancy (like plasma processing or dense phase carbon dioxide pasteurization) to techniques that are comparatively well developed and, in certain cases, commercialized, albeit on a relatively small scale (ohmic heating and high-pressure processing are two examples).



Fig. 1: Objectives of preservation

Criteria of food preservation techniques

Three groups can be formed from the food preservation techniques based on their manner of action.

- ✓ Slowing down or inhibiting the chemical deterioration and microbial growth.
- ✓ Involving bacteria, yeasts, molds, and enzymes directly.

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- ✓ Preventing food from being contaminated again both before and after processing.

The majority of preservation methods used today to preserve food have something to do with one of the three aforementioned criteria. To suit customer demands, great efforts have been made to avoid using a single preservation process for food preservation. But when it comes to food safety and shelf life, one needs to find a more intricate method of food preservation. Failure to preserve food can result in anything from mild degradation (such as color loss) to potentially dangerous food.

Novel Technology for Preservation

In the past ten years, there has been a significant focus on non-thermal inactivation approaches in research due to the growing demand from consumers for wholesome, fresh-looking food products that have a good organoleptic quality and a reasonable shelf life. Ionization radiation, high pressure homogenization, pulsed electrical fields, UV decontamination, pulsed high intensity light, high intensity laser, pulsed white light, high power ultrasound, oscillating magnetic fields, high voltage arc discharge, and streamer plasma are among the inactivation techniques under investigation.

High hydrostatic pressure

HHP is a material science technique that allows a product to be treated at or above 100 MPa. The industrial machinery currently in use is semicontinuous (producing liquid foods in batches of one to four tons hour^{-1}) and discontinuous (with a capacity of 10 to 500 L) for solid, viscous, and particle foods. Large-scale processing (Yuste *et al*., 2002). Commercial fruit preserves, jellies, sauces, juices, rice wine, cake, avocado pulp, guacamole, and cooked ham have all been recorded to be produced. The method has been researched for dairy uses, including extending the shelf life of goat cheese to reduce the ripening time of cheese to 3 days at 250 MPa. It also helpful to prevents over acidifications. Numerous studies have shown how HHP inactivates microorganisms, increasing the microbiological shelf life and enhancing the microbial safety of food goods. HPP is inefficient against bacterial spores and enzymes, but it has been shown to kill viruses, yeasts, molds, and pathogenic and spoilage bacteria. A few examples of the variables that impact microbial inactivation effectiveness are the kind of microbe, food composition, pH, and water activity.

Pulsed electric fields

Pulsed electric field technology (PEF) is a non-thermal inactivation method that is becoming more and more popular in the commercial sector and moving from the laboratory and pilot size to the industrial scale. The PEF chamber's treatment gap is contained by a series of electrodes that are used to deliver pulsed power to the product (Gongora-Nieto *et al*., 2002). The application of brief, high-voltage pulses between the set of electrodes disrupts the membranes of microorganisms, resulting in their demise. Food items that can be pumped just need to be treated. Currently, industrial PEF equipment is expensive and scarce, with a capacity of only about 1800 L h^{-1}. Nonetheless, a lot of work being done in

a variety of ways to expand the supply of high capacity PEF equipment. Research on the impact of PEF on dairy products, specifically skim milk, whole milk, and yoghurt, have been carried out. Generally speaking, yeasts exhibit greater sensitivity to PEF than bacteria do, however Gram-positive vegetative cells are more resistant than Gram-negative bacteria. The majority of papers discuss how PEF inactivates vegetative cells, but there are very few that discuss how PEF inactivates spores, indicating that PEF's effects are restricted. Similar to how HHP therapy works, administering PEF in conjunction with other stressful variables including the presence of antimicrobial agents like nisin and organic acids, enhanced water activity, pH, and mild heat treatments might improve its inactivation impact.

New packaging systems

Over the past ten years, new packaging techniques have played a significant role in increasing the shelf life of chilled, minimally processed food items. The food sector has used MAP extensively, frequently without having the necessary understanding of the mechanics underlying its preservation effect. “The enclosure of food products in gas-barrier materials, in which the gaseous environment has been changed” is one definition of MAP (modified atmosphere packaging). The susceptibility of the product to particular microbiological, chemical, and enzymatic degrading responses will be determined by the intrinsic characteristics. Goods like yogurt and cheese that are prone to microbial deterioration as a result of the growth of Gram-negative bacteria and yeasts will be packed in an environment enhanced with CO_2, since CO_2 considerably slows down the growth of those microorganisms.

Bio preservation

A growing percentage of consumers favor meals that have been prepared with little to no processing and no artificial preservatives. With regard to health hazards and the correlation between spoiling and food, many of these newly developed and ready-to-eat food kinds reflect new food systems. In light of this, and with the help of enhanced comprehension and awareness of the intricacy of microbial interactions, current methods are more focused on the opportunities provided by bio (logical)-preservation. Using natural or regulated microflora, primarily LAB, and/or their antibacterial compounds, such as lactic acid, bacteriocins, and others, might prolong the shelf life and/or improve the safety of food products during biopreservation.

Use of Nano emulsion in food packaging

Nanoemulsions are nano-sized emulsions synthesized to enhance the delivery of active ingredients to food, also known as ultrafine emulsions, submicron emulsions and mini-emulsions. These are aqueous phases, surfactants, and oils combined to form colloidal dispersions. An emulsifying agent, such as a surfactant or co-surfactant, unites two incompatible liquids into a single phase in these isotropic, thermodynamically stable systems. Changes in pH or other physical or chemical parameters have no effect on nanoemulsio-

ns as opposed to thermodynamically stable micro-emulsions (Aswathanarayan *et al*., 2019). Food grade Nano emulsions can be used in the food packaging systems to improve their morphological, structural, and biological properties by encapsulating active agents, i.e., essential oils, plant extracts, phenolic compounds, antimicrobials, antioxidants, anti-browning agents, preservatives, flavors, coloring agents, nutraceuticals, etc (Nirmala *et al*., 2020).

Conclusion

Food is essential to our existence since it provides the majority of the energy needed to carry out our daily tasks. Innovative technologies enable items to exceed client expectations by producing goods that are safe and uphold strict quality requirements. These newly developed techniques could be used to pasteurize food while reducing heat-induced quality losses. The trend toward using "natural" ingredients (colors, flavors, or preservatives), despite their technical difficulties, has prompted research into milder, more energy-efficient, but equally effective processing technologies that can preserve the structure, and therefore the benefits and function, of novel ingredients while also maintaining other food product qualities and nutritional value. Enhancing the quality of their products has always been the main objective of the food and beverage industries. Among the most promising novel processing techniques are cold plasma, pulsed electric field (PEF), and high-pressure processing (HPP).



References

Aswathanarayan, J. B. and Vittal, R. R. (2019). Nanoemulsions and their potential applications in food industry. *Frontiers in Sustainable Food Systems*, 3: 95.

Góngora-Nieto, M. M., Sepúlveda, D. R., Pedrow, P., Barbosa-Cánovas, G. V. and Swanson, B. G. (2002). Food processing by pulsed electric fields: Treatment delivery, inactivation level, and regulatory aspects. *LWT-Food Science and Technology*, 35(5): 375-388.

Nirmala, M. J., Durai, L., Gopakumar, V. and Nagarajan, R. (2020). Preparation of celery essential oil-based nanoemulsion by ultrasonication and evaluation of its potential anticancer and antibacterial activity. *International Journal of Nanomedicine*, 7651-7666.

Pal, M. (2014). Preservation of Various Foods (Doctoral dissertation, Ph. D. Lecture Note, Addis Ababa University, College of Veterinary Medicine and Agriculture, Debre Zeit, Ethiopia).

Probiotics in Fruit Juice: A New Kind of Functional Food

Janhvi Makwana, Oksana Mandal and Manjula

Introduction

Currently, consumers are increasingly interested in so-called 'functional foods' containing bioactive compounds such as fibre, oligosaccharides or probiotic microorganisms whose consumption can lead to the prevention or reduction of the risk of food borne illness. Probiotics together with prebiotics (non-digestible food ingredients that positively and selectively stimulate the growth and/or activity of beneficial bacteria in the colon, phytonutrients and unsaturated fatty acids complement the traditional functional food ingredients such as vitamins, minerals and micro nutrients (Jankovic *et al*., 2010). Many meals containing probiotics or prebiotics come from milk, however manufacturers and customers are also interested in non-dairy goods. Fruit juices, which are drunk by people of all ages and are thought to be healthful because they contain a high concentration of bioactive components, are currently receiving more attention. Recent developments in the food industry have shifted their main focus to the creation of functional food products. The basis of this movement is consumer demand for foods that are healthy and devoid of chemical additives. Foods that provide health advantages beyond only fulfilling nutritional requirements are referred to as "functional foods." Foods that have undergone fermentation by probiotic microorganisms are known as probiotic foods, and they are considered a prominent subcategory of functional foods. They can prevent vitamin deficiencies, protect against a range of ailments, and encourage normal growth and development. The idea of functional food was created in Japan at the beginning of the 1980s, and the term "food for specified health use" (FOSHU) was first used in 1991. Described as any food or substance that, in addition to its nutritional worth, positively affects a person's health, physical performance, or state of mind. Therefore, the formulation of probiotic beverages based on the fruit juices might be a compromise solution as they provide an excellent carrier for these probiotic bacteria.

Need of non-dairy probiotics

Probiotic goods are generally offered as fermented milks and yoghurts, however there are two major drawbacks: lactose intolerance and the product's cholesterol content. Because they are vegan-friendly, have lower cholesterol, and don't include dairy allergens, nondairy probiotic beverages

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are very enticing. Furthermore, different substrates can supply different combinations of vitamins, minerals, dietary fiber, and antioxidants. The aforementioned drawbacks of dairy probiotics have led scientists to hunt for novel and different probiotic microbe carriers. The best non-dairy probiotic product innovations have been demonstrated to be fruits, vegetables, and cereals, and demand for these products is growing.

Fruits used as Probiotics

Fruits are nutrient-rich and vital for sustaining excellent health, making them one of the most necessary diets for humans. Both fresh and processed fruits improve diet quality and provide essential nutrients like antioxidants, carbs, vitamins, and minerals. Fruit juices are a great source of minerals, vitamins, and carbohydrates all of which support the survival of probiotics in storage. For consumers who have a lactose intolerance or who prefer low-cholesterol diets, fruit juices are an excellent choice. Due to their structural characteristics and nutritional makeup (which includes sugars and other nutrients including antioxidants, dietary fibers, minerals, and vitamins), fruits are a preferred and ideal substrate for probiotic microbes.

Microorganisms used as probiotics

The most prominent probiotic microorganisms are LAB and *Bifidobacteria* species which are renowned generally recognised as safe (GRAS) in food industry. The strains of *Lactobacillus plantarum, Lactobacillus acidophils, Lactobacillus rhamnosus, Lactobacillus reuteri, Lactobacillus johnsonii, Lactobacillus lactis, Lactobacillus casei, Lactobacillus paracasei, Lactobacillus delbrueckii* sub sp *bulgaricus, Bifidobacterium lactis, Bifidobacterium infantis, Bifidobacterium longum,* and *Bifidobacterium brevis* were frequently used as commercial starter cultures. In addition to these, *Streptococcus thermophillus, Enterococcus francium, Pediococcus* and *Leuconostoc* species were also LAB and can be used as probiotics. The probiotics can be used as single or mixed cultures. In selecting probiotic bacteria for industrial manufacturing processes, safety, functional and technological characteristics should be considered.



How can nondairy probiotic products be developed?

The buzzword in business today is innovation. Experts declare on a regular basis that a company's ability to innovate is its only chance of survival. Within this framework, the creation of novel nondairy probiotic food products becomes more difficult since it must satisfy customer demands for delicious and healthful products (Shah 2007).

As per Jousse (2008), the creation of novel products is an ongoing issue for both scientific and applied research. It has been noted that the design of food products is essentially an optimization problem aimed at producing the optimal formulation.

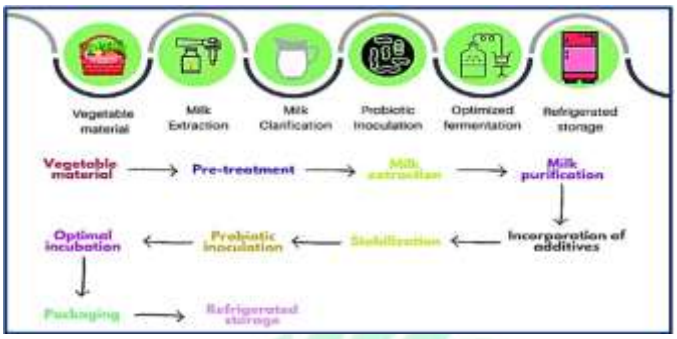


Fig. 1: Basic flow diagram of developing probiotics juices

Industries must ascertain the fundamental composition of every product for this reason, but this is a difficult task, particularly when there are several variables linked to various requirements that must be met. Second, in order to achieve the right physico-chemical and sensory qualities, a longer shelf life, chemical stability, and a fair price, the ideal concentrations of key constituents must be found. The methodologies that advance a firm's understanding of customer's choice motives and values, and its knowledge of management process, can increase the chances of new product success in the international market. The commercial success of dairy-free probiotic products ultimately depends on taste, appearance, price, and health claim appeal to consumers. They need to receive a comprehensible and reasonable message about the physiological effects of probiotics in humans, without appearing to be exaggerated; moreover, all the factors mentioned previously influence directly the consumers' attitudes toward effective purchase, which is necessary for the maintenance of industry.

Conclusion

Over the last decade, fruit juice consumption has increased. Their rise in popularity can be attributed to the belief that they are a quick way to consuming a dietary portion of fruit. Probiotics added to fruit juices produce various bioactive compounds, thus probiotic fruit juices can be considered as a new type of functional foods. Probiotic fruit juices have the ability to greatly improve health and help avoid certain diseases when taken as a functional food as part of a balanced diet and healthy lifestyle. Probiotic-containing fruit juices have shown to have major health benefits for humans, and using them to treat a range of ailments may reduce the need for antibiotics. New fruit-based probiotic products have been encouraged to emerge as a result of the growing need for non-dairy functional probiotics.

References

Jankovic, I., Sybesma, W., Phothirath, P., Ananta, E. and Mercenier, A. (2010). Application of probiotics in food products challenges and new approaches. *Current Opinion in Biotechnology*, 21(2): 175-181.

Jousse, F. (2008). Modeling to improve the efficiency of product and process development. *Comprehensive Reviews in Food Science and Food Safety*, 7(1): 175-181.

Shah, N. P. (2007). Functional cultures and health benefits. *International Dairy Journal*, 17(11)

Nutritional Composition and Potential Health Benefits of Flaxseeds

Krishna Patel, Janhvi Makwana and Oksana Mandal

Introduction

Flaxseed, or Linseed (*Linum Usitatissimmum*), popularly known as Alsi, Jawas, Aksebija in Indian languages, (Anonymous, 2000). Flax (*Linum usitassimum*) belonging to family Lineaceae, is a blue flowering annual herb that produces small flat seeds varying from golden yellow to reddish brown color. Flaxseed has a nutty flavor and a crisp texture. The entire flaxseed is circular, flat, and has pointy points. Its color varies. Measuring roughly 2.5 × 5.0× 1.5 mm, it ranges in color from black to yellow. Flaxseed, or *Linum usitatissimum* in Latin, translates to "very useful." It comes in two main varieties: brown and yellow or golden, or golden linseeds. According to Morris (2007), flaxseed has a nutty flavor and a crunchy texture. A good source of oil, protein, and dietary fiber is flaxseed. It is widely recognized for containing chemical substances with particular biological activity and functional characteristics, including as the omega-3 family of polyunsaturated fatty acids (PUFA), lignans, soluble dietary fibers, proteins, and carbs (Rubilar *et al*., 2010). Because flaxseeds have lignans, digestible proteins, and omega-3 fatty acids, they can be employed as functional dietary ingredients. Apart from being a high source of lignans and α-linolenic acid oil, flaxseed also contains phenolic compounds. The biologically active ingredients in flaxseed aid in the prevention of a number of chronic illnesses, including diabetes, heart disease, stroke, and several forms of cancer. The whole flaxseed is flat and oval with pointed tips and contains a seed coat or true hull (also called testa), a thin endosperm, two embryos and an embryo axis (Morris, 2007). Every part of the linseed plant is utilized commercially, either directly or after processing. The shell yields good quality fiber having high mechanical properties and low density instead the seed provides oil rich in omega-3, digestible proteins and lignans; it is also use to manufacture paints, varnishes, linoleum, oilcloths, printing inks, soaps and numerous other products. Owing to flaxseed's superior nutritional value despite its high oil content, it is used in ready-to-eat snack meals that are well-liked by consumers, as well as in classic cereal-based matrices like bread and pasta, egg products, and so on.

Nutritional Composition of Flaxseeds

Oomah (2001) states that flaxseed has gained attention as a potential functional food due to its high content of phenolic compounds, lignans, high quality

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protein, soluble fiber, and alpha-linolenic acid. Rich in nutritional fiber, protein, and fat is flaxseed. Flaxseed is rich in fat, protein and dietary fibre. The composition of flaxseed varied with genetics, growing environment and method of seed processing (Daun *et al.*, 2003). Flaxseeds constitutes about 6.5 g per 100 g moisture, 20.3 g per 100 g protein, 37.1 g per 100 g fat, 4.8 g per 100 g crude fibre, 24.5 g per 100 g total dietary fibre, 2.4 g per 100 g ash content and 28.9 g per 100 g carbohydrates. Flaxseeds exhibits calorific value of 530 kcal per100 g its edible portion. In terms of mineral content, flaxseeds had 2.7 mg of iron, 370 mg of phosph-orous, 170 mg of calcium, and 750 mg of potassium per 100 g. In terms of vitamins, flaxseeds provide around 30 mg of vitamin A, 0.6 mg of vitamin E, 0.23 mg of thiamine, 0.07 mg of riboflavin, and 1 mg of niacin per 100 g. It is widely known that flaxseeds are a source of a high concentration of polyun-saturated fatty acids, and that their protein level declines as their oil content increases (Pradhan *et al*., 2010).

Health benefits of Flaxseeds

- ✓ Flaxseed are rich in plant compounds especially lignans that have been studied for their potent cancer-fighting properties.
- ✓ Flaxseed's high fibre content may help lower cholesterol levels and improve heart health which may be especially useful for those with high blood pressure.
- ✓ Flaxseeds are also associated with a lower risk of breast cancer, particularly in postmenopausal women. Their intake also protect human body against colorectal, skin, blood, and lung cancer.
- ✓ Flaxseeds contains two types of fibre -soluble and insoluble fibre which get fermented by the bacteria in our intestines to support gut health and improve bowel regularity.
- ✓ Flaxseeds include soluble fiber, which decreases cholesterol and may help to balance and regulate blood sugar levels.
- ✓ The insoluble fiber found in flaxseeds is crucial for encouraging regular bowel movements and reducing constipation.
- ✓ Flaxseed can interact with several medications, including blood thinners and antiplatelet medications.
- ✓ Flaxseeds also helps in weight management.

Table 1: Nutritional composition of flaxseed (Source: Morris, 2007 and Gopalan *et al*., 2004)

Nutrients	Amount per 100 g of edible flaxseed
Protien (g)	20.3
Fat (g)	37.1
Minerals (g)	2.4
Crude fiber (g)	4.8
Total dietary fiber (g)	24.5
Carbohydrates (g)	28.9
Energy (Kcal)	530
Potassium	750
Calcium (mg)	170
Iron (mg)	2.7
Niacin (mg)	1.0
Thiamine (mg)	0.23

Food Applications of Flaxseed and Its Compo-nents

Flaxseed Kernel: The consumption of flaxseed has been emphasized in recent times owing to its good nutritional value, particularly the high amount of healthy fats, proteins, and lignans. Flaxseed is available for human utilization in four forms, including oil, whole seeds, ground, and defatted oil-

seed meal.

Flaxseed oil: Flaxseed oil has gained popularity among buyers worldwide due to its plentiful nutritional advantages and food applications. However, the susceptibility of flaxseed oil to oxidative degeneration is the main limiting factor, which limits its use in foods and other applied purposes. It has been discovered that using flaxseed in a nano-emulsion or microencapsulated form greatly increases the absorption of ω-3 poly-unsaturated fatty acids. These days, the food and health industries employ these technologies quite a bit. for the efficient delivery of delicate components to intended locations by shielding them from heat, light, air, water, and digestive processes.

Protein: Flaxseed proteins possess some unique functional properties, which make them a preferred plant-based alternative to eggs or other animal-derived proteins. Firstly, flaxseed protein has a strong emulsification capacity (EC), due to which it can form a strong emulsion in many food systems by forming a coating around the oil droplets. Flaxseed proteins exhibited good EC in both acidic and basic conditions; thus, they can also be used as an emulsification agent in nano-emulsions for the delivery of bioactive compounds.

Gum/mucilage: Gum or mucilage is an important component of flaxseed, which is mostly located on the outer layers of the seed. It constitutes almost 8-10% of the whole seed weight. FG attributes unique functional properties to foods owing to their unique polysaccharide composition, such as improving viscosity, emulsifying ability, rheology, and foaming ability. The hot water extraction method was found to be the best treatment for obtaining flaxseed gum that yielded polysaccharides with better stability, consistency, functional abilities, and commercial value.

Conclusion

Flaxseed (*Linum usitatissimum*) is an oil-based seed that is recommended for a better lifestyle due to its high concentrations of lignans, fiber, linoleic acid, and alpha-linolenic acid. Additionally, flaxseed met essential requirements in the human diet. The consumption of flaxseed increases the probiotic bacteria in the gut and also produces metabolites that play crucial roles in lipid and glucose metabolism and immune and homeostasis pathways.





References

Anonymous. (2000). Oil world statistics update. In: Oil World, 31: 9-10.

Morris, D. H. (2007). Flax-A Health and Nutrition Primer, 4th edition. Flax Council of Canada, Pp. 11.

Daun, J. K., Barthet, V. J., Chornick, T. L. and Duguid, S. (2003). Structure, composition and variety development of flaxseed. Flaxseed in Human Nutrition (2nd Edn), AOCS Press, USA, p. 1-40.

Gopalan, C., Sastri, R. and Balasubramanian, S. C. (2004). Nutritive value of Indian foods. National Institute of Nutrition, ICMR, Hyderabad, p. 52 (2004)

Oomah, D. B. (2001). Flaxseed as a functional food source. *Journal of Food Science and Agriculture*, 81: 889-894.

Pradhan, R., Meda, V., Rout, P. and Naik, S. (2010). Supercritical CO_2 extraction processes. *Journal of Food Engineering*, 98: 393-397.

Rubilar, M., Gutierrez, C., Verdugo, M., Shene, C. and Sineiro, J. (2010). Flaxseed as a source of functional Ingredients. *Journal of Soil Science and Plant Nutrition*, 10(3): 373-377

Quorum Sensing and It's Role in Plant Pathology

Meghana Deva, Sushma A. Rao and Sharanabasay Huded

Introduction

Quorum sensing (QS) is a bacterial cell to cell communication process that involves the production, detection, and sending signals in response to external environment. Bacterial cells communicate with one another using chemical signal molecules called autoinducers (AIs). The concept of quorum sensing (QS) conveys the idea that some features are only expressed when bacteria are crowded together and represents a well-understood method of bacterial cell-cell communication. This allows them to act in a coordinated manner and reinforces the notion that individual bacteria benefit from co-operative group behavior to survive, compete, and persist in nature or to colonize a particular host. QS is the process by which individuals of a limited population exchange diffusible, low molecular weight signal molecules. When the population produces more signals than they are lost through inactivation or diffusion, the signals build up to a threshold and activate the corresponding receptor proteins. Most quorum sensing-controlled processes are unproductive when undertaken by an individual bacterium acting alone but become beneficial when carried out simultaneously by a large number of cells. QS regulates gene that lead to actions that are advantageous when carried out by bacterial colonies functioning simultaneously. Bioluminescence, bacterial growth, sporulation/ proliferation, compete-nce, antibiotic synthesis, biofilm formation, environmental adaptation and virulence factor secretion are among the processes regulated by QS. Each individual cell is able to sense the amount of quorum sensing molecules (QSMs) present in the medium which, upon reaching a threshold concentration, coordinate specific gene expression (Bandara *et al*., 2012).

History

In 1970, the marine bacteria *Photobacterium fischeri* was found to secrete a chemical substance that controlled the luminescence of bacterial cells (Lerch, 1970). When the bacterial population density is high, the bacterium releases auto inducers, which activate the bioluminescence system. The bioluminescence-producing gene Luminescence (lux) in *Vibrio Fischeri* was found by scientists in the 1980s. Later, they identified the autoinducer in *Photobacterium fischeri* as an N-(3-oxohexanoyl)-DL-homoserine. In 1994, Fuqua first proposed the concept of QS, in which bacterial phenotypes are regulated according to the concentration of chemical

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stimulus produced by individuals or colonies of bacteria (Fuqua *et al*. 1994).

Mechanism of Quorum sensing

Both gram-positive and gram-negative bacteria use quorum sensing, but there are some major differences in their mechanisms. Wide range of autoinducers were reported in different bacteria like Acyl-homoserine lactone (AHL), Autoinducing peptides (AIP), LuxS/autoinducer-2 (LuxS/AI-2), AI-3, diffusible signal factor (DSF) and Pseudo-monas quinolone signal (PQS). Membrane-bound two-component histidine kinase receptor. It undergoes autophosphorylation, transfers phosphate to a cytoplasmic response regulator, initiates gene transcription, and ultimately manifests its functional activity. A further explanation could be that AIPs are returned to the cytoplasm of the cell, where they interact with transcription factors to alter their activity and, consequently, alter alterations in gene expression (Monnet and Gardan, 2015).

Quorum sensing mechanisms in yeast and dimorphic fungi

According to certain data, aromatic alcohols produced from amino acids appear to mediate a QS type of control in the yeast Saccharomyces cerevisiae (Hogan, 2006). This budding yeast controls the production of pseudohyphae and biofilms by producing tryptophol and phenylethyl alcohol. Some QSMs that were discovered first in other fungal species, such as *C. albicans*, have been subsequently described to have roles in S. cerevisiae. On the other hand, *Cryptococcus neoformans*, a human disease, is the only fungus within the basidiomycetes group to have QS mechanisms described. During infection, this fungus, which is the etiologic agent of *cryptococcosis*, goes through cellular alterations that cause several cellular types to emerge. “Titan cells” are created following the enlargement of the capsule and the cell as a whole.

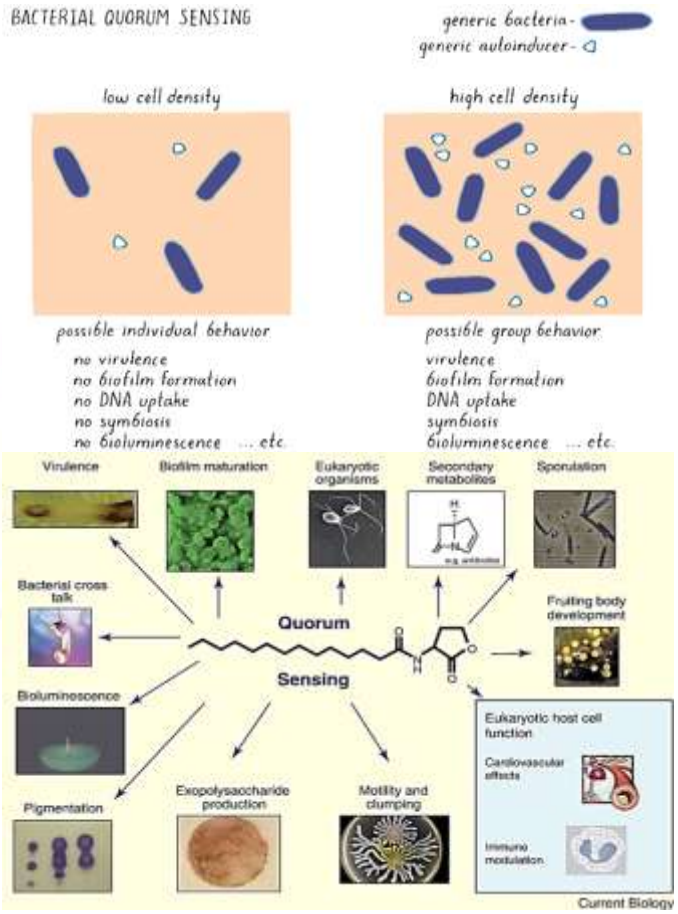


Fig. 1: Phenotypes shown to regulated by quorum sensing in Gram negative and Gram positive bacteria. Sporulation picture (top right) courtesy John Heap; fruiting body picture (middle right) courtesy Michiel Voss and Greg Velicer

Role of Quorum sensing in Plant Pathology

Quorum sensing regulates a number of processes that contribute either directly or indirectly to the pathogenesis of bacterial diseases, including the formation of biofilms, the synthesis of virulence

factors, bacterial growth and proliferation, competence, siderophore production and antibiotic resistance.

Biofilm development

In order to adapt to their surroundings, bacterial colonies adsorbed on the surface of inert or active materials produce a unique structure known as a biofilm. It is made up of proteins and polysaccharides found in the extracellular matrix. When bacterial colonies are gathered to sufficiently high densities, environmental cues set off the biofilm-forming process. For the bacteria to successfully approach a surface, stick to it, and produce a biofilm, flagella are needed. Biofilms protects the bacterial colonies from biotic or abiotic threats, which is huge problem in controlling bacterial plant diseases. Bacterial populations use QS to control biofilm formation, which provides members of the population superior access nutrients and thus enables them to out-compete non-biofilm producing neighbors (Bogino and Oliva, 2013). *V. cholerae* is a typical example of integrating QS and biofilm formation during its pathogenic life cycle. The pathogen Pseudomonas aeruginosa uses quorum sensing to coordinate behaviours such as biofilm formation, swarming motility, and aggregation. These bacteria grow inside a host organism without harming it, until they reach a threshold concentration

Production of virulence factors

A pathogen expresses a virulence factor to affect the pathogen's growth and colonization of the host. The Quorum sensing signal molecules for many bacterial plant diseases are synthesized by a LuxI type protein and recognized by a receptor protein. An interaction between the generated adduct and particular DNA sections in the QS regulon triggers the production of virulence components. According to Von Bodman *et al*. (2003), the expressed virulence factors include the generation of biofilm, cell wall destroying enzymes (PCWDE), and phytotoxins.

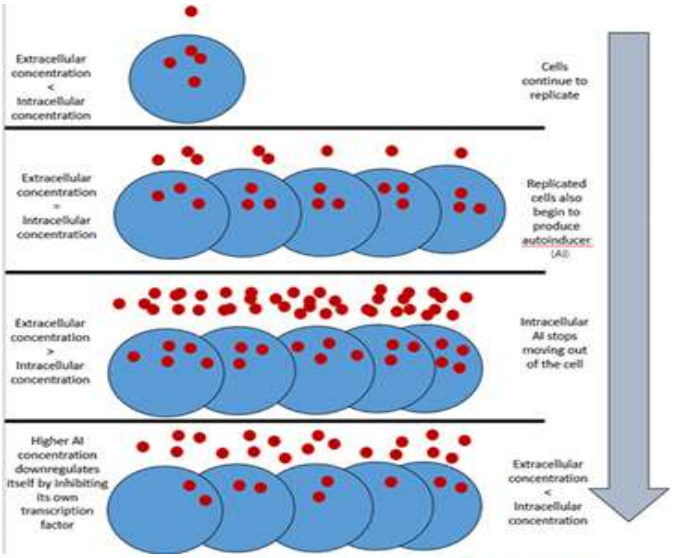


Fig. 2: Mechanism of quorum sensing

Competition

Bacterial communities frequently experience competition, which has a significant impact on the outcomes of bacterial diversity. According to Doekes *et al*. (2019), luxR and its homologues can detect and identify competitors, respond to AHL signals in the community, control the formation of biofilms, luminescence, release of virulence factors, production of toxins, swimming ability, and expression of protease activity genes, among other functions. They can also lessen interference by obstructing competition.

Antibiotic Resistance

The QS system plays an important role in the formation of bacterial antibiotic resistance mechanisms by regulating the formation of biofilms and the direct regulation of drug efflux pumps. The development of antibiotic resistance has aggravated the difficulty in prevention of bacterial diseases. The development of biofilms, the synthesis of virulence factors, the resistance to antibiotics, and other QS processes make it difficult to avoid plant illnesses. As a result, it has recently been thought that disrupting the quorum sensing network in pathogenic bacteria could be a therapeutic target. Quorum quenching (QQ) is one method of disruption wherein QQ molecules either partially or totally prevent the creation of signaling molecules.

Conclusion

The conclusion is that quorum sensing is a universal bacterial language that manifests itself as a pattern of group behavior. Developing disruption techniques to suppress quorum sensing among bacteria through quorum quenching or the introduction of quorum antagonist microorganisms can greatly aid in combating a variety of plant illnesses caused by bacteria. This can be achieved by understanding the role that quorum sensing plays in plant pathology. Thus, there are still many secrets hidden in this “chit-chat” between bacteria that will aid in finding solutions to a host of unsolved issues.

References

Hogan, D. A. (2006). Quorum sensing: alcohols in a social situation. *Current Biology*, 16(12): R457-R458.

Bandara, H. M. H. N., Lam, O. L. T., Jin, L. J. and Samaranayake, L. (2012). Microbial Chemical Signaling: A Current Perspective. *Critical Reviews in Microbiology*, 38(3): 217-249.

Bogino, P. C., de las Mercedes Oliva, M., Sorroche, F. G. and Giordano, W. (2013). The role of bacterial biofilms and surface components in plant-bacterial associations. *International Journal of Molecular Sciences*, 14(8): 15838-15859.

Doekes, H. M., De Boer, R. J. and Hermsen, R. (2019). Toxin production spontaneously becomes regulated by local cell density in evolving bacterial populations. *PLoS Computational Biology*, 15(8): e1007333.

Fuqua, W. C., Winans, S. C. and Greenberg, E. P. (1994). Quorum sensing in bacteria: the LuxR-LuxI family of cell density-responsive transcriptional regulators. *Journal of Bacteriology*, 176(2): 269-275.

Lerch, I. A. (1970). Bioluminescence and radiation response of *Photobacterium fischeri* H-2. *Radiation Research*, 43(1): 161-172.

Monnet, V. and Gardan, R. (2015). Quorum-sensing regulators in G ram-positive bacteria: ‘cherchez le peptide’. *Molecular Microbiology*, 97(2): 181-184.

Von Bodman, S. B., Bauer, W. D. and Coplin, D. L. (2003). Quorum sensing in plant-pathogenic bacteria. *Annual Review of Phytopathology*, 41(1): 455-482.

Role of Artificial Intelligence in Agriculture

Oksana Mandal, Charu Sharma, Gayatri Sinha and Dixit Mistry

Introduction

Any economy's foundation for sustainability is agriculture. Although it varies per country, it is essential to long-term economic growth and structural transformation. Agriculture used to be restricted to the production of crops and food. However, over the past 20 years, it has changed to include the production, distribution, marketing, and processing of agricultural and livestock goods. Nowadays, agriculture provides the majority of people's income, boosts GDP, contributes to national trade, lowers unemployment, supplies raw materials for other industries' production, and generally advances the economy. The development of computer systems that can carry out tasks that traditionally require human intelligence is called artificial intelligence (AI).

Artificial intelligence comprises several subfields and approaches, like machine learning, linguistic processing, computer vision, robotics, specialized systems and brain networks. Artificial Intelligence (AI) has been gradually introduced in agriculture over the past decade, with increasing adoption in recent years. In the early 2000s, the idea of precision agriculture which entails using technology to manage crops according to their specific sites came into being. This created the groundwork for the application of AI technology in agriculture through the use of GPS, remote sensing, and yield monitoring as data collecting techniques. AI-powered imaging and sensing technologies started to be used in agriculture in the 2010s. For tasks like planting, weeding, and harvesting, these systems made use of robotic automation, computer vision, and machine learning. Drones with autonomy have also developed into useful instruments for data collection and agricultural monitoring. The following lists the different domains where knowledge-based solutions for agriculture's benefit are available.

The Internet of things (IoT) driven development

Every day, enormous amounts of both structured and unstructured data are produced. These data include information on soil reports, weather patterns, recent studies, rainfall, insect attack susceptibility, and drone and camera imagery.

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Cognitive IoT systems would perceive, identify, and produce intelligent ways to improve crop yields. Proximity and remote sensing are the two main technologies used in intelligent data fusion. Testing the soil is one of the key uses for this high resolution data. In contrast to remote sensing, proximity sensing just requires sensors that are in close proximity to the soil; it doesn't require sensors integrated into aerial or satellite systems.

Image-based insight generation: One of the most contentious aspects of farming in the modern world is precision farming. Drone imaging can help with thorough field analysis, crop monitoring, and field scanning. Drone data, IoT, and computer vision technologies will work together to make sure farmers respond quickly. Data fed from drone image could bring forth alerts in real time which would accelerate precision farming.

Weather & Price Forecasting: Many times it is difficult for the farmers to make the right decision for harvesting, sowing seeds, and soli preparing due to climate change. But with the help of AI weather forecasting, farmers can have information on weather analysis, and accordingly, they can plan for the type of crop to grow seeds to sow and harvest the crop. Price forecasting helps farmers maximize their profit by providing them with precise information about crop prices for the upcoming few weeks.

Health Monitoring of Crops: The crop quality widely depends on the soil type and nutrition of the soil. Various factors degrading the soil quality day by day and it is hard to determine it. To resolve this issue, AI based mobile application Plantix was developed to identify deficiencies in soil, including plant pests and diseases. With the help of this application, farmers can get an idea to use better fertilizer to improve the harvest quality.

Agriculture Robotics: Robots are being employed extensively to carry out difficult jobs in a variety of industries, primarily manufacturing. These AI farm robots are designed to be able to do a variety of farming jobs. AI robots are also taught to inspect crops for quality, identify and manage weeds, and harvest crops more quickly than a human.

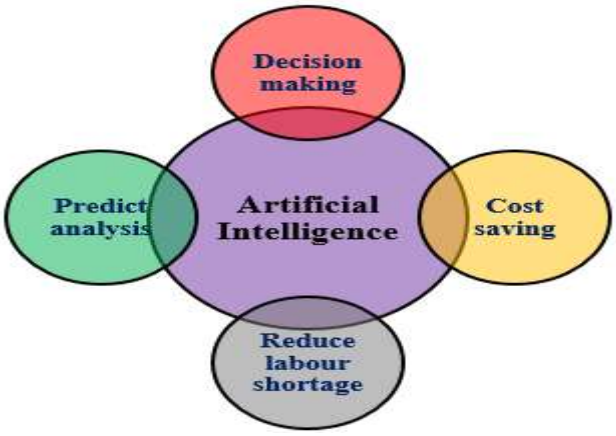
Intelligent Spraying: AI sensors enable the rapid detection of weeds and the identification of areas impacted by weed growth. Herbicides can be accurately sprayed in these locations to minimize the need for herbicides while also saving time and crop damage. AI sprayers can cut down on the amount of chemicals applied to fields, enhancing crop quality and resulting in cost savings.

Disease Diagnosis: Plant leaf images are segmented into surface areas such as background, diseased area, and non-diseased area of the leaf thanks to image sensing and analysis. After that, the unhealthy or infected region is clipped and sent to the lab for additional testing. This provides further support in identifying pests and detecting dietary deficiencies.

Water and resource management: Artificial intelligence (AI) can assist optimize water usage by monitoring soil moisture levels, weather patterns, and crop water requirements. Irrigation systems equipped with AI can distribute water precisely when

and where it is required, protecting water supplies and boosting water use effectiveness.

Advantages of artificial intelligence in agriculture



Challenges in AI adoption in agriculture

Despite the enormous potential that artificial intelligence (AI) offers for the agricultural sector, there is still a lack of knowledge about sophisticated, high-tech machine learning solutions in farms all over the world. Farming is highly exposed to environmental elements such as weather, soil conditions, and pest attack susceptibility. When harvesting begins, a crop-raising plan that was planned at the beginning of the season may not seem to be the best option because of outside factors. Large amounts of data are also needed by AI systems in order to train robots and make accurate forecasts or predictions. In the unlikely event of a very big area on agricultural land, temporal data is difficult to obtain whereas spatial data is readily obtainable. Adopting AI and emerging technologies in agriculture for developing countries can be challenging. It will be challenging to sell such technologies in areas where no such agricultural technology is being used. In such areas, to use these technologies, farmers need someone's help.



Conclusion

A large part of how agriculture is changing and being optimized is due to artificial intelligence. AI is having a significant impact on a number of industries, including supply chain optimization, livestock management, autonomous farming, precision agriculture, crop and soil monitoring, and disease and insect control. AI in agriculture offers the potential to improve productivity, reduce resource wastage, increase sustainability, and enhance food security by providing farmers with valuable insights and decision support tools. In conclusion, adopting cognitive solutions will be critical to farming's future in the coming years. Even with extensive research ongoing and a plethora of applications already available, the farming business is still underserved and does not have access to adequate services. Despite the fact that farming with AI is still in its infancy, it involves addressing practical needs and issues that farmers confront and employing AI decision-making systems and predictive solutions to address them.

Crop Nutrient Enrichment through CRISPR based Genome Editing

Oksana Mandal, Priyanka Antala and Pallavi Parmar

Introduction

Global food security is under severe pressure due to the world's changing environment and ever-growing population. A United Nations (UN) report states that the global population and by 2030, there will be an increase in food demand to 8.5 billion and 11.6 billion tons, respectively. By 2030, there may be more than 840 million people suffering from hunger if current trends continue. The UN set zero hunger as Sustainable Development Goal 2 (SDG2) in order to stop this. Human efforts have resulted in increased crop yields in the past. For example, the Green Revolution produced significant crop production improvements from the 1940s to the late 1960s. This increase was achieved by the development of short-stature, high-yielding, and disease-resistant crop varieties, aided by advances in farm mechanization and chemical fertilizers, pesticides, insecticides, and fungicides (Tilman, 1998). The resultant rise in global food production improved the socio-economic status of many regions of the world and boosted agricultural development by reducing hunger and malnutrition. In the late twentieth century, advances in biotechnology, hybridization, mutation, and transgenic technologies paved the way toward developing genetically improved crop varieties. It will take constant innovation in crop breeding and genetics to overcome these obstacles and achieve sustainable food production. In this sense, the development of genome editing technologies, particularly the CRISPR-Cas system, has accelerated the shift to precision breeding for crop enhancement by making targeted and precise genetic modification of crops more practicable. The food production sector is now in a position to make some of the most exciting breakthroughs since the Green Revolution.

CRISPR achievements: Improving the nutritional content in crop plants

It will take constant innovation in crop breeding and genetics to overcome these obstacles and achieve sustainable food production. In this sense, the development of genome editing technologies, particularly the CRISPR-Cas system, has accelerated the shift to precision breeding for crop enhancement by making targeted and precise genetic modification of crops more practicable. More recently, the trend of using modern genome editing strategies like the CRISPR/Cas technique progressively focussed on genes for the improve-ment of crop quality (Wada *et al*., 2020). Without changing the agronomic characteristics of the dominant valued

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traits, the CRISPR/Cas9 system produces permanently heritable changes (Feng *et al*., 2014). This potent editing innovation has already been enforced in several plant species for its explicit genome modifying capacities.

Rice being the principle food crop has been the primary target for quality enhancement. Amylose is regarded as an important nutrient quality parameter in rice grains. Targeting the starch branching enzymes, resulted in lower amylose content of rice grains. Liang *et al*. (2014) developed edited maize lines with low phytic acid content. Maize/corn grains contain significant levels of phosphorous. However, this phosphorous was stored in the form of phytate, which was ineffectively digested by humans. Employing the CRISPR/Cas9 approach, the reduction of phytic acid/phytate (an anti-nutritional compound) in maize grains was performed by targeting two key enzyme coding genes of its biosynthetic pathway. Isoflavonoids, which are abundant in pulses, played a significant role in plant-environment interactions. Through the simultaneous targeting of three genes, the gene editing technology has recently revealed significant advancements in the soybean isoflavone pathway.

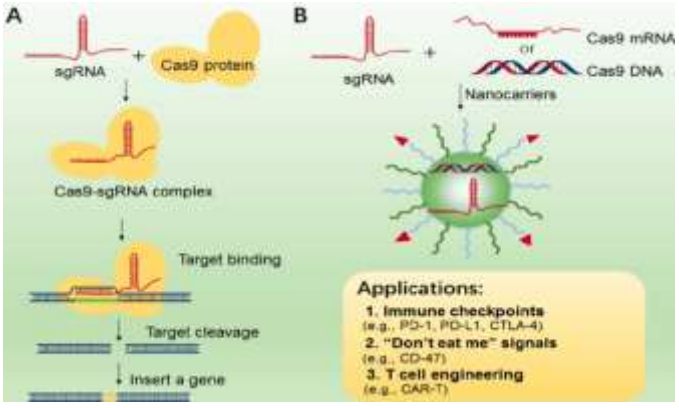
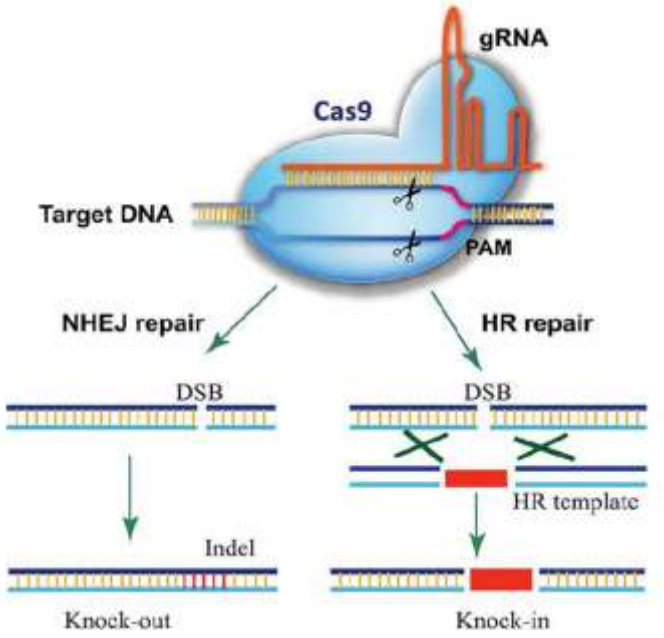


Table 1: Different CRISPR-Cas delivery systems in crops

Crop	Delivery method	Target gene	Target trait
Maize	Biolistic	LIG gene, ALS2, Male sterility gene (MS26 & 45)	Stress tolerance
Potato	Particle Bombardmnt (Gold nano particle and infiltration of RNP complexes)	Colin	Defence response to biotic and abiotic stress
Tomato	Agrobacterium mediated transformation	SP, OVATE, FN2	Regulating fruit ripening
Apple	Direct delivery of purified CRISPAR -Cas9 RNP to the protoplast	DIPM-1, DIPM-2	Resistance to fire blight disease
Sweet orange	XCC-faciliated Agro infiltration delivery	PDS	Albino phenotype and decrease of carotenoid content



Future Perspectives for the Improvement of Agriculture

Although genome editing offers several benefits over conventional plant breeding, there are still a number of obstacles in the way of its use with horticultural crops. It is challenging to discover the genes responsible for desired traits in horticulture

crops due to the challenges associated with molecular and genetic investigations. The genomes of interesting agricultural crops must be sequenced in order to identify genes associated with desired traits. For crops without a reference genome, the target sequence might be cloned using degenerate primers tailored for retained protein patterns with possible roles linked to desired traits. An excellent example is the MLO, which has been well described in barley; the phylogenetic conservatism of the MLO has contributed to the emergence of powdery mildew-resistant plants in wheat, tomato, and strawberry. Once a gene has been selected for editing, scientists need to understand both the process used to deliver the editing reagents and the process utilized to recover the changed mutants. More than 25 horticultural plant species have been successfully altered to far, typically using editing reagents given via agrobacteria or virus systems, and the modified plants are regenerated in vitro via tissue culture.

Conclusion

The precipitous development in CRISPR technologies to their versatile and precise genome engineering in the last few years has been spectacular. These versatile tools now consider as an umbrella term, which revolutionized the life sciences and enabling advances in basic research for a variety of applications. Compared to traditional breeding, the scientists can more quickly and precisely introduce the needed traits into modern breeding processes. CRISPR/Cas9-based genome editing represents a significant advancement. Subsequent research endeavours will centre on using genome editing methodologies to enhance several attributes such as disease resistance, nutritional content, and agricultural productivity. Several plant systems have been extensively used in the last five years to carry out functional research, combat biotic and abiotic obstacles, and enhance other crucial aspects of agriculture.

References

Feng, Z., Mao, Y., Xu, N., Zhang, B., Wei, P., Yang, D. L. and Zeng, L. (2014). Multi generation analysis reveals the inheritance, specificity, and patterns of CRISPR/Cas-induced gene modifications in Arabidopsis. Proceedings of Natinal Academic Science, USA, 111: 4632-4637.

Liang, Z., Zhang, K., Chen, K. and Gao, C. (2014). Targeted mutagenesis in Zea mays using TALENs and the CRISPR/Cas system. *Genetic Genomics*, 41: 63-68.

Tilman, D. (1998). The greening of the green revolution. *Nature*, 396(6708): 211-212.

Wada, N., Ueta, R., Osakabe, Y. and Osakabe, K. (2020). Precision genome editing in plants: state of the art in CRISPR/Cas9-based genome engineering. *BMC Plant Biology*, 20: 234.

Application of Biotechnology for Providing Alternative of Fossil Fuel

Oksana Mandal and Ajay Baldaniya

Introduction

Biotechnology has received the greatest attention among the various new technologies that have emerged since the 1970s. Biotechnology has demonstrated its ability to generate vast wealth and influence every key sector of the economy. Biotechnology has already had a significant impact on healthcare, food production and processing, agriculture and forestry, environmental protection, and the manufacturing of minerals and chemicals. The majority of countries are classified as developing or developed depending on their use of fossil fuels. One of the most essential sources of energy for humanity is fossil fuel. Automobiles, thermal power plants, and other similar devices require fossil fuel. The entire globe is today confronting a massive fossil fuel issue and is concerned about it. For millions of years, buried plants and animals produce fossil fuel. Carbon is found in fossil fuels, which contributes to environmental damage. When fossil fuels are used, they emit carbon in the form of carbon dioxide and other byproducts that harm the ecosystem and living beings on the planet. Coal, oil, and natural gases are examples of fossil fuels.

Transition from fossil fuels to renewable energy

As we move toward a low-carbon energy economy, it is critical that we discover new methods for extracting energy from fossil fuels while minimizing environmental damage. This require-ment is based on the Intergovernmental Panel on Climate Change's proposal that total global CO_2 emissions from fossil fuels between 2011 and 2050 be limited to between 870 and 1240 Gt (Clarke *et al*., 2014). The simple expedient of increasing the amount of energy produced from natural gas can contribute to reduction in CO_2. Generation of 1 kWh of electricity from natural gas produces just over 0.5 kg of CO_2, which is approximately 70% of the amount of CO_2 emitted from oil kWh^{-1} of electricity generated and 60% of the equivalent CO_2 emissions for coal. An appealing alternative possibility is to retrieve the energy stored in fossil carbon while maintaining at least a fraction of the carbon in the earth.

Biofuel is a Source of Green Energy

Because biofuels are made from renewable resources, they help to reduce the amount of fossil fuels used for combustion and the production of CO_2. They aid in their renewal and are made from biological materials such as plants and natural wastes. Since biofuel is derived from plants, microorganisms, animals, and wastes, its basic concept is to be a source of renewable energy. Biofuel works on

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the present-day photosynthetic conversion of solar energy to chemical energy, to reduce the use of fossil fuels (Jamwal *et al*., 2020). Biodiesel is chemically monoalkylester made by transesterification reaction of free fatty acids with alcohols and obtained from renewable resources like vegetable oils and animal fats. Biodiesel has received immense interest in past few years as the sustainable choice to petroleum diesel fuel due to its renewa-bility, nontoxic and eco-friendly characteristics.

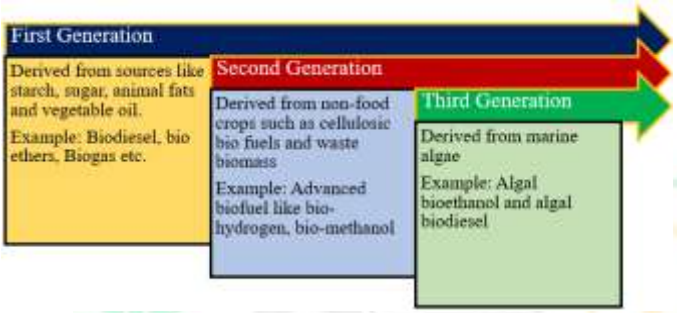
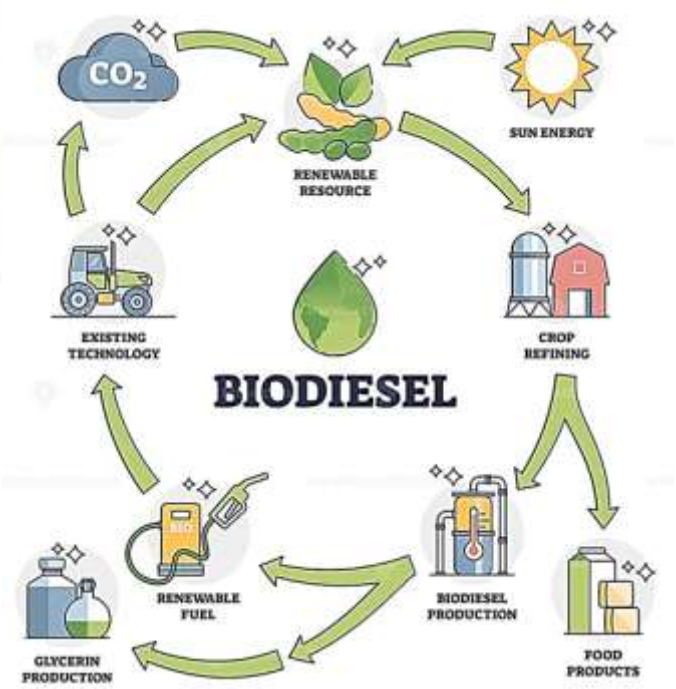


Fig. 1: Generation of Biofuels

First Generation: First-generation biofuels, also refer to conventional biofuels, are produced from sugar and starch from food crops or edible oil (Ho *et al*., 2014). First-generation biofuels are produced using different processes such as fermentation, distillation and transesterification. Because biofuels release fewer greenhouse gases into the atmosphere than fossil fuels, they improve the quality of the air and water. Biodiesel and ethanol (bioethanol) constituted the majority of first-generation biofuels. An agricultural bioresource, a significant amount of water, fertilizers, and pesticides are needed for the production of feedstocks for first-generation bio-fuels.

Second Generation: Second-generation biofuels were created to solve the drawbacks of first generat-ion biofuels, which jeopardized the food supply due to resource use. Energy crops, corn and wheat stalks, woody trees, and other non-food crops are used in the production of second-generation biofuels (Eisent-raut, 2010). Second-generation bio-fuels also generate higher energy yields than first generation fuels. The technology is fairly immature, so it still has potential of cost reductions and increased production efficiency as scientific adva-nces occur. Compared to fossil fuels, second-generation biofuels release comparatively fewer greenhouse emissions, and overall, they are more environmentally and socially responsible than first-generation biofuels.



Third Generation: Single-celled microorganisms called microalgae can be found in both freshwater and marine environments. Compared to higher plants, microalgae are more effective in converting solar energy. Microalgae are great options for quick and enhanced biomass production, lipid synthesis, and biofuel production because of their high photo-

synthetic rate. Microalgae biomass is utilized as feedstock for third-generation biofuel production. Economy has significant role in the commercial feasibility of production of biofuels using micro-algae. Cost of microalgae oil production relies on different factors, such as biomass yield, oil content, scale of production systems and cost of recovering oil (Rodolfi *et al.*, 2009).

Conclusion

Energy security is greatly endangered by a continued reliance on fossil fuels, and the extraction of these resources from natural reserves endangers the ecosystem. Investigating novel and sustainable energy sources is crucial to allay these worries. The utilization of biotechnology in many industry domains has consistently yielded economic and ecological advantages, such as reduced processing costs, improved product quality, creation of new goods, and ecologically friendly processing in comparison to traditional operations.

Future perspective

Throughout the entire year, much larger biomass accumulation with noticeably higher oil content is required, ideally in open ponds. The concept of bio-based products with bio refinery frameworks needs to reduce the barriers to the combination of biotechnological instruments and the synthesis of newly discovered compounds. It is crucial that the advancement of non-fossil based energy sources not be hindered, because it is evident that new transition technologies can be developed to lessen the environmental effects of our continued reliance on fossil fuels, which will unavoidably continue for the next many decades.

References

Clarke, L. E., Jiang, K., Akimoto, K., Babiker, M., Blanford, G. J., Fisher-Vanden, K. and Zwickel, T. (2015). Assessing Transformation Pathways. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (No. PNNL-SA-102686). Pacific Northwest National Lab (PNNL), Richland, WA (United States).

Eisentraut, A. (2010). Sustainable production of second-generation biofuels: potential and perspectives in major economies and developing countries.

Ho, D. P., Ngo, H. H. and Guo, W. (2014). A mini review on renewable sources for biofuel. *Bioresource Technology*, 169: 742-749.

Jamwal, V. L., Kapoor, N. and Gandhi, S. G. (2020). Biotechnology of biofuels: historical overview, business outlook and future perspectives. *Biotechnology Business-Concept to Delivery*, 109-127.

Rodolfi, L., Chini Zittelli, G., Bassi, N., Padovani, G., Biondi, N., Bonini, G. and Tredici, M. R. (2009). Microalgae for oil: strain selection, induction of lipid synthesis and outdoor mass cultivation in a low-cost photobioreactor. *Biotechnology and Bioengineering*, 1021: 100-112.

Polyploid Rice: New Resources for Future Rice Breeding

Oksana Mandal and Ajay Baldaniya

Introduction

Asian rice (*Oryza sativa* L.) is a diploid with two sets of 12 chromosomes (2n=24). Although Asian cultivated rice may have undergone genome duplication over 96 million years ago, it is nonetheless considered diploid due to lack of recent polyploidization. Polyploid individuals have more than two sets of chromosomes in somatic cells. Polyploidization is a key aspect of plant evolution. Polyploid plants are distinguished by their huge size and high nutrient and secondary metabolite levels. They exhibit high vitality, adaptability, drought and cold resistance, and other benefits. Polyploid technology is commonly employed in plant breeding to increase the number of vegetative organs and overall biomass. Polyploid technology is commonly employed in plant breeding to increase the size of vegetative organs and overall biomass. Polyploids can directly breed variants and act as a bridge for distant hybridization, encouraging gene flow between species and populations. At present, the most widely cultivated rice is diploid. Compared with polyploid crops (such as wheat), rice has a smaller genome and lower DNA content. The genetic resources of cultivated diploid rice are limited. Therefore, further development of rice breeding is hindered. The genetic resources of cultivated diploid rice are limited. Therefore, further development of rice breeding is hindered. Polyploid rice was first discovered and reported by Nakamori in 1933. A surge in polyploid rice breeding and research followed this discovery. Researchers studying rice have been interested in polyploid rice because it has favorable agronomic characteristics over diploid rice, such as large grain size, high 1000-grain weight, strong stem, great stress tolerance and high adaptability. By encouraging slower development, delayed reproduction, longer life spans, enhanced defense against diseases and herbivores, larger seeds, and reduced reproductive effort with a greater emphasis on vegetative reproduction, polyploidiz-ation generally results in higher stress tolerance. These studies suggest the potential usefulness of tetraploid rice for breeding. Low numbers of spikelets per panicle and low fertility have frequently observed in tetraploid rice throughout its known existence.

Method of induction of polyploidy in rice

We know that polyploidization leads to the emergence of new species based on the connections between the genomes and evolution of plants. Prior to the discovery of polyploidy, the majority of polyploids were created naturally. Since Blakeslee establ-

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ished in 1937 that colchicine can generate poly-ploidy, artificial polyploid induction has advanced to a new level (Huange *et al*., 2001). Research involves more and more plants, and research methods are constantly being improved and expanded (Xie *et al*., 2002). Physical, biological, and chemical induction are the three types of artificial polyploidy induction. Polyploidy can arise through physical induction through many means like as temperature shocks, ionizing radiation, radiation, grafting, etc. Scholars have attempted to induce rice polyploidy by physical means. Colchicine is the most often employed chemical mutagen, along with napht-halene pentane and naphthalene ethane. Colchicine prevents spindle formation, which prevents chromo-somes from splitting. As a result, more ploidy cells are created. Chimeras frequently arise from the extremely low efficiency of doubling with seedlings, buds, or anthers. With the development of tissue culture technology, colchicine has been used to treat plant tissues or cells (such as callus, embryoids, protoplasts, etc.) *in vitro*. Other researchers have attempted to induce polyploidy by plant regener-ation. Compared with traditional methods, plant regeneration methods lead to more efficiency and less chimerism.

Kinds of polyploidy rice

Autotetraploid rice: In auto polyploidy, diploid chromosomes are directly doubled, resulting in additional genome copies that originate from the same species. In plants, it is typical. Compared to diploid rice, autotetraploid rice has larger, heavier grains. Grain bulk density is steady and has a significant chance of raising yield at the same time. However, compared with diploid rice, autotetraploid rice has weaker sexual reproduction ability and lower seed setting rate. This problem has been perplexing breeders, resulting in the slow progress of polyploid rice breeding research. The light compensation point of diploid rice was about 2.5 Klux, and that of tetraploid rice was about 4 Klux. Net photosynthetic rates fluctuated with the light intensity, but their fluctuation amplitude was different from each other. Xie *et al*. (2007) analyzed the specific expression results of autotetraploid rice at protein level.

Indica-Japonica tetraploid hybrid rice: Three subspecies of Asian cultivated rice are recognized: indica, japonica, and javanica. Their morphological, physiological, and metabolic features differ from one another. Research has indicated that there is far more heterosis between indica and japonica than there is within either strain. Using heterosis between indica and japonica is a significant new breeding strategy for rice. Between indica and japonica, there are notable variations in genome sizes, gene counts, and gene classifications. Due to the fact that under diploid conditions, this influences not only the regular pairing of chromosomes during meiosis but also the expression of genes at every developmental stage, indica-japonica hybrids are challenging to employ. The hybrids of typical indica and typical japonica usually show obvious biological yield heterosis effect. Using tetraploid indica-japonica hybrid as a bridge is a way to tap into the greater

yield potential of rice. From the perspective of genomics, there are significant differences in genome sizes, gene numbers and gene categories between indica and japonica (Hu *et al*., 2006).

Allopolyploid rice: Allopolyploidy is a type of polyploidy that arises from the doubling of chromosomes in hybrids between distinct species. Heterozygosity between genomes, which results from allopolyploidization, can expand genetic diversity ranges, boost tolerance to unfavorable environmental conditions and increase genomic capabilities. It offers clear benefits for genetic evolution. Fertility can frequently be fully or partially restored following allopolyploidization, which is crucial in overcoming the sterility of distant hybridization. There are many varieties of heteropolyploid rice in nature, such as *Oryza minuta* (BBCC), *Oryza latifolia* (CCDD), *Oryza coarctata* (HHLL), *Oryza longiglumis* Jansen (HHJJ), *Oryza schlechteri Pilger* (HHKK), etc. Allopolyploid rice is important resource for biological research and rice breeding.

PMeS (Polyploid Meiosis Stability): The PMeS lines have been developed and analysed by Chen *et al*. (2021). They derive from the progenies of crosses between indica and japonica rice subspecies. Unlike other autotetraploid rice lines, PMeS lines do not show abnormal chromosomal behaviour during meiosis. In addition, their pollen development pattern appears normal at all stages, lacking the many abnormalities seen in other autotetraploid rice lines.

Conclusion: Rice is one of the world's three major food crops. Faced with the press ure of a growing world population and the decrease in available arable land, it has become important to increase rice yield. Rapid climate change is now making this problem even more severe because it poses yet another serious danger to food security and agriculture. Consequently, it is imperative to create new high-yielding rice varieties that are more resistant to natural calamities and climate fluctuation. The advantages of polyploid plants include robust response to environmental changes, robustness, and genomic buffering. Rice has a tiny genome and a low DNA content. On the other hand, the *Oryza* genus has abundant genetic resources. For this reason, ploidy levels, genome capabilities, and genetic variation range expansion are useful research topics for the fundamental principles and real-world applications of rice breeding.

References

Huang, Q. C., Sun, M. Y. and Deng, Q. Y. (2001). Polyploid rice and its potential value. *Hybrid Rice*, 16(1): 1-3.

Xie, Z., Mou, C., Wang, B., Wu, X. and Wang, X. (2002). Polyploidization of plants and its application in breeding. *Chinease Agriculture Science Bulletin*, 18: 70-76.

Chen, R., Feng, Z., Zhang, X., Song, Z. and Cai, D. (2021). A new way of rice breeding: Polyploid rice breeding. *Plants*, 10(3): 422.

Hu, H., Mu, J., Zhang, H. J., Tao, Y. Z. and Han, B. (2006). Differentiation of a MITE system in Asian rice cultivars and its inference for a diphyletic origin of two subspecies of Asian cultivated rice. *J. of Int. Pl. Bio.*, 48(3): 260.

Robotics in Agriculture: Types and Applications

Oksana Mandal, Dixit Mistry and Charu Sharma

Introduction

It is now necessary to automate agricultural processes in order to increase productivity using equipment and technology. There has been a surge in interest in the development of autonomous vehicles for agriculture in recent years. Numerous researchers began creating more vehicles that are sensible and flexible for agricultural tasks. A proposal was adopted in the field of agricultural autonomous vehicles to replace traditional large tractors with several tiny, efficient autonomous machines (Bisgaard *et al*., 2004). Moreover, such system may have a less environmental impact as it can reduce over-application of chemicals and high usages of energy and inputs by the control that is better matched to stochastic requirements. There are numbers of field operations that can be executed by autonomous vehicles, giving more benefits than conventional machines. Most of the researcher are working for autonomous vehicle design for precision agricultural mobile robots. Three distinct verticals are being implemented by the design: 1. Mobile robot navigation 2. Puts into practice 3. Sensor modules (Framework & Applications). Under these verticals, several nations, including the United States the European Union, Denmark, Australia, Finland, India, and others, are developing mobile robots primarily for use in agriculture farming as opposed to commercial industries. Robotics is being used by nations including the US, Australia, Japan, and Europe to solve production issues, and its use in agriculture is predicted to grow dramatically in the future. The UN projects that by 2050, there will be 9.7 billion people on Earth, up from the current 7.3 billion.



Fig. 1: Applications of robot in agriculture

Harvesting and picking are the most prevalent uses of robotics in agriculture because of their accuracy and speed, which increase crop yields and reduce agricultural waste from leftover crops. However, automating these applications can be difficult. For example, there are many obstacles for a robotic system that has to gather sweet peppers. Vision systems have to find the pepper and determine its maturity in difficult conditions with moving winds, dust, varying light levels, and temperature swings. Still, more is needed for pepper picking than just advanced vision systems. To meticulously remo-

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ve and arrange a pepper, a robotic arm needs to maneuver through equally cluttered settings. This technique is considerably different from picking and installing a metal part on an assembly line. The agricultural robotic arm must be flexible in a dynamic environment and precise enough to harvest peppers without breaking them.

Current status of agricultural robots

MF-Scamp Robots Designed by Blackmore: MF-Scamp robots are designed for scouting, weeding and harvesting (Nikos Alexandratos and Jellebruinsma, 2015). The robot is intended to remove or eliminate weeds using either a four-wheel or six-wheel drive system. Crops are typically cultivated in rows and columns, thus hoeing the space between the rows and columns can help get rid of weeds. These days, the intelligent hoe tools use a vision sensor to precisely direct itself and locate and identify the crops in rows and columns, thereby lowering the amount of herbicide used.

Autonomous Plant Inspection (API) Research Platform designed by Danish institute of Agricultural science (DIAS): The API Platform was initially developed by Madsen and Jakobsen in the year 2001. Further it was developed by Aalborg University in Denmark. It is third generation autonomous research platform for precision farming prototype designed having four wheel-drive, four-wheel steering with two motors per wheel, one for providing traction and the other provides steering to obtain high mobility in the movement of the robot. The API platform can cover 4.32 hectares hour^{-1} at a pace of 3.6 km h^{-1} when utilized for autonomous field scouting. The system should be having intelligent sensor to implement micro spraying or laser weeding.

Sub canopy robot ISAAC 2 from Hohenheim University, Germany: The purpose of this prototype is to gather precise and timely data from a variety of sensors in the crop to evaluate the health and condition of the crop. GPS is used by this high clearance platform to carry instruments over the crop canopy. The portal robot used to provide automated crop survey as well as to measure crop nutrient status and multispectral responses (stress), visible images (pan Chromatic), weed species and weed density (Bak and Jakobsen, 2004).

Agribot, India: Agrarian economies characterize several Asian nations, including India, where the majority of the rural populace depends on agriculture for a living. The agricultural robot Agribot was created by Indian students at BIT Hyderabad (Gollakota and Srinivas, 2011). It is designed to increase the productivity, speed, application accuracy of the work and minimizing the labor of farmers. Its major area of function involved in farming i.e. harvesting, spraying, seeding and removing the weeds. The system is having a camera equipped to give a live vision of the field, also for large farms a GPS based module can be installed depending on the map specific land can be fixed for harvesting.

HortiBot, Denmark: Hortibot is a commercially produced and robust tool carrier designed for high

tech plant nursing for e.g. organic grown vegetables. A guiding system based on computer vision is used to control the bot's steering. The primary purpose is to manage weeds and facilitate the automatic implementation of repetitive, one-sided weeding for outdoor gardening (Chi and Ling, 2004). The topography of the tracks between beds is recognized by computer vision, which is how the HortiBot navigates. Additionally, it can pass multiple parcels with visible rows using a little amount of GPS thanks to an Agrocom Vision-designed row detecting algorithm.

Lettuce Bot, California: Lettuce Bot also known as Rambo of weeds was designed by Heraud and the Bot's cocreator, Lee Redden at Standford University. It searches for weeds or lettuce plants that are planted too near to other plants or crops. When it detects a weed, it shoots a powerful stream of fertilizer around the plant, killing the weeds and feeding the surrounding lettuce.

Advantages of robotics technology

- ✓ The robots can deliver products of high quality and lower the cost of production.
- ✓ They make fewer errors and operate at higher velocities and higher quality.
- ✓ They can be small in size, allowing to accumulate near-crop data and perform mechanical weeding, mowing, spraying, and fertilizing.
- ✓ Robots provide an opportunity to replace human operators with a good return on investment by providing effective solutions.

Conclusion

The field of agricultural robots has gained popularity recently, both among academics and businesses. This is due to the fact that agricultural robotics tackles important problems like the need for ecologically friendly practices and the seasonal shortage of physical labor during harvest, for example. An agricultural robot is a single platform that combines multiple technologies, including mechatronics, machine vision and image processing, to provide the best possible outcome for autonomous agricultural activities.



References

Bak, T. and Jakobsen, H. (2004). Agricultural robotic platform with four wheel steering for weed detection. *Biosystems Engineering*, 87(2): 125-136.

Bisgaard, M., Vinther, D. and Østergaard, K. Z. (2004). Modelling and fault-tolerant control

of an autonomous wheeled robot. Aalborg University. Department of Control Engineering.

Chi, Y. T. and Ling, P. P. (2004). Fast fruit identification for robotic tomato picker. In 2004 ASAE Annual Meeting (p. 1). American Society of Agricultural and Biological Engineers.

Gollakota, A. and Srinivas, M. B. (2011, December). Agribot-A multipurpose agricultural robot. In 2011 Annual IEEE India Conference (pp. 1-4). IEEE.

Nikos, A. and Jelle, B. (2015). World agriculture towards 2030/2050: the 2012 revision. FAO Agricultural Development Economics Division.

Speed Breeding for Crop Improvement and Food Security: An Overview

Jagruti Mahla, Oksana Mandal and Saumya Shruti

Introduction

Food production to consumption has decreased tremendously in recent years, while rates of urbanization and population growth have risen dramatically globally. Plant breeding has had a significant impact on global food production and has been essential in assuring food security and safety since the early 1900s. But in recent years, issues with food quantity and quality have emerged globally as a result of the unsustainable food demand brought on by the rapidly growing human population. Furthermore, drastic variations in weather patterns driven by global climate change are generating heat and drought stress, resulting in considerable production losses for farmers all over the world. In any crop improvement programme, the following breeding procedures can be distinguished in the order presented: (a) selection of desirable parents with complementary traits to be combined; (b) crosses involving the selected parents and the development of progenies; (c) selection and genetic advancement of the best progenies based on target traits; (d) selection of the best progenies for screening in multiple target production environments to identify the best performing and stable candidate cultivars; and (e) cultivar registration, and seed multiplication and distribution to growers (Shimelis and Laing, 2012). Most crop cultivar development programs utilize these traditional breeding techniques. In the absence of an integrated pre-breeding program, conventional breeding methods can take over ten years to develop and release an improved variety (Ahmar *et al.,* 2020). The long duration of field selection procedures takes a full season, and the intrinsic characteristics of crop cycles account for the sluggish progress of every generation in conventional breeding. Speed breeding is a suite of techniques that involves the manipulation of environmental conditions under which crop geno-types are grown, aiming to accelerate flowering and seed set, to advance to the next breeding generation as quickly as possible. The method saves breeding time and resources through rapid generation advancement. Particularly in regions with tough environmental circumstances, speed breeding can greatly accelerate the development of genetic gain and help address challenges related to food security. Speed breeding may lessen the environmental impact of agriculture while also helping to provide people with healthier and more nutritious food by creating crops

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have higher yields that can endure climate changes and use water more effectively.

Advanatages

- ✓ Speed breeding is a promising breeding technology that can drastically shorten breeding cycles and increase selection efficiency, regardless of the seasonal change in day length, temperature, and precipitation.
- ✓ In comparison, speed breeding occurs two or three times more quickly than conventional breeding.
- ✓ Because speed breeding is low-cost and labor-intensive, it might be widely used even in less developed areas.
- ✓ Many germplasms could be densely grown in a small space, which is especially useful for large-scale population screening.
- ✓ Speed breeding could be carried out at any period of the year, regardless of the external environments and climate changes.

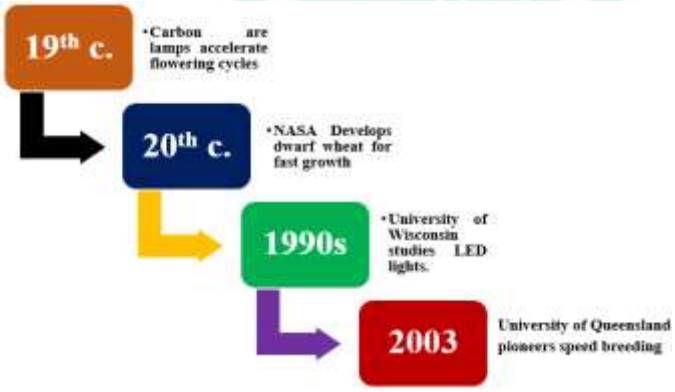


Fig. 1: Evolution of speed breeding over the periods

Application of speed breeding (SB)

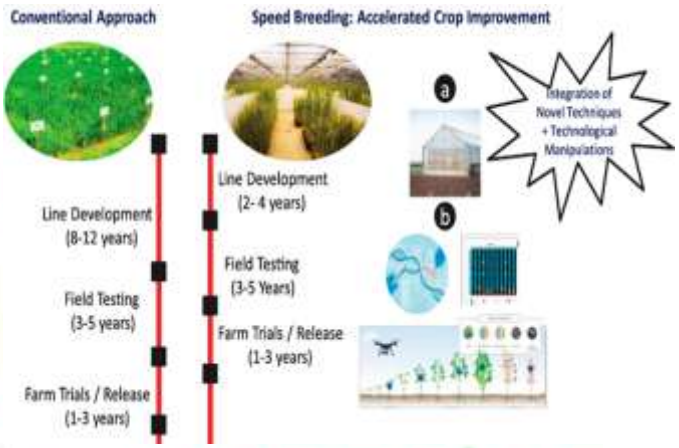
Due to the lengthy and extended cycles of selection and inbreeding inherent in traditional selection techniques, including pure line, recurrent, bulk, mass, and pedigree selection, they are considered unsuitable for application in SB. SB is quite effective when employing SSD techniques, particularly for cereal crops like wheat and barley. In SB, higher seeding density made it possible for numerous generations to cycle quickly each year. Under specific LED-supplemented glasshouse setups, up to six generations of wheat and barley per year were achieved at a density of 1000 plants/m^2. Research has indicated that adjusting light quality, more especially the red to far-red ratio, has a major impact on when cool-season grain legumes like peas, chickpeas, faba beans, lentils, and lupins flower. These results provide useful applications in biotechnological techniques for improving legume crops, and they are essential for accelerating SSD in legume breeding (Croser *et al*., 2016). Similar procedures have been employed in peanut breeding studies, where controlled circumstances, constant light, appropriate temperature, and SSD were coupled in a greenhouse setting. The generation time for full-season maturity peanut cultivars was consistently shortened by these efforts, from 145 to 89 days. The development of peanut varieties could be greatly accelerated by this novel speed breeding method, cutting the conventional six to seven year timeframe from the initial cross to commercial release (O'connor *et al.,* 2013). Researchers can use these techniques to speed up experiments and gather data more efficiently. This accelerates progress in the understanding of plant responses to environmental stressors, optimizing cultivation practices and explo-

oring plant physiology.

Table 1. Advantages of different aspects of speed breeding

Aspect	Description	Advantages
Diverse Mapping Populations	Efficient creation of genetically diverse population	Facilitates the development of crop varieties with broad genetic diversity.
GM Crop Develop-ment	Shortened timelines for GM crop creation	Accelerates the development of genetically modified crop varieties with specific traits
Trait Stacking	Streamlined development of resilient crop varieties	Enables the incorporation of multiple desirable traits into a single crop variety, enhancing resilience.
Enhancing research across disciplines	Integrating SB to accelerate research in diverse fields	Expediting experiments, data collection, and hypothesis testing, thus aiding in a deeper understanding of plant responses to environmental stressors, refining cultivation practices, and exploring plant physiology. It enables informed decision-making and innovative problem-solving across diverse research areas.

By utilization of various methods such as biparental population mapping, phenotyping, and genetic transformation experiments, Speed breeding stands out as a superior alternative to the doubled haploid (DH) technique, primarily due to its remarkable ability to overcome the hurdles of poor vigor and germination rates. The cultivation of durum wheat involved the application of the speed breeding technology. A phenotypic analysis was carried out on a biparental population that was produced from Outrob 4 and Caoaroi, with a focus on different features such as resistance to crown rot, plant stature, root number, root angle, and leaf rust. Genomic selection, genotyping, gene editing, genetic improvement, and high-throughput phenotyping can all be merged with new techniques in a harmonious way that broadens the scope of agricultural innovation. In addition to maximizing the potential of each technology, this collaborative approach develops a holistic framework for pushing the boundaries of contemporary plant breeding and crop enhancement. SSD methods hasten the progression and assessment of segregation generations within a condensed time frame under the accelerated conditions of Speed breeding.



Conclusion

Given the uncertainty surrounding the environment and the world's expanding population, speed breeding appears to be a potential way to address the urgent problems of food security. The history of speed breeding, from its early days of experimenting with artificial lighting to its use of cutting-edge technology like solar power and LED lights, demonstrates how revolutionary crop breeding could become. The advantages of SB are significant. It helps to achieve the important objectives of food security and sustainability in addition to hastening the development of crops with desired features.

References

Ahmar, S., Gill, R. A., Jung, K. H., Faheem, A., Qasim, M. U., Mubeen, M. and Zhou, W. (2020). Conventional and molecular techniques from simple breeding to speed breeding in crop plants: Recent advances and future outlook. *International Journal of Molecular Sciences*, 21(7): 2590.

Croser, J. S., Pazos-Navarro, M., Bennett, R. G., Tschirren, S., Edwards, K., Erskine, W., ... and Ribalta, F. M. (2016). Time to flowering of temperate pulses in vivo and generation turnover *in vivo-in vitro* of narrow-leaf lupin accelerated by low red to far-red ratio and high intensity in the far-red region. *Plant Cell, Tissue and Organ Culture (PCTOC)*, 127: 591-599.

O'Connor, D. J., Wright, G. C., Dieters, M. J., George, D. L., Hunter, M. N., Tatnell, J. R. and Fleischfresser, D. B. (2013). Development and application of speed breeding technologies in a commercial peanut breeding program. *Peanut Science*, 40(2): 107-114.

Shimelis, H. and Laing, M. (2012). Timelines in conventional crop improvement: Pre-breeding and breeding procedures. *Australian Journal of Crop Science*, 6(11): 1542-1549.

Role of Biotechnology in Horticulture Crops

Ravinder Kaur, Rachel Y. D. and Gayatri Sinha

Introduction

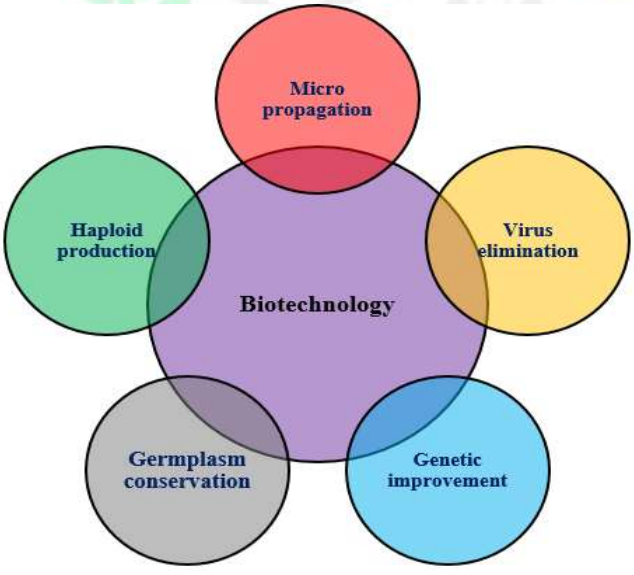
Over the last 10 years, the scientific community has demonstrated an extraordinary ability to work with novel biotechnology instruments, such as the rapidly developing fields of proteomics, genomics, and recombinant DNA. However, the majority of the time, public institutions lack access to the entire spectrum of supporting technologies and characteristic genes, nor the financial means to meet the stewardship and regulatory standards required to create a commercial biotech variety, which makes public-private collaborations a desirable path for growth. Recently, a number of significant and fascinating developments have occurred in the field of biotechnology. The country's growing population is correspondingly increasing the need for fruits and vegetables. How can we maintain horticulture output to keep up with the growing number of people? Despite significant advancements in the creation of superior varieties, traditional plant breeding methods have not been able to keep up with the rising demand for fruits and vegetables in emerging nations. Consequently, there is a pressing need to use biotechnology in order to expedite crop development initiatives.

Through the development of novel plant strains, superior fertilizers, more effective and targeted insecticides and planting materials, biotechnological tools have completely transformed agricultural enhancement initiatives. Many genetically modified fruits and vegetables are already in the market in developed countries. Modern biotechnology encompasses broad areas of biology from utilization of living organisms or substances from those organisms to make or to modify a product, to improve plant or animal or to develop microorganisms for specific use. Also, the RNAi technology has found its most powerful expression in plant biology these days. The applications of this technology cover a wide range from producing insect, viral and disease resistant plants to developing designer flower colors by knocking down the expression of certain endogenous genes. It is being used as a potential tool in tweaking the regulation of various metabolic pathways in plants and assigning functions to the genes involved, thereof. A very little work has been carried out in the field of improvement of fruit quality and male sterility development.

Improvement of Horticultural Crops with Biotechnology

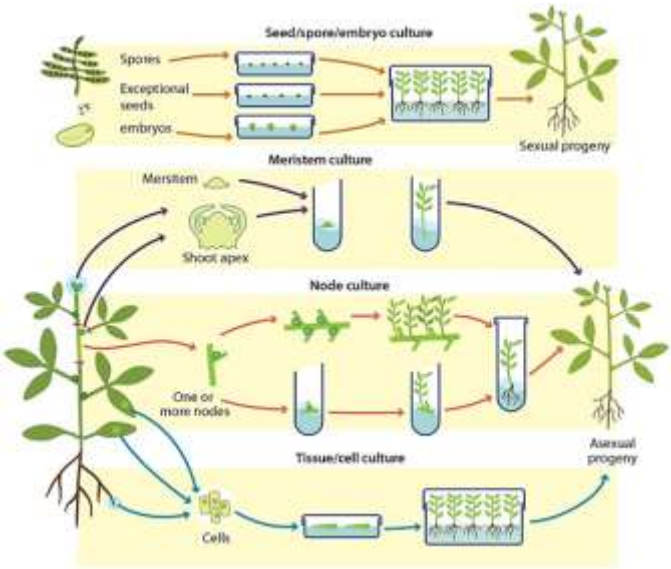
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In vitro culture techniques have had numerous applications to fruit crops beginning nearly 60 years ago with embryo rescue techniques for stone fruits. Later on, the method has been applied successfully to produce commercially acceptable early-ripening peach and nectarine cultivars. The techniques have also been applied to other crops, such as in breeding initiatives to create seedless and early-ripening grapes. In the past, the second use of in vitro culture techniques for fruit crops was the removal of viruses that cause disease from strawberries. Since then, meristem-tip culture has been a crucial component of virus-indexing programs for several fruit crops, typically in conjunction with thermotherapy. As with citrus, it has occasionally been necessary to micro-graft the meristem tip into an in vitro-grown seedling.



The above mentioned methods have been employed for fruit crops, plantation crops and vegetable crops. Examples of plantation crops are- Pineapple, palms, banana, cacao (*Theobroma cacao*), coffee (*Coffea* spp.), tea (*Camellia* spp.) rubber (*Hevea brasiliensis*), Vanilla (*Vanilla planifolia*), clove (*Syzygium* spp.) ginger (*Zingi berofficinale*), turmeric (*Curcuma longa*), cardamom (*Elleteria cardamomum*). Some of these plants are produced in millions by plant tissue culture industry.

Tissue Culture: Particularly in the domain of tissue culture and micro propagation, biotechnology has found widespread use. It is among the most popular methods for quick asexual in vitro multiplication. This method produces elite propagules free of disease and requires less time and space, allowing for a higher production. Additionally, it makes international transfers of germplasm safer and more confined. Since conventional methods have several drawbacks, such as heterozygosity and a long generational gap, the potential application of tissue culture methods in crop improvement is particularly significant. As a result, numerous researchers are developing strategies that will allow tissue culture to be fully utilized to improve crop varieties.



Genetic Engineering of Plants: Many desirable qualities have been introduced into plants via the

application of genetic engineering techniques, and numerous transgenic plants have been generated in which the remote DNA has been progressively coordinated and resulted in the union of suitable quality item. Up until 2001, transgenic plants have gained approximately 52.6 million hectares in the Mechanical and developing countries.

Pest resistance: A large number of insect species attacks plants and causes severe damage to yield. From a grower's perspective, any genetic improvement that could reduce the cost of chemical application to combat pests would be of significant benefit. The bio insecticidal δ-endotoxin gene (Bt. gene) isolated *from Bacillus thuringiensis* is currently in use to make the plants resistant to insect pests. Fruit trees like persimmon transgenic for cry-I gene were found resistant to *Plodia interpunctata* and *Monema flavescens* (Tao *et al*., 1997). For a number of years, Colorado potato beetle-resistant potato cultivars were grown commercially. These varieties proved to be both technically and agronomically effective, resulting in a notable decrease in the usage of insecticides (Shelton *et al*., 2002).

Herbicide Tolerance: Weeds are a major problem in horticulture. Herbicides were introduced to deal with such situations, but regrettably, plants were also damaged along with the weeds. As a result, transgenic plants that are resistant to herbicides are produced, allowing farmers to spray crops to kill only weeds but not their crops.

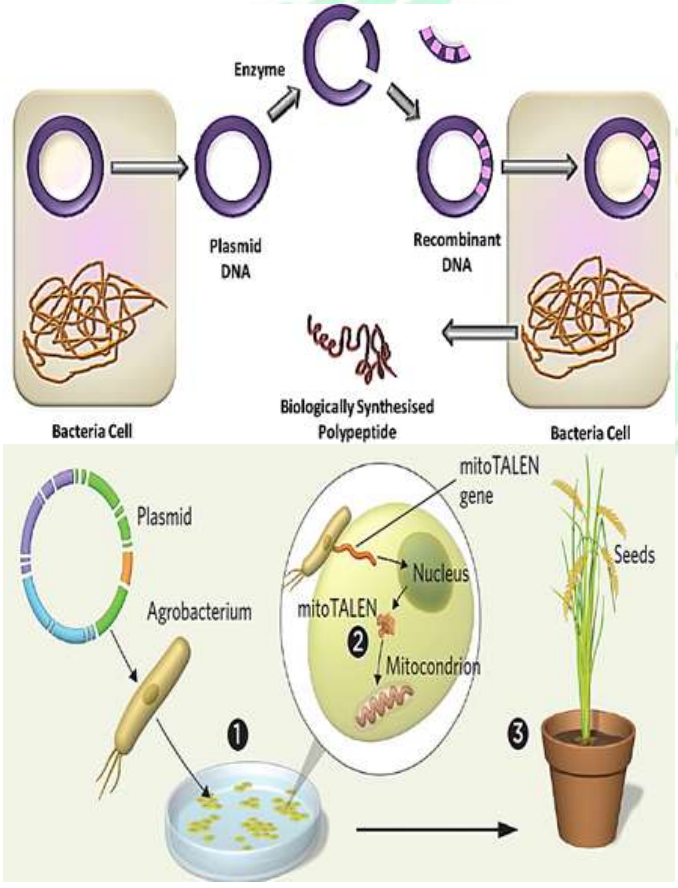
Molecular Markers: Using molecular markers, it is now possible to detect DNA segments and genes and pinpoint their precise location. The ability to choose agronomic qualities using gene tags or molecular markers has simplified the job of the breeder. At the seedling stage, the plants could be scored for various qualities or disease resistance. Plant breeding makes extensive use of RFLP (Restriction Fragment Length Polymorphism), RAPD (Random Amplified Polymorphic DNA), AFLP (Amplified Fragment Length Polymorphism), and isozyme markers. RFLPs have an advantage over morphological and isozyme markers in that their number is limited only by genome size and they are not affected by environmental or developmental factors.

Bio pesticides: In order to control pests, biological organisms known as bio pesticides are applied in place of insecticides. It is without a doubt a noteworthy development in the field of plant sciences. The use of bio pesticides in pest management programs for public health, horticulture, and agriculture is growing in significance.

Conclusion

One of the most important tools the nation has for achieving the objectives of its development policies is biotechnology. These days, there are numerous research groups across the nation that are focused on horticultural biotechnology projects that are quite strategic in the short- and long-term terms. These projects include developing crops that are resistant to pests and diseases and can withstand abiotic stresses; enhancing the nutritional composition of edible crops; modifying secondary metabolite routes in plants; lowering post-harvest storage losses,

shortening juvenile cycles for quick improve-ment of native and exotic forests and fruit trees; and lowering the amount of lignin in wood species. We cannot disregard the potential of this technology at this point in time for genetic crop enhancement to overcome biotic or abiotic stressors and increase fruit quality, among other production constraints. For the comer-cialization of such genetically modified crops in our nation, a one-window regulatory structure is also necessary in order to maximize the true benefits of this technology.



References

Chaudhary, R., Sengar, R. S. and Singh, B. (2009). Role of biotechnology in the development of horticultural crops. *Annals of Horticulture*, 2 (1): 1-10.

Shelton, A. M., Zhao, J. Z. and Roush, R. T. (2002). Economic, ecological, food safety, and social consequences of the deployment of Bt transgenic plants. *Annual Reviews of Entomology*, 47: 845-881.

Tao, R., Dandekar, A. M., Uratsu, S. L., Vail, P. V. and Tebbets, J. L. (1997). Engineering genetic resistance against insects in Japanese Persimmon using the cryI(A)c gene of *Bacillus thuringiensis*. *Journal of American Society of Horticultural Sciences*, 122: 764-771.

Price Optimization in Agriculture: Strategies to Ensure Fair Market Returns

Rohit Rawat, Aditi Sharma and Gayatri Sinha

Introduction

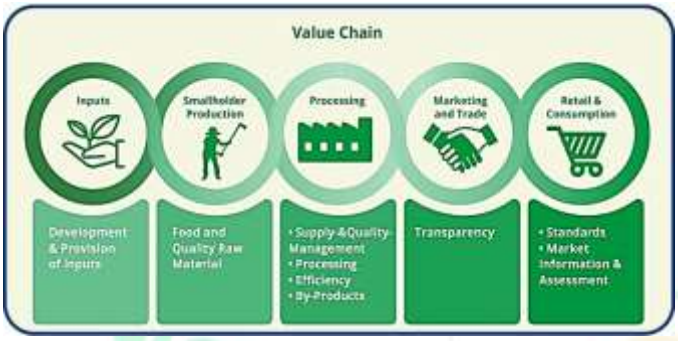
There is no doubt that agriculture is the foundation of every economy, providing food and nutritional security to people worldwide. However, farmers frequently struggle to get reasonable prices for their products. Farmers must adopt an economist's mindset in today's competitive market, where a variety of factors influence pricing dynamics, in order to optimize prices and secure fair market returns. Farmers can improve their economic viability and ensure equitable returns for their hard work by understanding market forces, analyzing supply and demand dynamics, and implementing effective strategies. Pricing is one of the essential elements in product marketing. The change in price-cost margin results in a percentage change in the innovative business's profitability (Panda and Nanda, 2018). Setting a pricing that is excessively high or too low could have a negative impact on profitability. This research makes reference to Smart farmers: agribusiness farmers. A prudent farmer would understand the importance of setting a fair price for a high-quality produce. Prior research in the fields of economics and marketing has evaluated pricing optimization using cost function or field tests. However, when the price on the worldwide market is less than the cost of production, the issue gets worse. Individual agribusiness farmers lack price power, rendering them unprofitable. According to Srisompun *et al*. (2020), the government has made an effort to come up with a policy that would fairly stabilize the cost of production factors and encourage the use of efficient production techniques.

Unreasonable Prices for Agricultural Produce

For farmers, the devaluation of agricultural goods has presented serious difficulties. A number of causes have contributed to this state of affairs, such as variations in supply and demand, an excess of output due to a boom, speculation, traders stock-piling, and a lack of infrastructure for marketing and storage. Unfair pricing for agricultural commodities is still a topic that frequently makes the headlines. Farmers from a variety of industries who devote their life to growing and manufacturing commodities and food are sometimes left with little reward for their labors due to market forces. When there is a bumper harvest or increased production, the market becomes flooded with the produce, leading to a surplus. This

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surplus production drives down prices, as the demand cannot absorb the excess volume. Finding a fair market for their goods is difficult for farmers, especially small and marginal farmers who depend on middlemen to sell their production. Speculation and hoarding are two ways that traders might manipulate the market by controlling supply to inflate scarcity and lower prices.



Strategies to Ensure Fair Market Returns

Value Chain Analysis: Farmers can determine the different steps required in getting their food to market, from production to consumption, by using a value chain analysis. By comprehending the value chain, farmers can spot inefficiencies and chances for value addition. Farmers can use this study to find possible areas for quality improvement, cost reduction, and securing a higher portion of the final price.

Market information: Access to reliable market intelligence and price information is vital for farmers to make informed decisions about when, where, and how to sell their produce. By monitoring market demands and price trends, farmers can align their production and marketing strategies accordingly.

Product Differentiation and Branding: Product differentiation plays a vital role in securing reasonable prices for agricultural produce. By focusing on quality, sustainability, and unique characteristics of their products, farmers can distinguish themselves from competitors. Effective branding and marketing strategies that highlight the value proposition of their produce can justify higher prices while also attracting discerning consumers willing to pay a premium for quality and ethical sourcing.

Direct-to-Consumer Marketing: Direct-to-consumer marketing channels, such as farmers' markets, online platforms, provide an opportunity for farmers to get market information and receive fair prices for their products. By eliminating middlemen, farmers can retain a larger portion of the final price paid by consumers.

Cooperative Marketing and Collective Bargaining: Farmers can determine the different steps required in getting their food to market, from production to consumption, by using a value chain analysis. By comprehending the value chain, farmers can spot inefficiencies and chances for value addition. Farmers can use this study to find possible areas for quality improvement, cost reduction, and securing a higher portion of the final price.

Market Diversification: Overreliance on a single market or crop can expose farmers to price volatility and market risks. Diversifying both the range of products and the markets where farmers sell their produce can mitigate these risks and increase the chances of obtaining reasonable prices. Exploring export markets, niche markets, and value-added products can open new avenues for farmers and redu-

ce dependence on fluctuating commodity prices (Chen and Chen, 2021).

Policy Advocacy: Farmer organizations and associations can play a crucial role in representing farmers' concerns, engaging with policymakers, and pushing for reforms that prioritize fair market returns for agricultural produce.

Financial Literacy and Risk Management: Improving farmers' financial literacy is essential to ensuring they possess the knowledge and abilities needed to successfully manage risks and negotiate fair prices. Farmers can make wise selections if they have a solid understanding of pricing strategies, contract negotiations, and financial planning. In order to reduce price risks and stabilize their income, farmers might also investigate risk management instruments like crop insurance and futures contracts.

Infrastructure Development: Enhancing infrastructure is essential to lowering post-harvest losses and extending perishables' shelf life. Investing in cold storage facilities, transportation networks, and market connections can assist farmers in reaching more markets and lowering their need on middlemen. Furthermore, the growth of farmers' cooperatives and associations can strengthen their group bargaining power and allow them to bargain for more equitable prices.

Conclusion

Agriculture's pricing problem necessitates a multifaceted solution. For farmers to attain equitable market returns for their agricultural output, they must embrace an economic perspective and utilize allencompassing tactics. Farmers can maximize prices and ensure just rewards for their labor by knowing what causes the price difference, performing value chain analysis, remaining up to date on market trends, differentiating products, adopting direct-to-consumer marketing, utilizing cooperative marketing, diversifying markets, leveraging technology, advocating for supportive policies, and improving financial literacy.

References

Chen, J. and Chen, Y. J. (2021). The impact of contract farming on agricultural product supply in developing economies. *Production and Operations Management*, 30(8): 2395-2419.

Panda, A. K. and Nanda, S. (2018). Working capital financing and corporate profitability of Indian manufacturing firms. *Management Decision*, 56(2): 441-457.

Srisompun, O., Simla, S. and Boontang, S. (2020). Influential factors for the decision to participate in a rice-pledging scheme: evidence from jasmine rice farmers in north-east Thailand. *World Review of Entrepreneurship, Management and Sustainable Development*, 16(3): 262-275.

Bacillus subtilis: A Potential Bicontrol Agent

Sharanabasav Huded and Ajay Baldaniya

Introduction

Beneficial bacteria are exploited as bio pesticides to control the diseases in plants. They are gram positive, rod shaped bacteria that can form a protective endospores. It is a facultative anaerobe, heavily flagellated. Optimal temperature range for this bacteria is 25-35˚C. They produce colonies which are dry, flat with lobate margins. They can tolerate extreme environmental conditions by forming endospores. The most known species hosting biocontrol agents are *Bacillus subtilis* and *B. amyloliquefasciens*. The rhizobacterium Bacillus subtilis (Sonenshein *et al.*, 2001) has been used for genetic and biochemical studies for several decades, and is regarded as paradigm of Gram-positive endospore-forming bacteria. Several hundred wild-type *B. subtilis* strains have been collected, with the potential to produce more than two dozen antibiotics with an amazing variety of structures. All of the genes specifying antibiotic biosyntheses combined amount to 350 kb; however, as no strain possesses them all, an average of about 4-5% of a *B. subtilis* genome is devoted to antibiotic production. The disease process is an interplay between susceptibility of host or resistance to pathogen environmental conditions and disease-causing potential of a pathogen (Wang *et al*., 2018).

Mode of action

Biocontrol of fungal and bacterial phyto-pathogens involves the competition for nutrients or colonization sites, cytolytic effects, and antibiotic production (Han *et al*., 2015). *B. subtilis* produces antimicrobial metabolites such as antibiotics the lipopeptides representing various antifungal and antibacterial antibiotics, which include fengycins, iturins, and surfactins; secretes hydrolytic enzymes, which have cell lysis effect; produces endospores; and alters the microenvironment conducive for plant growth, which favors its use as a biocontrol agent. The ability of biocontrol agents to shield crops from pests and diseases is what determines their effectiveness; these agents also need to be environmentally benign. In the rhizosphere, *B. subtilis* colonizes plant roots. This potential is enhanced by genetically engineered strains that overexpress one or more qualities, enabling the strains with various anti-pathogen traits to work in concert when utilized. Under both greenhouse and field conditions, *B. subtilis* isolates B_4, which is utilized as a biofungicide to reduce peanut soil-borne illnesses while maintaining Rizolex-T as the standard fungicide (Ahmad *et al*., 2019).

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Table 1: Disease control by different strains of *B. subtilis*

Strain	Crop	Disease	Causal agent	Mode of action
B. subtilis	Tomato	Root knot	Nematodes	Activates ISR
B. subtilis	Tomato	Botrytis rot	*Botrytis cinerea*	Uses as one of the biocontrol agent for disease suppression
QST 713	Tomato	Bacterial speck	*Pseudomonas syringae*	Reduces disease significantly
LCA 1 and M24	Mung bean	Seed sprout pose	*Salmonella enterica*	Production of antimicrobial substances
PHY S77	Onion	Cape and umbel blight	*Botrytis spp.*	Biocontrol agent
B15	Rice seed	Leaf blight	*Xanthomonas oryzae*	Enhances activities of defense-related enzymes
QST 713	Wheat	Head blight	*F. graminearum*	Bioactive metabolites

Through the use of several scavenging enzymes, Bacillus-based bacterial associations in plants can lower the creation of ROS in cells.

Trade names of *Bacillus subtilis*

- ✓ Bio-Mate
- ✓ Mildown
- ✓ Florabacibs
- ✓ Subweln
- ✓ Bio Downking
- ✓ Leaf Care
- ✓ Bacilin



Uses of *Bacillus subtilis*

The peat-based formulation of *Bacillus subtilis* is mainly used as seed treatment for the control of root rots and wilt diseases of crop plants. The method of application and the precautions to be followed are mentioned below:

- ✓ Bacillus strains are effective against a broad spectrum of plant pathogens and they can be used either as foliar application or root application before transplanting.
- ✓ In case of soil or root application the ability of the specific strain to colonize and permanently establish on the roots of the specific crop is crucial. Sometime the colonization is not simply crop-specific, but cultivar-specific.
- ✓ Root application of *Bacillus spp*. should be done to improve resistance of the plant or to protect the early stage of seed germination, rather to directly control soil-borne inoculum of pathogens.
- ✓ 600 grams of peat based *Bacillus subtilis* product is required to treat the seeds required for sowing in one hectare.

Mass multiplication of *Bacillus subtilis*

The nutrient broth medium is prepared as mentioned below. The medium is taken in conical flasks. Autoclaved at 15 lbs psi pressure for 15 minutes. A loopful of *B. subtilis* is inoculated into the medium and incubated for 2 days. This serves as mother culture.

Glucose	:	5.0 g
Peptone	:	5.0 g
Beef extract	:	3.0 g
Sodium chloride	:	3.0 g
Distilled water	:	1000 ml

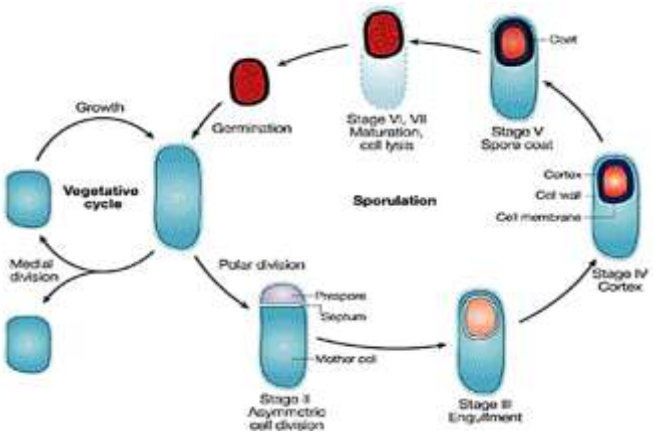


Fig. 1: Mechanism of *Bacillus subtilis* spore germination

Nutrient broth is prepared in fermentor and sterilized at 15 lbs psi pressure for 15 minutes. The mother culture is added @ 1 L/100 L of the medium and incubated at room temperature for 2 days. The medium containing the bacterial growth of *B. subtilis* is mixed with talc powder.

Conclusion

Because plant diseases are so severe, there is a greater risk to food and finances. Plant diseases were effectively controlled by biocontrol agents using a variety of methods. It is important to focus on using biocontrol agents, or antagonists, to manage different plant diseases instead of relying just on toxic chemical fungicides that destroy soil micro-flora and micro fauna. Because plant diseases are so severe, there is a greater risk to food and finances. Plant diseases were mostly controlled by biocontrol agents using a variety of methods. It is imperative to prioritize the use of biocontrol agents, also known as antagonists, in the management of diverse plant diseases instead of relying exclusively on toxic chemical fungicides that deplete the soil's microflora and micro fauna.

References

Ahmad, A. G. M., Attia, A. G., Mohamed, M. S. and Abd-Allah, H. E. (2019). Fermentation, formulation and evaluation of PGPR *Bacillus subtilis* isolate as a bioagent for reducing occurrence of peanut soil-borne diseases. *Journal of Integrated Agriculture*, 18(9): 2080-2092.

Han, Y., Zhang, B., Shen, Q., You, C., Yu, Y., Li, P. and Shang, Q. (2015). Purifcation and identifcation of two antifungal cyclic peptides produced by Bacillus amyloli-quefaciens L-H15. *Applied Biochemistry and Biotechnology*, 176: 2202-2212.

Sonenshein, A. L., Hoch, J. A. and Losick, R. (2001). *Bacillus subtilis* and Its Closest Relatives. From Genes to Cells. Washington, DC: American Society for Microbiology Press.

Wang, X., Zhao, D., Shen, L., Jing, C. and Zhang, C. (2018). Application and mechanisms of *Bacillus subtilis* in biological control of plant disease. Role of rhizospheric microbes in soil. Springer, pp 225-250.

Cultivation of Vegetables in Greenhouse

Shrikant G. Wankhade and Rutuja N. Deshmukh

Introduction

Greenhouse cultivation has revolutionized the way vegetables are grown, providing a controlled environment that maximizes yields and extends growing seasons. In this innovative method, various vegetables thrive under carefully monitored conditions, optimizing temperature, humidity, and light. Popular choices for greenhouse cultivation include tomatoes, cucumbers, bell peppers, and lettuce. This approach ensures consistent, high-quality produce, shielding crops from adverse weather, pests, and diseases. With year-round production, efficient resource use, and sustainable practices, greenhouse-grown vegetables are a testament to the advancements in modern agriculture.

Choice of Vegetables to Grow in a Greenhouse

It depends various factors, including local climate, market demand, and grower preferences. However, certain vegetables are well-suited for greenhouse cultivation due to their adaptability to controlled environments. Here are some vegetables commonly grown in greenhouses, along with their specifications:

Tomato

Varieties

Beefsteak cultivars: Cultivars of this category produce large slicing type fruits having weight about 180 to 250 g. The fruits are harvested individually and usually packed with calyx attached. The important and popular varieties in this group are FA-574, FA-514 and FA-180

Big fruited varieties: The average fruit weight under this group ranges from 120 to 160 g fruit^{-1}. Arka Vardhan, Arka Vishal, Roma, Sioux etc. are some important varities of this group.

Cherry tomato: This is another category of tomato, which are very small in sizeand average fruit weight is 12-20 g. NS Cherry-1 NS Cherry-2, BR-124, HA-818 are famous varieties of this group.

Temperature: Optimum temperature range for growing tomato is 18-25°C.

Light: Require full sunlight; supplemental lighting may be used for extended growing season.

Support: Staking is often necessary for vine support.

Cucumbers

Varieties: Japanese long green, Pusa Sanyog, Priya, Poinsett are some of the important cultivars.

Temperature: 24 to 29°C is optimum temperature for proper growth and development of crop.

Light: Requires full sunlight; vertical farming systems are commonly employed.

Bell Peppers

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Varieties: California wonder, Yolo wonder, Golden wonder, Pusa Deepti, Arka Mohini, Arka Gaurav are the some of the important varities of bell pepper.

Temperature: Optimal temperature range is 21-27°C.

Light: Requires full sunlight; supplemental lighting may be used in low-light conditions.

Beans

Varieties: Pole type and bush type are two types of varieties of bean. Pole type varieties are indeterminate growth habit which are used for greenhouse cultivation. Kentuky wonder, Pusa himlata, Laxmi are some of the important varieties.

Temperature: 21-27°C is optimum temperature range for this crop.

Light: Requires full sunlight; vertical farming systems can be employed.

Support: Staking is often necessary for vine support.

These specifications provide general guidelines, but it's crucial to consider specific requirements for each vegetable, including nutrient levels, humidity, and air circulation. Additionally, advancements in greenhouse technology, such as climate control systems and hydroponic methods, can further enhance the cultivation of a wide range of vegetables in controlled environments.

Conclusion

Greenhouse cultivation of vegetables represents a cutting-edge solution to modern agricultural challenges. The controlled environment within a greenhouse ensures optimal conditions for plant growth, resulting in consistent yields, high-quality produce, and extended growing seasons. By protecting crops from external elements like extreme weather and pests, greenhouse farming promotes sustainable practices and resource-efficient agriculture. This method not only provides a reliable supply of fresh vegetables year-round but also contributes to local food production and reduces the environmental impact associated with traditional farming. In embracing greenhouse technology, we foster a more resilient and efficient future for vegetable cultivation.

Applications of GIS in Various Field

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Introduction

Geographical Information System, better known by its abbreviation GIS, is software that aids professionals in acquiring, managing, analyzing, and visually representing large amounts of geospatial data. This data helps to shape operational as well as strategic decisions around the world. Geographic Information Systems (GIS) have different applications and technological advancements have significantly enhanced GIS data, specifically how it can be used and what can be achieved as a result.



The Geographic Information System is a decision-making tool for any business or industry since it allows the collection, storage, management, and analysis of environmental, demographic and topo-graphic data. The growth in GIS technology over the past decades has led to the proliferation of GIS applications in many sectors like government, industry, NGO, public bodies, etc. It facilitates business by substantially saving resources in terms of time, cost, and effort. Innovative GIS technologies are useful to virtually any industry.

Geographic Information Systems (GIS) can be used in various fields, including:

Mapping

- ✓ The Geographic Information System (GIS) is used to gather, manage, and analyze spatially related data.
- ✓ It includes analyzing spatial location and organizing layers of information into visualizations using maps and 3D scenes.
- ✓ Mapping is considered the central function of GIS. It is the visual representation of data that is stored by GIS in the database.
- ✓ Maps are the basic requirement for several entities in the current situation.

Telecom Services

- ✓ Telecom services benefit a lot from GIS in terms of efficient planning and operational decision-making.
- ✓ GIS data facilitates the wireless telecom sector by helping them incorporate geospatial data into the complex network design and optimization activities.

Urban Planning

- ✓ In urban planning, GIS can be used as a spatial database and as an analysis and modeling tool. It

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also helps the urban planner to identify and establish zoning criteria that allow for the expansion of urban development. As populations grow, so do urban settlements. This gives the planners much less space and resources to develop the infrastructure. Also, the planners need to account for the impact this has on the flora and fauna in the region.

- ✓ Urban planners depend on GIS to a great extent to minimize the negative impact on existing historic structures or natural spaces while responsibly accommodating humans.
- ✓ The advanced GIS mapping capabilities help the users produce high-accuracy base maps for urban information systems.

Environmental Management

- ✓ GIS is useful in environmental management as it facilitates monitoring of changes in soil, water, air, and tree cover. It helps in environmental conservation, waste management and mitigation of disasters.
- ✓ Examples of GIS applications are hazard mitigation strategies, air pollution control, disaster management, forest fire management, natural resource management and allocation, waste management, oil spills, and so many more issues that are a threat to the environment.

Water management

- ✓ At present, GIS is being used in the monitoring of natural and man-made water bodies, managing water supply, modeling sewer systems, modeling groundwater, modeling storm water and non-point source pollution modeling for urban and agricultural areas.

Agricultural Applications

- ✓ GIS is used for the monitoring of crops and the prediction of their possible production in agriculture.
- ✓ GIS helps improve the efficiency of farming techniques and post-harvest crop management.
- ✓ It can also give an insight into the soil properties, including mineral content and topography, hinting at what crop to sow, which in turn increases the yield.

Disaster Risk and Management

- ✓ Disasters are spatial. GIS facilitates decision-making by combining the analysis of different layers of relevant information.
- ✓ Socio-economic and geo-spatial data help authorities rapidly access and visualize critical information to tackle disastrous conditions.
- ✓ It also comes in handy for hazard zone mapping.
- ✓ This in turn enables early mitigation of emergency conditions using real-time weather, traffic, infrastructure, and demographics.
- ✓ GIS has been used to manage environmental problems and specifically in disaster relief, ranging from predicting larger natural disaster events to managing post-disaster actions.

Health Section

- ✓ GIS is vital to the planning and analysis of the provision of health care services across states and cities.
- ✓ Health and human services are a sector that is

benefiting the most in this digital era.

- ✓ GIS helps the officials focus on patterns of spread within communities.
- ✓ This in turn enables them to direct preventive measures and efficiently address problems as they emerge.
- ✓ Also, GIS facilitates tracking and quarantining entire clusters in cases of contagious epidemics. It has helped the officials analyze significant trends and identify high-risk points.
- ✓ GIS incorporates a geographic approach, like visualizing the information from the available datasets, for monitoring and maintaining health services.

Navigation

- ✓ Online navigation maps encourage safe travel on both land and water.
- ✓ GIS facilitates safe navigation by providing accurate topographic and hydrographic data.
- ✓ The maps are regularly updated to keep travelers informed about hazards and enable them to minimize the risk of collision.

Mineral Exploration

- ✓ Starting from exploration and production to mine rehabilitation, many mining activities depend on GIS.
- ✓ GIS is used to collect data in the field, making the mapping process easier.
- ✓ Exploration tools are provided by GIS to manage, display, and analyze data. This makes the whole process more efficient and cost-effective.
- ✓ Both short- and long-term scheduling can be done with the help of GIS to optimize the products and increase operational efficiency.

Defence and Military

- ✓ Terrain analysis is crucial for defence and military. This information is being derived from digital images provided by GIS technology. The data provided by GIS regarding terrain features is useful in war strategies as well as in peacetime. Also, GIS can be used for extracting information about the disputed territories to learn about enemy movements in order to gain a strategic advantage.

Supply Chain Management

- ✓ The supply chain has changed immensely over the last decade. Also, with the emergence of e-commerce, the process of buying and delivering products and services has rapidly evolved. Tracking shipments and inventory is imperative. The ability to track shipments can increase the supply chain's efficiency and save money and resources for businesses that use GIS.

Land Records Management

- ✓ GIS technology, along with GPS, is being used in managing land records and the development of a land records system as well. It helps preserve the records, which in turn lessens the number of boundary disputes. It also localizes land boundaries, irrespective of the constantly changing conditions of the physical piece of land.

Banking Sector

- ✓ Planning, organizing, and decision-making are

enabled by GIS in the banking sector. While the banking sector rapidly grows, it has become more market-driven and responsive. The banks are dependent on GIS technology to give their customers a personalized experience.

Digital Taxation

- ✓ GIS can be used to improve the efficiency of the taxation system and maximize government income. It can be used to store information about tax payables and revenue collection with accuracy. This data can also be viewed visually to monitor compliance.

Natural Resources Management

- ✓ GIS is of utmost use when it comes to monitoring and managing natural resources like agriculture, water, forests, minerals, and more. The geographic distribution of these resources can be analyzed, and hence, these resources can be judiciously used. Forests can be easily monitored, crop yields can be managed, crop rotations can be planned, and water resources can be utilized sustainably.

Smart City

- ✓ The smart city concept is emerging as the next big player around the world to improve the efficiency and security of urban development. GIS is responsible for integrating all the major aspects of city planning and management. It provides a common operating platform for all the sectors of the region. A comprehensive digital environment provided by GIS helps to enhance urban systems in terms of pollution abatement, water and waste management, energy optimization, tax and revenue collection, and much more.

The Role of Remote Sensing and GIS for Forest Fire Management

- ✓ Given the urgency of the situation, comprehensive monitoring of land use, from local to global scales, has become essential. Earth observation data is essential for monitoring fire, predicting hazards, and creating risk maps. These geospatial models use diverse factors, like vegetation, topography, and proximity to human activities, to calculate risk estimates for specific regions.
- ✓ Satellite data plays a pivotal role in measuring fire severity and mapping burned areas. This data forms the basis for predictive risk assessments, utilizing parameters such as surface temperature, vegetation indices, and moisture metrics. To optimize the use of remote sensing and GIS, the GIS platform offers in-built robust algorithms for identifying high-risk areas for forest fires. GIS is designed to save time and simplify data analysis by integrating indices like the differenced normalized burn ratio (dNBR), the normalized difference vegetation index (NDVI), the relative difference normalized burn ratio (RdNBR), etc.

References

https://mgiss.co.uk/geographic-information-system-different-applications-of-gis/

https://www.sgligis.com/applicationsofgis/#:~:text=Examples%20of%20GIS%20applications%

Pest Management Strategies under Natural Farming

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Introduction

Over the past few decades, the use of pesticides has become one of the most important agro-inputs for raising crop yields. However, studies and data from scientific survey point to certain risks connected to the use of these compounds. Furthermore, improper use causes residues in food, contamination of soil, air, surface, and ground water, biomagnification of toxicants in food chains, and resistance in pests and pathogens. It also kills a variety of beneficial organisms, including fish, birds, wildlife, pollinators, and microbes.

Natural farming is the practice of producing crops without the use of chemicals while maximizing the use of available resources and combining trees, crops, and livestock. The major goals of natural farming are to protect the natural flora and fauna, restore soil fertility, and control pests and diseases. They also aim to reduce input costs associated with agricultural production by recycling soil nutrients, controlling pests and diseases, producing a diverse range of crops, and efficiently using land and natural resources (such as air, water, and light). Natural farming also provides a variety of habitats and essential resources for predators and parasitoids. Under Natural farming farmers can use natural products that they can easily prepared from local resources at very little or no expense to manage plant pests. These naturally made blends, or Astras, will simultaneously address the harmful effects of pesticides while protecting the crop from disease and insect pests.

Strategies for crop pest management in natural farming

Using bio resources as seed protectants

Beejamrita (Seed treatment): The majority of plant diseases, pest infestations, are transmitted through seeds and soil. In order to avoid soil- and seed-borne diseases as well as insect pest infestation in plants, it is crucial to treat seeds, seedlings or other planting material with beejamrita prior to sowing. A mixture of cow dung (5 kg), cow urine (5 lit), soil (50 gm), calcium carbonate (50 gm), and water (20 lit) from native cow species is used to produce bijamrit, which is used to cure 100 kg of seeds. It should be applied within 24 hours of preparation.

Use of natural pesticides (Astras)

Agniastra: This spray is effective against leaf rollers, stem borer, fruit borer pod borer and catterpi-

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llars.

Procedure for preparation

- ✓ Fill a container with 20 litres of desi cow urine, 2 kg neem leaves, 500 g of tobacco powder, 500 g of chilli powder, and 250 g of crushed garlic.
- ✓ Bring the solution to a boil over a low burner. After then, take the solution off of the flame and allow it to cool for 48 hours.
- ✓ Pour the mixture through a cotton swab and keep it chilled. The solution can be stored upto six months.

Rate of application: 2-2.5 litres in 100 litres water for spraying in 1 acre area.

Brahmastra: This spray is effective against all kinds of sucking pests, including fruit borer and pod borer.

Procedure for preparation

- ✓ Place 2 kg of ground and crushed leaves of Datura, castor, guava, mango, lantana, apple, custard and karanj in a large container.
- ✓ Fill the container with 20 liters of cow urine and seal it with a lid.
- ✓ Bring the mixture to a boil over a low heat before taking it off and setting it aside to cool.
- ✓ After 48 hours, utilize the solution for up to six months by storing it in a container.

Rate of application: 2-2.5 litre brahmastra in 100 litres water as foliar spray on 1 acre area

Neemastra: The spray is effective against all sucking pests and catterpillars infesting various crops.

Procedure for preparation

- ✓ Crush and grind 5 kg of neem leaves or fruits into a fine powder, then transfer to a drum. Pour 100 liters of water into this powder.
- ✓ Add 1 kg of cow manure to 5 liters of Desi cow urine. A wooden stick used to stir the mixture in a clockwise direction. Cover the mixture for 48-hour.
- ✓ After stirring the mixture three days, filter it through a cloth and use the filtrate for spraying the crop

Rate of application: 2-2.5 litre brahmastra in 100 litres water as foliar spray on 1 acre area.

Dashparni: It's used to get rid of all kinds of insect pests that infest fruits, vegetables, and crops. This mixture includes turmeric powder, ginger paste, asafoetida powder, and tobacco powder, green chilli powder, garlic paste, leaves of papaya, marigold, guava, bana, basuti, darek, dhatura, marigold, turmeric and ginger. It also contains cow urine and cow dung. It also acts as an antibacterial and antifungal.

Procedure for preparation

- ✓ Fill a barrel with 20 liters of cow urine, 2 kg of cow dung, 500 grams of turmeric powder, 500 grams of ginger paste, 10 grams of asafoetida powder, and 1 kg of tobacco powder. Cover with a jute bag.
- ✓ Include 1 kg of green chili pulp, 500 g of garlic paste, and 500 g of darek leaves the following morning. Using a wooden stick, stir the contents for two to three minutes in a clockwise motion.
- ✓ For up to a day, cover the solution with a jute bag.
- ✓ Add 2 kg of each of the following leaves to the

mixture the following day: lantana, Dhatura, papaya, marigold, guava, bana, basuti, turmeric, and ginger leaves.

- ✓ For a duration of 30 to 40 days, stir the mixture clockwise for two to three minutes each morning and evening.
- ✓ Store the solution after straining it using a cloth. The mixture can be stored for up to six months.

Rate of application: 2-2.5 litre dashparni in 100 litres of water for spraying in 1 bigha area.

Conclusion

Using natural farming practices can recycle nutrients from the soil, reduce the prevalence of pests and diseases, and produce a wide variety of crops by making efficient use of the land and available natural resources. While there are few research reports in the literature regarding the use of natural products to manage diseases and insect pests on crops, further studies are required to support these findings and support their application in future.

References

https://naturalfarming.niti.gov.in/

https://naturalfarming.dac.gov.in/

Badiyala, A. and Sharma, G. D. (2021): Pest management under natural farming. *Indian Farmer*, 8(03): 253-258.

Kumar, R., Kumar, S., Yashavanth, B. S. and Meena, P. C. (2019). Natural farming practices in India: Its adoption and impact on crop yield and farmer's income. *Indian Journal of Agricultural Economics*, 74(03): 421-431.

Betal Vine: A Time Honoured Herbal Wonder

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Introduction

Betel vine, scientifically known as *Piper betle*, is a tropical perennial plant native to South and Southeast Asia. It is widely cultivated for its medicinal and cultural significance. The leaves of the betel vine are the most commonly used part of the plant and are known for their diverse medicinal properties. Betel vine has been traditionally used in various forms, including chewing the leaves as a stimulant and mouth freshener, making herbal infusions, extracts, powders and culinary preparations. It is valued for its digestive, antimicrobial, anti-inflammatory, antioxidant and respiratory health benefits. However, excessive consumption or prolonged use may have adverse effects, especially when combined with other ingredients such as areca nut and tobacco. As with any herbal remedy, it's advisable to consult with a healthcare professional before using betel vine for medicinal purposes.

Medicinal Benefits of Betel Vine

Betel vine (*Piper betle*) is indeed considered a medicinal herb with a long history of traditional use in various cultures, particularly in South and Southeast Asia. The leaves of the betel vine are the most commonly used part of the plant and are known for their diverse medicinal properties.

- ✓ **Digestive Aid:** Betel leaves are often chewed after meals to aid digestion and alleviate gastrointestinal discomfort. They stimulate the production of saliva and gastric juices, which helps in the digestion process. Betel leaves are also believed to have carminative properties, helping to relieve gas and bloating.
- ✓ **Oral Health:** Chewing betel leaves is a traditional practice for maintaining oral hygiene and freshening breath. The leaves have antimicrobial properties that help reduce oral bacteria and plaque formation, thereby preventing bad breath and dental problems.
- ✓ **Anti-inflammatory:** Betel leaves contain compounds with anti-inflammatory properties that can help reduce inflammation and swelling. They are sometimes used externally as poultices or compresses to relieve pain and inflammation associated with conditions such as arthritis, sore muscles, and insect bites.
- ✓ **Respiratory Health:** In traditional medicine, betel leaves are used to alleviate respiratory symptoms such as cough, asthma, and bronchitis. They are believed to have expectorant properties, helping to clear mucus from the airways and improve breathing.

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- ✓ **Wound Healing:** Betel leaves are applied topically to wounds, cuts, burns, and insect bites to promote healing and reduce inflammation. The leaves have antimicrobial properties that help prevent infection, while their anti-inflammatory effects help reduce pain and swelling.
- ✓ **Antioxidant:** Betel leaves contain antioxidants that help neutralize harmful free radicals in the body, which are implicated in various diseases and aging processes. Consuming betel leaves may help protect cells from oxidative damage and reduce the risk of chronic diseases.
- ✓ **Antimicrobial:** Betel leaves have antimicrobial properties due to the presence of phenolic compounds, tannins, and essential oils. They can help inhibit the growth of bacteria, fungi, and viruses, making them useful for preventing and treating infections.

Different Processed Products of Betelvine

Betel vine, also known as *Piper betle*, is primarily used fresh or dried for chewing in many parts of Asia. However, there are several processed products derived from betel vine that are used for various purposes. Here are some of them:

- ✓ **Betel Leaf Oil:** Betel leaf oil is extracted from the leaves of the betel vine and is used in aromatherapy, perfumery, and traditional medicine. It is believed to have antimicrobial, anti-inflammatory and antioxidant properties and is used in the preparation of various medicinal and cosmetic products.
- ✓ **Betel Leaf Extracts:** Betel leaf extracts are obtained by extracting bioactive compounds from betel leaves using solvents such as ethanol or water. These extracts are used in traditional medicine for their antimicrobial, anti-inflammatory, and antioxidant properties. They are also used in the formulation of herbal medicines, dietary supplements, and personal care products.
- ✓ **Betel Leaf Powder:** Betel leaf powder is made by drying and grinding betel leaves into a fine powder. It is used in traditional medicine as a remedy for various ailments, including digestive disorders, respiratory problems and skin conditions. Betel leaf powder is also used in herbal teas, dietary supplements, and topical preparations.
- ✓ **Betel Leaf Mouth Fresheners:** Betel leaves are sometimes processed and flavored to create mouth fresheners or paan masala. These products typically contain betel leaves, areca nut, slaked lime (calcium hydroxide), and various flavoring agents such as cardamom, cloves, and menthol. They are popular in South Asian countries as a traditional after-meal snack and mouth freshener.
- ✓ **Betel Leaf Chutney:** Betel leaves can be used to make chutneys or sauces by blending them with other ingredients such as coconut, tamarind, green chilies, and spices. Betel leaf chutney is popular in some cuisines for its unique flavor and aroma and is served as a condiment or accompaniment to dishes.
- ✓ **Betel Leaf Infusions:** Betel leaves can be infused in hot water to make herbal teas or infusions. Betel leaf tea is believed to have diges-

tive, respiratory, and antioxidant benefits and is consumed for its refreshing flavor and aroma.

These are some of the processed products of betel vine that are used for various purposes, including medicinal, culinary and aromatic applications.

Different Ways to Consume Betel Vine

Betel vine, also known as *Piper betle*, is consumed in various ways in different cultures, particularly in South and Southeast Asia, where it holds cultural and traditional significance. Here are some common ways in which betel vine is consumed:

- ✓ **Chewing Betel Leaves:** One of the most well-known and traditional methods of consuming betel vine is by chewing the fresh leaves. Betel leaves are often used as wrappers for areca nut (also known as betel nut), slaked lime (calcium hydroxide), and other ingredients such as tobacco, spices, and sweeteners. This combination is known as "paan" and is chewed for its stimulant and refreshing properties. It is commonly offered to guests as a sign of hospitality and is also consumed after meals as a digestive aid and mouth freshener.
- ✓ **Betel Leaf Infusions:** Betel leaves can be infused in hot water to make herbal teas or infusions. Betel leaf tea is believed to have digestive, respiratory, and antioxidant benefits and is consumed for its refreshing flavor and aroma. It is often served hot or cold and may be sweetened with honey or sugar.
- ✓ **Betel Leaf Extracts:** Betel leaf extracts are sometimes used in traditional medicine for their medicinal properties. These extracts can be obtained by macerating or distilling betel leaves to extract bioactive compounds such as essential oils, phenols, and tannins. They may be used internally or externally for various health purposes.
- ✓ **Betel Leaf Powder:** Betel leaves can be dried and ground into a fine powder, which can be used in various ways. Betel leaf powder may be consumed directly or mixed with other ingredients to make herbal formulations, dietary supplements, or topical preparations.
- ✓ **Betel Leaf Mouth Fresheners:** Betel leaves are processed and flavored to create mouth fresheners or paan masala. These products typically contain betel leaves, areca nut, slaked lime, and various flavoring agents such as cardamom, cloves, and menthol. They are popular in South Asian countries as a traditional after-meal snack and mouth freshener.
- ✓ **Betel Leaf Culinary Uses:** Betel leaves are sometimes used in cooking to add flavor and aroma to dishes. They may be used as wrappers for stuffing ingredients such as minced meat, vegetables, or fish, or they may be added to curries, chutneys, salads, or rice dishes for their distinctive taste.

These are some of the common ways in which betel vine is consumed, each with its own cultural, social and traditional significance.

However, it's important to consume betel vine in moderation and be aware of potential health risks associated with excessive consumption, particularly when combined with other ingredients such as areca nut and tobacco.

Conclusion

Betel vine (*Piper betle*) is a medicinal herb with a long history of traditional use in various cultures, particularly in South and Southeast Asia. The leaves of the betel vine possess diverse medicinal properties, including digestive aid, oral health benefits, anti-inflammatory effects, respiratory support, wound healing, antioxidant activity, and antimicrobial properties. Betel vine is commonly consumed by chewing the fresh leaves, making herbal infusions, using betel leaf extracts, powder, or as a flavouring agent in culinary dishes.

However, it's essential to use betel vine in moderation and be aware of potential health risks associated with excessive consumption or when combined with other ingredients such as areca nut and tobacco. As with any herbal remedy, it's advisable to consult with a healthcare professional before using betel vine for medicinal purposes.

Bio-plastics from Fruit Wastes

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Introduction

Plastics being an inseparable part in our day-to-day life with harmful effects. It is also a massive threat to flora, fauna and environment with its disposal being a real challenge. Because of the plastics environmental havoc, the need of the hour is in potential green alternatives. Fruit wastes being rich in starch, cellulose, protein and lipid etc. serves as one of the sources for green alternatives for plastic production i.e., bio-plastic. The remains of fruits such as orange peels, banana peel and jack fruit perianth etc. are used in bio-plastics production. The alternative solution involved in fruit waste management is by eco-friendly bio-plastics.

Bioplastics are biodegradable polymers of biological origin. The exhausting fossil resources and ever-increasing environmental pollution caused by plastics derived from these resources is driving the growth of the bio plastic industry. There is increasing focus on developing low cost and durable bio-based plastics, with a wide range of applicability. Currently, a majority of raw material for bioplastics production comes from agricultural crops, which indirectly poses threat to food security. Hence using organic wastes from biological origins, will not only limit our dependency on agricultural crops, but may also assist in solid waste management, in an effective manner. Industries, particularly food and agriculture sector, produce significant amounts of organic wastes, which can be harnessed for this purpose. It will also reduce the cost of production to a remarkable extent. It is indeed, the need of time to intensify innovations and research in this field to overcome the hindrances and developing viable processes for manufacturing bio-based plastics. This environmentally friendly approach can remove our dependency from fossil based conventional polymers and will lead us to a much more sustainable future.

According to the European Bioplastics Organization (EBO), a material could be defined as bioplastic if it is either bio-based, biodegradable, or features both the properties. The term bio-based refers to materials that are completely or partly derived from the biomass.

Potential of fruit waste as bioplastic material

Fruit waste is a challenge for sustainable development since it can increase greenhouse gas emissions and other environmental issues. Food processing and manufacturing are known to raise fruit waste. Many fruit wastes have the potential to be developed as bioplastics if they contain bio-polymers such as starch, cellulose, or other biopoly-

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mers. Some of the wastes are obtained from the food processing industry such as, banana peel, pineapple peel, durian seed, jackfruit seed and perianth, avocado seed and orange peel. The development of bioplastics from fruit waste has a double benefit that can solve two problems indirectly, namely reducing plastic waste and fruit waste at the same time, thereby promoting environ-mental sustainability.

Banana peel: Banana peels as agricultural process-ing waste can be used in making bioplastics because they contain cellulose, starch, pectin, and other polymers. Cellulose is modified to obtain thermos-plastic materials through acetylation (cellulose acetate).The use of pectin in making bioplastics functions as an emulsifier and that increases intermolecular bonds in the film. The utilization of banana peels has been done by adding citric acid to prevent browning so that pectin produced by banana peels is brighter. Pectin of banana peel extracted with citric acid at 90°C for 3 hours, has a water content of 11.55%, ash content of 3.060%, methoxyl content of 3.966%. Bioplastics produced from banana peel has a film thickness ranging from 0.00311-0.00387 cm, permeability 35.30-63.63%, with traction strength of 2.6286-10.5620 MPa, extension value 16.66-58.33%. The polymer produced using the banana peel blended with the glycerol could help in the formation of plastic having the characteristic features of pliability, user friendliness and strength.

Orange peel: Orange peels are food wastes that are highly challenging. It contains about 25 % of pectin, an essential source in providing bioplastic strength. It also consists of hemicelluloses (11%), cellulose (22%), lignin (6.4%). Juice processing industries generates 50-60 per cent of residues, which are disposed of in landfills contribute 20 per cent of methane gas emission which leads to global warming. Orange peel contains limonene, it can be converted into Poly limonene carbonates (PLimC) which can be an excellent replacement for commercial polycarbonates bisphenol-A (Carcino-genic). Poly Limonene Carbonate (PLimC) is Antimicrobial in nature and prevents *E. coli* growth.

Pineapple peel: Pineapple peel is a waste that comes from household consumption as well as the pineapple processing industry. The main constituent of the peel is extracted as cellulose through refluxing with acid or alkaline solutions. Cellulose is a natural polymer, consisting of glucose units with a homogeneous chain structure. Here the cellulose can be converted to carboxy methylcellulose (CMC) through the etherification process. Pure cellulose potentially can be made from pineapple by refluxing pineapple skin powder with 0.5 M HCl and 1 M NaOH solution at 90°C for 1 hour and 2 hours. Then, the solid material bleached with Calcium hypo-chlorite.

Jackfruit perianth: Jack fruit constitutes about 20-22% of perianth, which is usually not edible and goes as wet waste. Rich in Cellulose (27.75%), Pectin (7.52%) and Starch (4%). Cellulose, starch and glycerol, influence properties like good tensile strength, Bio-degradable nature of synthesized bioplastics.

Avocado seed: Avocado seed, which represents 10-22% of the total weight. Avocado seed starch used had the starch content of 67.69%, amylose content of 32.47%, amylopectin content of 35.32%. The best bioplastic conditions of avocado seeds were obtained at 90° C with a ratio of starch: chitosan (w / w) = 7: 3 and glycerol 0.2 ml / g with a tensile strength of 5.096 MPa, breaking extension 14.016%.

Advantages of bio plastics

There are so many advantages for the environment due to the use of bioplastic such as:

- ✓ Potentially lower the carbon footprint.
- ✓ Greenhouse gases emission will be less.
- ✓ Lower energy cost in manufacturing.
- ✓ Reduction of permanent litter and much safer to the environment.
- ✓ Bioplastics also have advantages in the characteristics of the material such as much greater water vapor permeability than standard plastic, less oily feel, softer, and more tactile.

References

Muthaszeer, A. M., Ramanan, M. V., Cherian, R. K., Biji, P. and Cherian, E. (2020), Production of bioplastic using Jackfruit perianth. *Indian Journal of Experimental Biology*, 58(12): 875-878.

Oo, M. Z. K., Thu, M. and Tun, Z. N. N. (2019). Bioplastics from Fruit Waste. *International Journal of Advance Science and Research*, 5(8): 209-215.

Orenia, R. M., Collado, A., Magno, M. G. and Cancino, L. T. (2018). Fruit and vegetable wastes as potential component of bio-degradable plastic. *Asian Journal of Multidiscipline Studies*, 1(1): 61-77.

Yaradoddi, J. S., Banapurmath, N. R., Ganachari, S. V., Soudagar, M. E. M., Sajjan, A. M., Kamat, S., Mujtaba, M. A., Shettar, A. S., Anqi, A. E., Safaei, M. R., Elfasakhany, A., Siddiqui, M. I. H. and Ali, M. A. (2021). Bio-based material from fruit waste of orange peel for industrial applications. *Journal of Material Research and Technology*, 1-12.

Yaradoddi, J., Patil, V., Ganachari, S., Banapurmath, N., Hunashyal, A. and Shettar, A. (2016). Biodegradable plastic production from fruit waste material and its sustainable use for green applications. *International Journal of Pharmacy Research and Allied Sciences*, 5(4): 55-66.

Role of Farming System for Sustainable Agriculture

D. D. Sharma and Shareya

Sustainable agriculture involves those practices and methods which meets man's changing needs for food, forage and livestock with due protection of natural resources such as soil, water and environment. Sustainability development is the only way to promote national utilisation of resources and environmental protection without hampering the economic growth. In this context, Integrated Farming System holds special position of all farming systems as it meets all requirements of sustainable agriculture. The most important thing is that in this system, no by-products go waste. However, the methods should be economically viable, environmentally sound and public health protecting. It not only emphasizes on natural resources aspect of farming but also on the economic aspects of farm produced and market purchased inputs use in the process thoughtfully and effectively. Agriculture is called as never static system in which farmers are the land cultivators and agricultural scientists are their mentors, guides and philosophers who disseminate improved farm practices of soil, crop, weather and other marketing aspects to them from time to time. Now, let us discuss various farming systems and how they meet sustainable agriculture requirements.

Natural Farming: The philosophy of natural farming is working with nature to produce healthy food to keep people, land and environment healthy. It believes that everything in nature is useful and serves a purpose in the web of life. Being called 'Do Nothing Farming'- as the farmer is considered only to be a facilitator and the real work is done by the nature herself i.e. no tillage and farming without the application of inorganic fertilizers and pesticides. Actual physical work and labour has been observed to be reduced by 80 percent compared to other farming systems. Dr. Fukuoka started natural farming in Japan by experimenting with the nature and following the natural ways of crop propagation. In fact, when we follow nature without destruction, it takes care of us. In our country, Zero Budget Natural Farming (ZBNF) was proposed by Mr. Subhash Palekar with the same philosophy but with the indigenous supplements. Here, the soil is supplemented with microbial inoculums like *Beejamrit* and *Jeevamrit* to accelerate the propagation of soil micro-flora which is very beneficial to soil environment. Indigenous pesticide decoctions of leaves with cow urine and cow dung. *Neemastra* and *Brahmastra* etc. are applied as plant protection measures. The whole crop is not harvested to let the nature breed the beneficial insects by the left-out material of fruits/crops/seeds or remnants on the field. These fruits or seeds remnants attract other

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beneficial birds and insects which increases the biodiversity and sustain original ecosystem.

Organic Farming: It is a method of crop and livestock production that involves much more than choosing not to use synthetic chemical fertilizers, pesticides, genetically modified organisms, anti-biotics and growth hormones besides relying on ecologically balanced agricultural principles like tillage, crop rotation, green manure, organic waste, biological pest control, minerals and rock additives. In brief, organic farming in based on various laws and certification programmes of certification agency which avoids the use of all synthetic inputs; and the soil as well as the environmental health are main-tained. Though both natural and organic farming are environmentally sound and protect public health, yet these cannot meet the growing population's needs for food, fuel, forage and fodder for animals.

Mixed Farming: It refers to the farming system which represents an appropriate combination of farm enterprises like horticulture, livestock, fishery, forestry, apiculture, sericulture, poultry etc. and the means available to the farmers to raise them for profitability. Mixed farming refers to subsistence level of farming while the farming system aims at profit making. Livestock + cereal cropping is an example of mixed farming in which the whole straw and some grains of crops are used as forage and feed the animals. The dung and urine from livestock is used as manure for crops at subsistence level. Similarly, in aquaponics as mixed farming, the fish wastes are used in the form of manures for vegetable crops like lettuce which, in turn, cleans the water for the fish. Rice-fish farming system in North-east India, China and Thailand is another good example of mixed farming where the fish like *Carp* and *Tilapia* are breed in rice field's water. Thus, mixed farming system meets all the requirements of sustainable agriculture.

Precision Farming: It is an approach to farm management which uses information technology to ensure that the crops and soil receive exactly what they need for optimum health and productivity. We know that all aspects of environment like water, soil, weather, vegetation etc. vary from place to place and all these factors determine crop growth and farming success. Precision farming manages these factors accurately and in required quantities in the field and thus, reduces cost of production while sustaining the same productivity. Precision agriculture is one of the modern practices that make production more efficient, and the farmers are able to manage large fields. This reduces the imbalanced and wrong dosage of inputs, their time of application, method of application while increasing crop and farm efficiency. Crops are rotated to improve diversity; and irrigation rates are monitored for efficient use of water. Thus, precision farming facilitates the farmers to apply nutrients, water, seed and other agricultural inputs in required time. The inputs so saved can be used on more area, more crops can be grown in a wide range of soil environment and the ecosystem is protected. However, it is not cost-effective and presently is in infancy stage.

Integrated Farming System (IFS): It is a system which comprises of inter-related set of enterprises such as livestock, pisciculture, poultry, apiculture etc. with crop activity as base. It is a promising approach for increases overall productivity and profitability through recycling of farm waste and by-products through efficient utilisation of available resources. About 95 percent of inputs requirement of the system is self-sustained through resource recycling. As the number of enterprises increases, the famers' profit margin also increases. In brief, IFS is an arrangement of recycling of products, by-products or waste of one enterprise where as an input used fed to another linked component offers huge employment, regular production and income besides reducing production risks, cost of cultivation through optimal use of natural resources and internal resource recycling by effective utilisation of family labour. Watershed, farm pond, bio-pesticides, biogas, solar energy utilisation unit, vermicompost units, livestock and allied units, green manuring, agroforestry unit and rainwater harvesting unit are the main elements of IFS. Crop husbandry, horticulture, aquaculture, apiculture, sericulture, mushroom cultivation etc. are the allied components. There are different IFS for different ecosystems *viz*; irrigated low and upland, rainfed and dry land areas and hill regions.

From various research studies, it has been observed that through successful IFS models, there was 2-3 times gain in productivity, 3 to 5 times in net returns, 40-50 percent in resource saving and 50 percent increase in gender empowerment. There was 100 percent household nutritional security, 50 percent reduction in greenhouse gases, 70-80 percent additional employment generation and with an average regular net daily income of Rs.800 per household of one hectare.

Popular enterprises linked to different agro-ecosystems

Dry land	Garden land	Wet land
Dairy	Dairy	Dairy
Poultry	Poultry	Poultry
Goat and sheep	Mushroom	Mushroom
Agroforestry	Apiary	Apiary
Farm pond	Piggery	Fishery
Grass and fodder	Sericulture	Duckery
Lamb rearing		

Source: PGDAEM, Indian Institute of Agricultural Extension Management, (AEM 204), Hyderabad

Productivity and Economic analysis of successful IFS

IFS	Duration of system (days)	Net Returns (Rs. ha^{-1})	Employment Generation (Mandays)
Cropping alone	369	36,190	369
Crop + Poultry	420 (369+51)	1,14,665	515
Crop + Pisciculture + Pigeon pea	420 (369+51)	1,18,462	515
Crop + Pisciculture + Goat rearing	420 (369+51)	1,78,47	576

Source: www.manage.gov.in 2021 (AEM 204)

Hence, there is need to create database on IFS in relation to its types, infrastructure, economic sustainability under different farming systems coupled with developing research modules of IFS under different farm holding sizes with economically and socially viable system along with assessment and refinement of technologies at research stations suitable to farmers' fields. Besides, there is need to frame contingent planning to counteract any kind of weather and climate threats under different farming and agro-ecological conditions.

Integrated Pest Management in Arecanut Ecosystem

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Arecanut (*Areca catechu* L.) is an important commercial crop and commonly known as beetle nut in most South Asian countries. In India, it is mainly grown in coastal, plain and hilly regions of states such as Karnataka, Kerala, Tamil Nadu, West Bengal and Assam. Presently, India is the largest producer of arecanut worldwide, producing 15.65 lakh metric tonnes from an area of 7.8 lakh ha (Anon, 2022). The yield potential of arecanut is greatly influenced by both biotic and abiotic factors such as cultural operations, nutrients, pest and diseases, soil type and weather parameters. Among them, the incidence of pest and diseases pose a serious threat and are major limiting factors on arecanut production. Till date, more than 90 species of insect and non-insect pests have been reported from arecanut. Integrated management approaches are necessary to combat pest attack and to produce sustainable yield. Therefore, an outline of pest incidence, symptoms and their management strategies are summarized here under.

Insect Pests

Root grub (*Leucopholis* spp.): Root grub, *Leucopholis* species complex *L. coneophora*, *L. lepidophora and L. burmeistri*) (Fig. 1) are polyphagous and it attacks on arecanut, banana, coconut, sweet potato, cashew, rubber and coffee. The maximum population of root grubs usually noticed during monsoon season and causes extensive damage to arecanut as well as intercrops grown in arecanut based cropping system.



L. coneophora *L. burmeistrei* *L. lepidophora*

Fig. 1: Different Species of root grub

Symptoms

- ✓ It is difficult to identify the symptoms in the early stages of infestation; however, infestation on younger palms (<3 years) may wither if attacked severe.
- ✓ Continuous feeding on roots results in poor supply of water and nutrients to the palm which lead to uniform pale yellowing of leaves and decrease in yield.
- ✓ Reduction in stem girth and size of the crown and tapering of palms are characteristic symptoms in the advanced stage of damage (Fig. 2).
- ✓ In severely infested plots 30-40 grubs can be seen in the base of a single palm and such palms can

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be easily pulled out as most of the roots are eaten away by the grubs.



Fig. 2: The larvae feeding on roots and reduction in internodal length

Management

Based on above mentioned symptoms, suspected garden may be examined at random by digging the base of the palm to a depth of 30 cm for the presence of grubs at the root zone.

- ✓ Repeated ploughing (3-4 ploughings) of gardens from October - December to expose the grubs to predators.
- ✓ Provide good drainage facilities.
- ✓ Hand picking of adults during peak emergence period which commences during May last to June first week in plains and during August in hilly tracts (Peak emergence timing: 6:30-7:30 PM)
- ✓ Application of neem cake @ 2 kg palm^{-1} year^{-1} during June to July in the basin which help in the rejuvenation of roots.
- ✓ Patch application of chlorpyriphos 20EC @ 10 litre ha^{-1} or bifenthrin 10 EC @ 20 litre ha^{-1} covering interspaces and root zone area where grub infestation is noticed during last week of August. If needed, second round root zone application of chlorpyriphos 20 EC @ 7 ml palm^{-1} or bifenthrin 10 EC @ 14 ml palm^{-1} after 45 days of first round may be given.
- ✓ Application of Entomopathogenic nematode liquid suspension, *Steinernema carpocpasae* @ 1.5 billion infective juveniles (IJ's) ha^{-1} (approximately 1 crore IJ's palm^{-1}) during September - October in plains and November - December in hills.

Spindle bug (*Mircarvalhoia arecae*): It is one of the major pests of arecanut palms first reported from Dakshina Kannada district of Karnataka. *Mircarvalhoia arecae* is considered as an endemic species of southern India, and are of a chronic problem in areca plantations of Kerala, Karnataka and parts of Tamil Nadu. Observation on gardens in Southern Kerala and parts of Dakshina Kannada district revealed that feeding by these bugs caused 80 per cent damage to the spindle.

Symptoms

- ✓ The nymph as well as adult suck the sap from the unopened spindle leaves. They found below the spindle leaf on the innermost leaf axils.
- ✓ While feeding, the bug injects toxic saliva, as a result linear dark brown necrotic lesions develops on spindles or leaves (Fig. 3).



Fig. 3: Spindle bug feeding on young palm and presence of necrotic lesions

- ✓ Later these necrotic regions tear off and leaving a shot hole symptoms.
- ✓ Severely infested spindle leaf fails to unfurl. Such feeding damage results in stunted growth

and reduction in yield.

- ✓ Infestation on seedlings leads to complete decay and drying of seedlings.

Management

- ✓ Regulation of shade in the garden.
- ✓ Placement of Thiamethoxam 25 WG of (2 g) in perforated poly-sachets in the inner most two leaf axils of areca palms during April- May or
- ✓ Spraying with Thiamethoxam 25 WG (0.25 g per litre water) in and around the spindle and inner whorl of leaves.

Pentatomid Bug (*Halyomorpha picus*): Recent past, pentatomid bug assumed status of serious pest and spreads extensively in major arecanut growing tracts. It is a seasonal pest occurs from February-March and continues up to July-August with a peak infestation in June depending on the availability of green nuts. The bug pierces tender nuts with long proboscis and feeding continues for several hours.

Symptoms

- ✓ Continuous feeding of nymphs and adults on developing nuts results into depletion of the most vital sap, leading to the nut shedding (Fig. 4).



Fig. 4: Pentatomid bug infestation and nut dropping from the infested palm

- ✓ The typical symptom of attack is premature shedding of nuts with pin- prick like black puncture marks.
- ✓ The severe infestation also led to blackish discolouration of kernel.

Management

- ✓ Adopt clean cultivation practices: Collection and destruction of the various stages of this insect seen on alternate hosts like cowpea, bhendi, bitter gourd, chillies *etc*, before adults shift to areca palms.
- ✓ If infestation is low, neem oil emulsion (5 ml litre^{-1} water) can be sprayed, two - times in fortnightly intervals only to the infested and surrounding palms. Care may be taken to avoid spraying of oil emulsion in freshly opened inflorescence.
- ✓ If infestation is severe spraying of Clothianidin (0.24 g lit^{-1}) or Pymetrozine (0.6 g lit^{-1}) to the developing bunches will reduce the incidence of pentatomid bug at greater extent.

Mites - Red mite (*Raoiella indica*) and white mite (*Oligonychus indicus*): Two mite species are reported so far from arecanut palm. Palms grown under the conditions of poor drainage and low organic and mineral matter are vulnerable for mite infestation. Plants cultivated with proper irrigation and shade are less prone to mite attack.



Fig. 5: Red and white mite colonies under the lower surface of leaf

Symptoms

- ✓ Both nymphs and adults colonize on the lower leaf surface and suck the sap resulting in the formation of yellow speckles or blotches which coalesce to give a bronzed appearance to the leaves (Fig. 5).
- ✓ Infestation of red mite can be easily identifying based on presence of reddish colonies of mites on lower surface of leaves.
- ✓ Reddish/pinkish stains appear after rubbing the infested leaves on fingers/palm. Infestation of white mites can be identifying based on presence of whitish webs on lower surface of leaves.
- ✓ In case of severe infestation, the leaves become yellow and dry up later (Fig. 6).



Fig. 6: Infested young seedlings with characteristic yellowing and dry up later

Management

- ✓ Provide proper irrigation.
- ✓ Cut and remove the dried leaves due to mite attack.
- ✓ Conserve predatory mites *Amblyseius channa-basavanni* and coccinellid beetle *Stethorus keralicus* which will check the population of phytophagous mites.
- ✓ Application of neem oil emulsion (5 ml litre^{-1} water) two-times in 15 days intervals
- ✓ If the infestation is less, spray Wettable sulphur @ 2 gm litre^{-1}; whereas, under severe condition Spiromecifen 22.9 SC or Propargite 57 EC @ 0.1% is recommended as an *ad hoc* measure.

Red palm weevil (*Rhynchophorus* spp.): Apart from the coconut recently, red palm weevil (RPW) emerging as a major lethal pest of the arecanut. Since 2016, several reports confirmed the incidence of RPW from healthy arecanut palms belongs to different locality.

Symptoms

- ✓ Grubs bore through the soft tissues of the stem and feeds on internal content. Hence, round circular holes can be observed on the stem of infested palms.
- ✓ Yellowing, wilting and drying of spindle and innermost leaves are the initial symptom of attack.
- ✓ If the infested palms are closely observed, bore holes with or without extruded fibrous tissues can be found in green regions of stem near to crown (Fig. 7).



Fig. 7: Presence of bored holes from Red palm weevil and stunted infested palm

- ✓ If palm is more succulent, oozing of brownish gummy exudates occurs from freshly made holes.

- ✓ Crown of the severely infested palms produces foul smell.

Management

As occurrence of RPW in arecanut is meager in isolated tracts, management measures has not been evaluated widely. Hence, the following measures practicing in coconut and other palms can be adopted on *ad hoc* basis to manage RPW infestation in arecanut.

- ✓ Strict and regular surveillance to notice the incidence of RPW in the field is utmost important for timely management.
- ✓ Avoid causing any mechanical injury to the palm as it attracts adult for oviposition.
- ✓ Periodical crown cleaning to remove dried and disease affected leaves.
- ✓ Timely treatment of bud/crown rot infected palms will help in reduction of RPW incidence
- ✓ Spray Imidacloprid 17.8 SL @ 1 ml liter^{-1} of water to the crown after phytosanitation.
- ✓ Removal and proper disposal of dead palms is of utmost importance as the pest breeds more life cycles inside such palms and will lead to spread of infestation to nearby susceptible palms.

Inflorescence caterpillar (*Tirathaba* sp.): This lepidopteran caterpillar feeds on inflorescence particularly on tender female flowers and rachillae.

Symptoms

- ✓ Webbing of rachillae with silken thread and bore holes on spathe with frass.
- ✓ Yellowing of spadices and delayed spathe opening are the associated symptoms of infestation.
- ✓ It also enters into the nut and feed all the internal content by leaving faecal pellets under favourable conditions (Fig. 8).



Fig. 8: Caterpillar feeding nuts and inflorescence by webbing rachis

Management

- ✓ Cut and burn the infested female flowers and inflorescence.
- ✓ As an Ad-hoc recommendation, open the spadices and spray Lambda cyhalothrin (0.3 ml litre^{-1} of water) OR Indoxacarb 14.5 SC @ 0.1% or Chlorantraniliprole18.5 % (1 ml litre^{-1} of water) is advised.

Ambrosia beetle (*Euplatypus parallelus*): This pest is first reported during 2018 from Karnataka, India. Since 2018 onwards it is emerging as an important insect pest of arecanut.

Symptoms

- ✓ On younger palms- Oozing of a yellowish brown resinous exudation from infested stems.
- ✓ Small, pinhead size holes can be seen after removal of the resinous exudation (Fig. 9).
- ✓ On older/stressed/diseased palms- Extrusion of sawdust frass in the form of loose, cylindrical strings.

Management: Removal of resinous exudation/ sawdust frass and injection of Chlorpyriphos 20EC

or imidacloprid 30.5 SC @ 5 ml litre^{-1} in bored holes. Cover the injected holes with wet soil to improve the efficiency of treatment.



Fig. 9: Pin head size hole and gummy exudation from the infested palm

Scale insect (*Aonidiella orientalis* and *Ischnaapsis longinostris*): These sucking insects colonize on leaves, spathe, leaf sheaths and bunches and eventually suck plant sap from the infested tissues. Though, the insect is found throughout the year, but copious population is noticed between October and February.

Symptoms

- ✓ The scale insect sucks sap from leaves, rachillae and nuts that leads to yellowing of nuts.
- ✓ Severe infestation leads to withering and shedding of nuts.

Management

- ✓ Regulation of shade in the garden.
- ✓ Conservation and augmentation of lady bird beetle, *Chilocorus nigrita*.
- ✓ Application of neem oil emulsion @ 5ml litre^{-1} of water two-times in 15 days intervals.

Agricultural Subsidies in India: Evaluating Pros and Cons

Praneeta Rathore

Introduction

Agricultural subsidies play a crucial role in the Indian economy, supporting farmers and ensuring food security. These subsidies are aimed at providing financial assistance, resources, and incentives to farmers to enhance agricultural productivity and safeguard their livelihoods. However, the system of agricultural subsidies in India has been a subject of debate, with proponents highlighting its benefits and critics pointing out its drawbacks. This article explores the pros and cons of agricultural subsidies in India.

Pros of Agricultural Subsidies

- ✓ **Financial Support to Farmers:** Agricultural subsidies provide financial aid to farmers, enabling them to purchase essential inputs such as seeds, fertilizers, pesticides, and equipment. This support helps in increasing agricultural productivity and improving yields.
- ✓ **Food Security:** Subsidies help in ensuring food security by encouraging farmers to produce essential crops. This is vital for a country like India with a large population dependent on agriculture for their sustenance.
- ✓ **Price Stability:** Agricultural subsidies can stabilize market prices for essential commodities by regulating production levels. Stable prices ensure affordability for consumers while ensuring a steady income for farmers.
- ✓ **Rural Development:** Subsidies contribute to rural development by strengthening the agricultural sector, which forms the backbone of the Indian economy. It helps in reducing poverty, creating employment opportunities, and boosting rural infrastructure.
- ✓ **Technology Adoption:** Subsidies encourage farmers to adopt modern agricultural practices and technologies. Access to better farming techniques can lead to higher crop yields, ultimately benefiting both farmers and consumers.

Cons of Agricultural Subsidies

- ✓ **Financial Burden on Government:** Providing substantial subsidies can strain the government's financial resources. The significant financial burden can affect the budget and block other important sectors requiring funding.
- ✓ **Inequitable Distribution:** Agricultural subsidies often do not reach small and marginal farmers effectively. The benefits might disproportionately favor large landholders, exacerbating income inequalities in rural areas.
- ✓ **Market Distortions:** Subsidies can distort the market dynamics by influencing production and consumption patterns. Over production of certain crops due to subsidies may lead to surplus and subsequent wastage.

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- ✓ **Environmental Degradation:** The subsidy-driven focus on certain crops might promote unsustainable agricultural practices, leading to soil degradation, water pollution, and loss of biodiversity. This can have long-term adverse effects on the environment.
- ✓ **Dependency Syndrome:** Continuous reliance on subsidies may create a dependency mindset among farmers, discouraging them from exploring alternative and more sustainable farming practices.

Conclusion

Agricultural subsidies in India are a double-edged sword, offering financial assistance and stability while also brings problems like not being fair to everyone, costing a lot, and harming the environment. Finding the right mix of helping farmers and dealing with the issues is really important for making farming better in the long run. People who make the rules need to plan well, so the good parts of giving money to farmers can be big, and the bad parts can be small. This way, farming in India can be successful and good for the Earth in the future.

Sustainable Agriculture in India: Addressing Challenges for a Greener Tomorrow

Praneeta Rathore

Introduction

Sustainable agriculture is a global imperative as we grapple with the need to feed a growing population while preserving our natural resources for future generations. In India, where agriculture is the backbone of the economy, the concept of sustainable agriculture is gaining momentum. This article talks about a type of farming that's good for the environment and future. It explains the problems this farming face in India in simple words.

What is Sustainable Agriculture?

Sustainable agriculture is an integrated approach to farming that seeks to address the ecological, economic, and social dimensions of food production while ensuring the long-term health of ecosystems. It aims to meet current food needs without compromising the ability of future generations to meet their own requirements. Sustainable agriculture is characterized by several key principles:

- ✓ **Environmental Responsibility:** It involves practices that minimize the negative impact on the environment, such as reducing the use of synthetic pesticides and fertilizers, conserving water, and protecting biodiversity.
- ✓ **Economic Viability:** Sustainable farming should be economically viable for farmers, ensuring that they earn a fair income for their produce and invest in the long-term sustainability of their farms.
- ✓ **Social Equity:** It promotes social equity by providing safe and decent working conditions for farm laborers and supporting rural communities.

Challenges for Sustainable Agriculture in India

- ✓ **Water Scarcity:** India faces acute water scarcity, and unsustainable water management practices in agriculture are a significant challenge. Overuse of groundwater, inefficient irrigation techniques, and lack of water management infrastructure jeopardize sustainability.
- ✓ **Soil Health:** Degradation of soil quality due to excessive use of chemical fertilizers and pesticides is a pressing concern. Sustainable practices like organic farming and crop rotation need wider adoption.
- ✓ **Climate Change:** Changing weather patterns, erratic rainfall, and extreme events affect crop yields and pest infestations. Adaptation to climate change through sustainable practices like drought-resistant crop varieties and agroforestry is essential.
- ✓ **Lack of Awareness:** Many farmers in India are not aware of sustainable farming practices. Promoting awareness and providing training and resources for sustainable agriculture is crucial.
- ✓ **Market Access:** Farmers often struggle to access

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fair markets for their sustainable produce. Developing sustainable supply chains and creating market incentives for eco-friendly products is vital.

- ✓ **Land Fragmentation:** Land fragmentation due to inheritance laws and population pressure makes it challenging to implement large-scale sustainable practices. Encouraging collective farming and land consolidation can help.
- ✓ **Policy Support:** Sustainable agriculture requires supportive government policies and incentives. Policymakers need to create an enabling environment through subsidies, research, and regulatory frameworks.
- ✓ **Financial Barriers:** Transitioning to sustainable agriculture can be capital-intensive. Access to affordable credit and financial assistance is crucial for small and marginal farmers.

Conclusion

Sustainable agriculture is not merely an option but a necessity for India's agricultural sector to thrive in the face of mounting environmental and socioeconomic challenges. It offers a path towards food security, economic stability, and environmental conservation. Addressing the challenges for sustainable agriculture in India requires concerted efforts from farmers, policymakers, researchers, and civil society. By adopting sustainable practices and creating an ecosystem that supports them, India can secure its agricultural future while safeguarding its environment for generations to come.

Cocoa: Scope, Production and Management of Tea Mosquito Bug

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Cocoa (*Theobroma cacao* L.: Malvaceae) is an important commercial perennial crop known for its beans to produce chocolates and it is native to South America, specifically in the region of American rainforest (Ploetz, 2007). Cocoa is widely cultivated in the humid tropical countries around the world (WCF, 2014); however, the maximum production comes from West Africa, Latin America and South East Asia. In India, cocoa is cultivated approximately 97,000 hectares and produce around 25,800 million tonnes annually (DCCD, 2022); however, maximum cocoa production is coming from Southern states of India like Karnataka, Kerala, Tamil Nadu and Andhra Pradesh (DCCD, 2022). Meanwhile, cocoa production represents an important breadwinning activity for cultivators, entrepreneurs and traders globally (Sujatha *et al*., 2018; Apshara, 2019; Voora *et al*., 2019).

The global demand for cocoa has increased from the past 15 years, leading to an expansion of cultivated area and intensification of production (WCF, 2014: Thothmihaly *et al*., 2019). However, there are several factors such as insect pests, diseases, nutrition and climatic conditions are known to influence the vitality and productivity of cocoa; Of these, insect pests are the major factor affecting cocoa production in India. More than 50 insect pests including sap suckers, defoliators, capsule and wood borers are known to affect cocoa production globally (Entwistle, 1972: Mohan *et al.*, 2022). As a commercial crop, cocoa planting materials are being dispersed to several places of the world and thus may favoring the occurrence and spread of pest and disease incidence in cocoa plantation (Mujica Mota et al. 2019: Ploetz, 2016). More often, the insect pests can adapt and feed on new host plants or closely related host species due to change in climatic conditions for survival and to meet nutritional demand for growth and development (Anim-Kwapong and Frimpong, 2008: Buxton, 2020). Therefore, integrated pest management approach is one of the imperative component in cocoa health management and which are described in this chapter.

Tea mosquito bug (*Helopeltis* spp.)

Tea mosquito bug (TMB), *Helopeltis* spp. is one of the most destructive pest on important agricultural, horticultural and plantation crops like tea, cocoa, cashew, cotton, guava, black pepper, tamarind and other crops in India. The important species of TMB are *Helopeltis theivora* Waterhouse, *H. antonii* Signoret and *H. bradyi Waterhouse* (Heteroptera: Miridae). It has been distributed and

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causing potential damage in major cropping regions of India (Sundararaju, 1996). Both nymphs and adults suck sap from young shoots, tender stems, leaves and fruits which resulting in curling up of leaves, die back from tip and reduced pod/fruit size. This pest will be active throughout the year and the population reaching a peak during pre and post monsoon season. In recent years, it has gained national and international importance, inflicting significant economic yield damage on tea (5-50%), cocoa (15-40%) and cashew (10-50%), respectively.

In recent years, TMB prevalence has increased and expanding its population in almost all parts of India. Under change in climatic conditions, it also survives on alternative hosts such as weeds during non-availability of main crops, as a result TMB population prevails throughout the year. As incidence and damage intensifies, the rate of insecticide application also enhanced and thus resulting ill effects on non-target organisms. Therefore, sustainable and eco-friendly management practices are need of the hour to reduce the TMB menace on cocoa.

Symptoms

Both nymphs and adults suck sap from the younger shoots, cherelles and pods. The injury made by the suctorial mouth parts of the insect cause exudation of a resinous gummy substance from the feeding punctures. Sucking of cell sap from plant parts resulting in the formation of black necrotic lesions. As infestation advanced, the infestation may lead to die back of shoots and scorchy appearance of garden. The incidence of TMB is positively correlated with average monthly temperature. Cherelles and younger pods are the most preferred stage for feeding as well as oviposition than shoots and mature pods. Consequently, population of TMB is highly depended on the phenological stages of cocoa *i.e.* more the younger pods in field more the TMB population.



Initial stage Later stage

Management

- ✓ Proper pruning and training is very essential to be followed for regulation of shade.
- ✓ Removal and destruction of alternate hosts like neem, cashew and guava from the surrounding regions should be practiced regularly.
- ✓ Encourage natural enemies like such as predators and parasitoids in the cocoa orchard.
- ✓ Sticky traps can be placed for effective monitoring and appropriate measures can be initiated.
- ✓ If the infestation is less, then *Beauveria bassiana* @ 4 gm litre^{-1} of water or *Metarrhizium anisopliae* @ 1 x 10^8 conidial suspension ml^{-1} or neem oil @ 3% can be recommended.
- ✓ If the infestation is persistent then repeat spray at 20 to 30 days interval.
- ✓ Under severe infestation: Spray any one of follo-

wing insecticides *viz*., Lamdacyhalothrin 5 EC (0.003%) 0.3 ml L^{-1} (or) Imidacloprid 17.8 SL (0.004%) 0.25 ml L^{-1}.

- ✓ At least one spray each during flushing, flowering and fruiting times.

References

Anim-Kwapong, G. J. and Frimpong, E. B. (2008). Vulnerability of agriculture to climate change-impact of climate change on cocoa production. Vulnerability and adaptation assessment under The Netherlands climate change studies assistance programme phase 2 (NCCSAP2). Annual ICCO Report. Cocoa Research Institute of Ghana, New Tafo Akim, (pp. 1-44).

DCCD (Directorate of Cashewnut and Cocoa Development). (2022) https://dccd.gov.in/Content.aspx?mid=1072&tid=1.

Buxton, D. N. B. (2020). Climate Change Responses of Cocoa Farmers in Ghana. International *Journal of Environment and Climate Change*, 10(8): 26-35.

Entwistle, P. F. (1972) Pests of Cocoa: Tropical Science Series; Longman Group Limited Publishing: London, UK, 1972.

Mujica Mota, M., El Makhloufi, A. and Scala, P. (2019). On the logistics of cocoa supply chain in Côte d'Ivoire: simulation-based analysis. *Computers & Industrial Engineering*, 137: 106034.

Ploetz, R. C. (2007) Cacao diseases: important threats to chocolate production worldwide. *Phytopathology*, 97: 1634-1639.

Ploetz, R. C. (2016). The impact of diseases on cacao production: a global overview. In: Bailey, B.A. & Meinhardt, L.W. (Eds.) Cacao diseases: a history of old enemies and new encounters. Cham, Switzerland: Springer, pp. 33-59.

WCF (World Cocoa Foundation). (2014). Cocoa market update, April 1, 2014. http://www.worldcocoafoundation.org/wp-content/uploads/Cocoa-Market-Update-as-of-4-12014.pdf. Accessed 23 October 2017

Tothmihaly, A., Ingram, V. and Von Cramon-Taubadel, S. (2019). How can the environmental efficiency of Indonesian cocoa farms be increased? *Ecological Economics*, 158: 134-145.

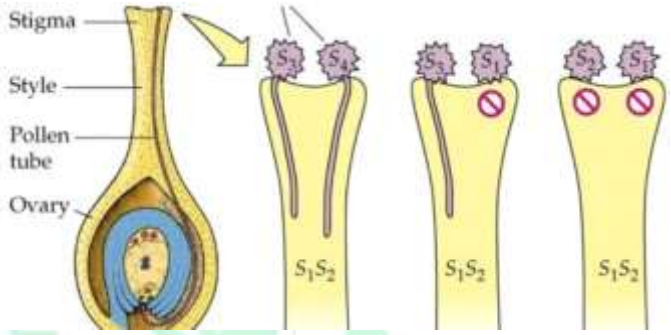
Unveiling Nature's Strategy: Self-Incompatibility in Fruit Crops and It's Impact on Genetic Diversity and Crop Productivity

Brijesh Patel, Abhishek Sonkar, Aman Kumar Maurya and Niharika Gurudev

Introduction

Self-incompatibility (SI) is a fascinating genetic mechanism that plays a crucial role in the reproductive biology of various fruit crops. This evolutionary strategy is a natural barrier against self-fertilization, preventing plants from mating with their pollen. Two main types of self-incompatibility exist gametophytic self-incompatibility (GSI) and sporophytic self-incompatibility (SSI). In GSI, compatibility is determined by the genotype of the pollen, with specific S-alleles influencing the success or failure of fertilization. On the other hand, SSI relies on the genotype of the plant itself to dictate compatibility. Many fruit crops, including apples, pears, cherries, and plums, employ self-incompatibility mechanisms. These mechanisms are essential for maintaining genetic diversity within populations, promoting the production of healthier and more resilient offspring. In commercial orchards, understanding and managing self-incompatibility is critical for ensuring successful pollination, fruit set, and overall crop productivity. Growers employ various strategies, such as planting compatible varieties and providing suitable pollinators, to harness the benefits of self-incompatibility in fruit crop cultivation.





Self-incompatibility is a genetic mechanism that prevents self-fertilization in plants, including many fruit crops. This mechanism ensures that a plant cannot fertilize its own ovules with its own pollen, promoting genetic diversity and healthier offspring. There are two main types of self-incompatibility: gametophytic self-incompatibility (GSI) and sporophytic self-incompatibility (SSI).

Gametophytic Self-Incompatibility (GSI)

- ✓ In GSI, the compatibility determination is based on the genotype of the pollen (male gametophyte).
- ✓ Each plant has a specific set of alleles that determines its compatibility with other plants.

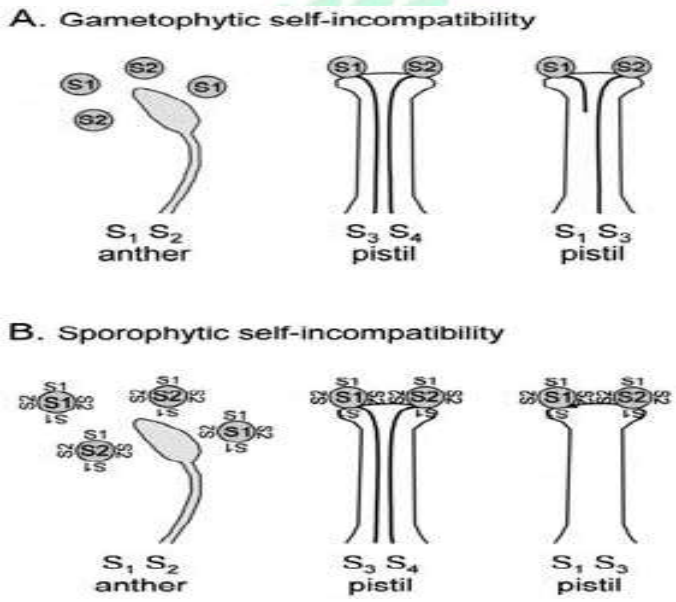
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These alleles are usually referred to as S-alleles.

- ✓ Pollen carrying the same S-allele as the pistil (female reproductive organ) is rejected, preventing self-fertilization.

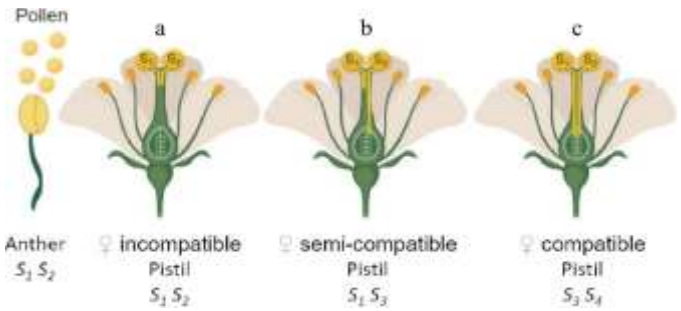
Sporophytic Self-Incompatibility (SSI)

- ✓ In SSI, the genotype of the plant (sporophyte) itself determines compatibility.
- ✓ The plant carries specific alleles that influence the acceptance or rejection of pollen.
- ✓ Pollen from plants with the same S-allele as the pistil is rejected.

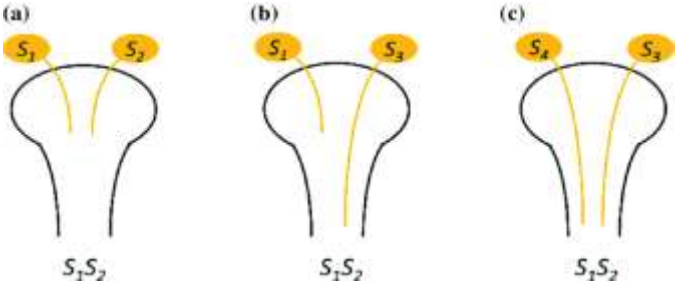


Examples of Fruit Crops

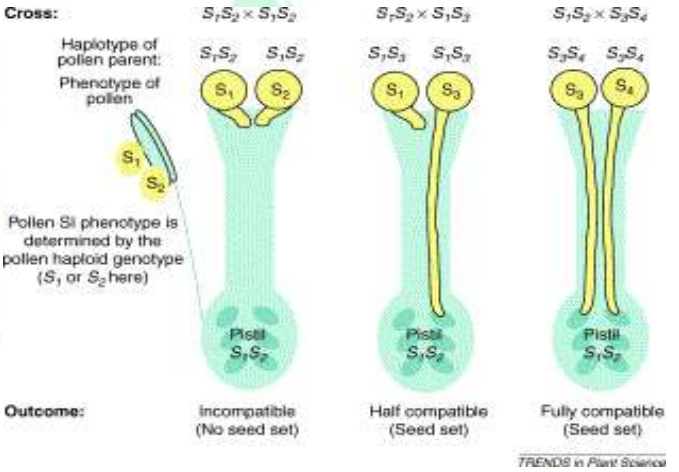
Apple (*Malus domestica*): Many apple varieties exhibit self-incompatibility. Cross-pollination with a different apple variety is required for the fruit set.



Pear (*Pyrus spp.*): Pears often have a high degree of self-incompatibility and different cultivars are planted together to facilitate cross-pollination.



Cherry (*Prunus avium, Prunus cerasus*): Both sweet and sour cherry trees may have self-incompatibility mechanisms, necessitating the planting of compatible varieties for good fruit production.



Plum (*Prunus domestica*): Self-incompatibility is present in some plum varieties, promoting cross-pollination.

Advantages of Self-Incompatibility

- ✓ **Genetic Diversity:** Prevents inbreeding, promoting genetic diversity within the population.
- ✓ **Healthier Offspring:** Cross-pollination often results in healthier and more vigorous offspring.
- ✓ **Evolutionary Advantage:** Offers an evolutionary advantage by reducing the risk of susceptibility to diseases or environmental changes.

Conclusion

Self-incompatibility is a pivotal and sophisticated genetic mechanism in the reproductive strategy of numerous fruit crops. The intricate dance between S-alleles and the compatibility of pollen and pistil highlights nature's ingenuity in fostering genetic diversity and healthier plant generations. As we navigate the complexities of modern agriculture, recognizing and leveraging self-incompatibility becomes imperative for sustainable fruit production. The advantages of preventing self-fertilization, such as resilience to diseases and environmental changes, underscore the evolutionary wisdom inherent in this mechanism. Moving forward, a continued understanding of the genetic intricacies of self-incompatibility, coupled with thoughtful cultivation practices will empower growers to optimize pollination, ensure robust fruit set, and ultimately secure the vitality of fruit crop ecosystems. Self-incompatibility thus not only enriches the biological tapestry of these crops but also serves as a testament to the elegance and effectiveness of nature's reproductive strategies.

References

Dogra, K., Kour, K., Kumar, R., Bakshi, P. and Kumar, V. (2018). Graft-incompatibility in horticultural crops. *International Journal of Current Microbiology and Applied Sciences*, 7: 1805-1820.

Adhikari, P. B., Xu, Q. and Notaguchi, M. (2022). Compatible graft establishment in fruit trees and its potential markers. *Agronomy*, 12(8): 1981.

Porika, H. K., Nimbolkar, P. K., Rajashekar, B. and Hussain, S. F. (2016). Graft compatibility-incompatibility in fruit crops: mechanism and determination techniques. *Asian Journal of Horticulture*, 11(1): 252-260.

Jain, S., Maurya, P., Jain, S., Kumar, V., Kiran, B., Subhasmita, S. and Kothiyal, K. (2023). Incompatibility Systems in Fruit Crops: Applications and Achievements. *International Journal of Environment and Climate Change*, 13(9): 2653-2663.

Empowering Growth: The Pivotal Role of Women in Agricultural Economics

Abhishek Singh, Anushi and Ashwani Kumar Singh

Abstract

This article titled "Empowering Growth: The Pivotal Role of Women in Agricultural Economics" delves into the transformative contributions of women within the agricultural sector. Recognizing their multifaceted roles as farmers, entrepreneurs, and community leaders, the article explores the challenges and opportunities women encounter in agriculture. Through an in-depth analysis, it highlights their influence on decision-making, entrepreneurship, sustainable practices, and community development. By examining successful initiatives and evaluating existing policies, the article advocates for the economic empowerment of women in agriculture as a strategic imperative for sustainable and inclusive sectoral growth. The findings underscore the need for continued efforts to address gender disparities and unlock the untapped potential of women in shaping agricultural economies worldwide.

Introduction

Empowering Growth: The Pivotal Role of Women in Agricultural Economics is a concept that encapsulates the profound impact of women's involvement in various facets of the agricultural sector. It goes beyond mere inclusion, emphasizing the transformative influence of women as decision-makers, entrepreneurs, and contributors to sustainable agricultural practices. In this context, empowering growth refers to creating an environment where women in agriculture are provided with equal opportunities, resources, and support to not only participate actively but also lead and innovate. It recognizes the economic significance of women-led initiatives, acknow-ledging their crucial role in shaping the trajectory of agricultural economies. This paradigm shift involves overcoming challenges such as limited access to resources and gender-based disparities, aiming to foster an inclusive and equitable agricultural landscape. The empowerment of women in agricultural economics is not just a matter of gender equality; it is a strategic imperative for unlocking the full potential of the sector and ensuring its long-term sustainability and prosperity.



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Overview of the historical context of women in agriculture

In tracing the historical context of women in agriculture, it becomes evident that their contributions have been intrinsic to the foundation and evolution of agricultural practices throughout the ages. Traditionally, women have played vital roles in the cultivation of crops, livestock management, and sustaining rural economies. However, historical narratives often overshadowed their contributions, and societal norms relegated many women to the background, minimizing their visibility and recognition. Over time, shifts in societal attitudes and economic demands have gradually brought to light the indispensable role women have played in shaping agricultural landscapes. From being the backbone of family farms to assuming roles as innovators and leaders, women have defied historical constraints to contribute significantly to agricultural development. Understanding this historical context is pivotal in appreciating the ongoing efforts to empower women in agriculture and recognizing their potential to lead transformative changes in the sector.

Significance of women's roles in shaping agricultural economies

The significance of women's roles in shaping agricultural economies cannot be overstated, as their contributions permeate every aspect of the sector. Historically, women have been the driving force behind food production, playing key roles in planting, harvesting, and processing crops. Their involvement extends beyond traditional farming tasks; women often serve as decision-makers in households, influencing choices related to crop selection, resource allocation, and agricultural strategies. Moreover, as active participants in agribusiness and entrepreneurship, women contribute significantly to economic growth by managing farms, engaging in value-added production, and fostering rural development. In many regions, women serve as custodians of indigenous agricultural knowledge, preserving traditional practices that are integral to sustainable and resilient farming. The diversification of the agricultural workforce through the inclusion of women brings unique perspectives, fostering innovation and adaptability. Women's involvement in sustainable agriculture practices, such as organic farming and agroecology, highlights their commitment to environmental stewardship.

Recognizing and empowering women in agriculture not only promotes gender equality but also leads to increased productivity, improved food security, and enhanced community well-being. Investments in education, training, and access to resources for women in agriculture amplify their impact, contributing to more resilient and prosperous agricultural economies. As the world faces evolving challenges, the significance of women's roles in agriculture becomes increasingly evident, emphasizing the need for continued support and recognition to harness their full potential in shaping the future of agricultural economies.

Farmers and Decision-Makers

The role of women as farmers and decision-makers is a critical aspect of agricultural economies that has undergone a transformative shift. Traditionally, women have been integral to the agricultural workforce, actively engaging in planting, harvesting, and managing livestock. However, their roles were often confined to the operational aspects of farming. In recent decades, there has been a noticeable evolution in this paradigm, with women assuming more prominent roles as decision-makers within farming households. Women now play a pivotal role in shaping key agricultural decisions, influencing choices related to crop selection, resource allocation, and overall agricultural strategies. This shift is driven by factors such as changing social dynamics, improved access to education, and the recognition of women's capabilities in driving agricultural productivity. As primary caregivers and managers of household resources, women contribute significantly to the resilience and sustainability of farming practices. The empowerment of women as decision-makers in agriculture is not only a matter of gender equality but also a pragmatic strategy for enhancing overall farm management and productivity. Studies indicate that farms where women actively participate in decision-making processes tend to be more diverse, adaptive, and economically successful. Recognizing and fostering the leadership roles of women in agriculture is crucial for unlocking the sector's full potential and ensuring a more inclusive and equitable future for rural economies. Policy-makers, agricultural organizations, and communities need to continue promoting initiatives that support and empower women as farmers and decision-makers, creating an environment where their contributions are valued and leveraged for the benefit of agricultural economies globally.

Analysis of the influence of women on crop choices, resource allocation, and long-term agricultural strategies

The influence of women on crop choices, resource allocation, and long-term agricultural strategies is a nuanced and increasingly recognized dimension in the agricultural landscape. Historically, women have been actively engaged in the cultivation of crops, but their role in decision-making processes related to agriculture was often underestimated. However, contemporary agricultural research and development initiatives are shedding light on the substantial impact that women have on shaping the trajectory of farming practices.

- ✓ **Crop Choices:** Women often exhibit a keen understanding of local ecological conditions and household needs, influencing decisions related to crop selection. Their choices may prioritize crops that fulfil nutritional requirements for the family or are well-suited to the local climate. Additionally, women may emphasize crops with market demand, contributing to the economic sustainability of the household.
- ✓ **Resource Allocation:** In many farming households, women play a central role in managing resources, including land, water, and labour. Their influence extends to decisions regarding

the allocation of these resources for various crops. This may involve optimizing land use for diverse crops, ensuring water-efficient farming practices, and managing labour resources effectively to enhance overall productivity.

- ✓ **Long-Term Agricultural Strategies:** Women contribute significantly to the formulation of long-term agricultural strategies that encompass sustainability and resilience. Their knowledge of traditional farming practices and commitment to environmental stewardship often guide decisions aimed at maintaining soil health, minimizing chemical inputs, and adopting agro ecological approaches. Moreover, women may focus on diversifying agricultural activities to enhance income generation and reduce risks associated with crop-specific challenges.

The analysis of the influence of women on these aspects is crucial for designing inclusive agricultural policies and programs. Recognizing and valuing women's contributions in decision-making processes can lead to more holistic and effective strategies for sustainable agriculture. Additionally, empowering women with access to education, resources, and technologies further enhances their ability to contribute meaningfully to crop choices, resource allocation, and the formulation of long-term agricultural strategies, ultimately benefiting both individual farming households and the broader agricultural sector.

Case studies and success stories illustrating women's leadership in agriculture

- ✓ **The Green Revolution in Bangladesh:** In Bangladesh, the Green Revolution witnessed the emergence of women like Fazilatun Nessa Indira. She successfully led initiatives to promote sustainable farming practices, emphasizing organic methods and reducing reliance on chemical inputs. Her efforts not only improved crop yields but also enhanced the economic well-being of local communities. Indira's leadership showcases how women can drive transformative changes in agriculture by prioritizing sustainable and environmentally friendly practices.
- ✓ **Kenyan Women in Horticulture:** The horticulture sector in Kenya has seen the rise of women leaders such as Mary Nkatha. As the founder of a successful flower and vegetable farm, Nkatha has not only demonstrated business acumen but has also empowered other women in her community by providing employment opportunities. Her story exemplifies how women can spearhead entrepreneurial ventures in agriculture, contributing to economic growth and community development.
- ✓ **Community-Based Agriculture in India:** In India, the Self Help Groups (SHGs) model has empowered women like Rajkumari Devi from Bihar. Through her leadership in an SHG, Rajkumari Devi mobilized women to collectively engage in agriculture, pooling resources and sharing knowledge. This cooperative approach resulted in increased agricultural productivity and improved socio-economic conditions for the

participating women. Rajkumari Devi's success underscores the potential of community-based models led by women in enhancing agricultural outcomes.

- ✓ **Women in Agribusiness in Nigeria:** Nigeria has seen notable women leaders like Ndidi Nwuneli, who founded an agribusiness enterprise focused on value addition in the agricultural supply chain. Through her initiatives, Nwuneli has empowered local farmers, especially women, by creating market linkages and promoting agribusiness entrepreneurship. Her story exemplifies how women can drive economic growth in agriculture by bridging the gap between farmers and markets.
- ✓ **Permaculture Practices in Costa Rica:** Costa Rica boasts women leaders like Karen Retana, who have pioneered permaculture practices. Karen's initiatives focus on regenerative agriculture, emphasizing the importance of biodiversity and soil health. Her success in implementing permaculture principles has not only led to increased farm productivity but also highlighted the role women can play in championing holistic and sustainable agricultural practices.

Entrepreneurship and Agribusiness

The realm of entrepreneurship and agribusiness has witnessed a remarkable surge in the participation of women, showcasing their aptitude for innovation, management, and economic leadership within the agricultural sector. Here are a few illustrative examples:

- ✓ **Sara Menker - Gro Intelligence (Kenya):** Sara Menker, a Kenyan entrepreneur, founded Gro Intelligence, an agtech company that leverages data analytics to provide insights into global agricultural markets. Menker's entrepreneurial journey exemplifies how women are breaking barriers in traditionally male-dominated fields. Her work not only contributes to agribusiness development but also demonstrates the potential for women to excel as leaders in the agtech industry.
- ✓ **Rural Women in Agribusiness - Rwanda:** In Rwanda, organizations like the Rwanda Women's Network (RWN) have been instrumental in empowering rural women to engage in agribusiness. Through various initiatives, including training programs and access to microfinance, women entrepreneurs in Rwanda have successfully established and managed agribusinesses, ranging from poultry farming to horticulture. These ventures not only enhance local economies but also empower women economically and socially.
- ✓ **Isatou Ceesay - Women's Horticultural Cooperative (Gambia):** Isatou Ceesay is the founder of the Women's Horticultural Cooperative in Gambia. Through this cooperative, women are engaged in agribusiness activities, particularly horticulture. Isatou's leadership has not only provided economic opportunities for women in rural Gambia but has

also contributed to community development. The cooperative's success showcases the potential of women-led agribusinesses to drive sustainable development in African communities.

- ✓ **Chetana Gala Sinha - Mann Deshi Bank (India):** Chetana Gala Sinha is the founder of Mann Deshi Bank in India, which focuses on empowering rural women through financial inclusion. Beyond traditional banking services, the institution supports women entrepreneurs in agribusiness by providing loans and training programs. Sinha's initiative has catalyzed the growth of women-led agribusinesses in rural India, showcasing the transformative potential of financial empowerment.
- ✓ **Women in Coffee - Latin America:** In coffee-producing regions of Latin America, women have been actively involved in agribusiness as coffee producers, processors, and exporters. Initiatives like the International Women's Coffee Alliance (IWCA) have been instrumental in supporting and connecting women entrepreneurs in the coffee industry. These women-led agribusinesses contribute not only to the economic viability of the coffee sector but also to gender equality in the traditionally male-dominated coffee supply chain.



Challenges Faced by Women in Agriculture

While women contribute significantly to agriculture, they often encounter numerous challenges that hinder their full and equitable participation in the sector. These challenges vary across regions and contexts, but some common issues include:

- ✓ **Limited Access to Land:** In many cultures, women face restrictions in land ownership and tenure rights. Limited access to land impedes their ability to engage in long-term agricultural planning and hampers their economic independence.
- ✓ **Unequal Access to Resources:** Women often have restricted access to essential resources such as credit, seeds, fertilizers, and modern agricultural technologies. This limits their capacity to adopt more efficient and sustainable farming practices.
- ✓ **Lack of Education and Training:** Insufficient access to education and training opportunities is a significant challenge for women in agriculture. Lack of knowledge about modern farming techniques and technologies hinders their ability to enhance productivity and adapt to changing agricultural practices.
- ✓ **Gender-Based Discrimination:** Gender bias and discrimination persist in various agricultural settings. This includes disparities in wages, access to extension services, and participation in decision-making processes. Such discrimination undermines the overall contribution of women to the agricultural sector.

- ✓ **Limited Market Access:** Women often face barriers in accessing markets for their agricultural produce. This can be due to inadequate transportation infrastructure, lack of market information, or exclusion from decision-making in agricultural cooperatives and value chains.
- ✓ **Time and Labour Constraints:** Women typically shoulder multiple responsibilities, including household chores and caregiving. Balancing these responsibilities with farm work poses a challenge, impacting the time and labor they can dedicate to agriculture.
- ✓ **Climate Change Vulnerability:** Women are disproportionately affected by the impacts of climate change, as they often lack the resources and adaptive capacities to cope with extreme weather events. Changes in weather patterns can lead to reduced crop yields, affecting food security and livelihoods.
- ✓ **Limited Access to Financial Services:** Access to credit and financial services is a critical barrier for women in agriculture. Without adequate financial support, women face challenges in investing in farm inputs, equipment, and other essential resources.
- ✓ **Inadequate Representation in Decision-Making:** Women are often underrepresented in agricultural decision-making bodies and institutions. This lack of representation diminishes their influence over policies and programs that directly impact their roles in agriculture.
- ✓ **Health and Safety Concerns:** Women engaged in agriculture may face health and safety risks, particularly when working with certain agro-chemicals or heavy machinery. The lack of protective measures and awareness further exacerbates these concerns.

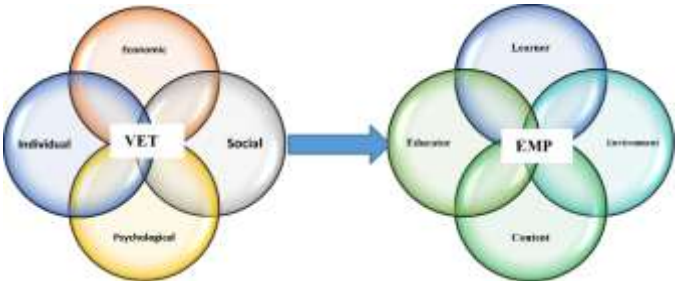
Community Development and Social Impact

The engagement of women in agriculture often extends beyond individual farm activities, influencing broader community development and generating positive social impact. Here are key aspects of how women contribute to community development and social impact within the agricultural context:

- ✓ **Empowering Rural Communities:** Women in agriculture often spearhead initiatives that empower entire rural communities. Through cooperative farming, self-help groups, and community-based organizations, women create platforms for collective decision-making, resource-sharing, and collaborative problem-solving, fostering overall community development.
- ✓ **Enhancing Food Security:** The active involvement of women in agricultural activities contributes significantly to food security. By diversifying crops, promoting sustainable farming practices, and ensuring efficient resource management, women play a crucial role in providing nutritious food for their families and communities, ultimately improving overall health and well-being.
- ✓ **Education and Skill Development:** Women

engaged in agriculture often take the lead in promoting education and skill development within their communities. Through awareness programs and training initiatives, they empower others with knowledge of modern agricultural techniques, environmental conservation, and diversified income-generating activities, fostering a culture of continuous learning.

- ✓ **Healthcare Initiatives:** Women in agriculture frequently champion healthcare initiatives within their communities. They may organize health camps, promote sanitation practices, and raise awareness about prevalent health issues. By addressing health challenges, women contribute to a healthier and more productive community.
- ✓ **Infrastructure Development:** Women-led agricultural activities can drive demand for improved infrastructure in rural areas. Access to better roads, irrigation systems, and storage facilities not only benefits individual farms but also stimulates economic growth and connectivity within the community.
- ✓ **Cultural Preservation:** Women often play a role in preserving and promoting cultural practices within agricultural communities. Traditional knowledge, rituals, and indigenous farming techniques are passed down through generations by women, contributing to the cultural richness and identity of the community.
- ✓ **Social Cohesion and Networking:** Women in agriculture foster social cohesion by creating networks and support systems. This sense of community helps in times of crises, encourages collaboration, and enables the sharing of resources and information, leading to a more resilient and connected community.
- ✓ **Youth Engagement:** Women engaged in agriculture often serve as role models for the younger generation. Their involvement inspires and encourages youth to pursue agricultural activities, contributing to the continuity of farming traditions and ensuring the transfer of knowledge across generations.
- ✓ **Entrepreneurship and Economic Growth:** Women-led agribusinesses stimulate economic growth within communities. By establishing value-added enterprises, women contribute to local economies, create job opportunities, and enhance the overall economic well-being of the community.
- ✓ **Environmental Conservation:** Women in agriculture often champion sustainable and eco-friendly farming practices. Their efforts contribute to environmental conservation by promoting biodiversity, reducing chemical inputs, and adopting agroecological approaches that benefit both the local ecosystem and the community.



Government Policies and Support

Government policies and support play a

crucial role in shaping the opportunities and challenges faced by women in agriculture. Here are key considerations regarding government policies and the support needed to empower women in this sector:

- ✓ **Land Ownership and Tenure Rights:** Governments can enact policies that address gender disparities in land ownership and tenure. Ensuring equal access to land for women in agriculture, either through legal reforms or targeted programs, is essential for fostering economic independence and sustainable farming practices.
- ✓ **Financial Inclusion:** Implementing policies that facilitate women's access to credit, microfinance, and other financial services is vital. Government-backed initiatives can provide tailored financial support, enabling women to invest in farm inputs, equipment, and agribusiness ventures.
- ✓ **Education and Training:** Governments can promote education and training programs focused on building the agricultural skills of women. By investing in agricultural extension services and training opportunities, policymakers can empower women with the knowledge needed to adopt modern farming techniques and technologies.
- ✓ **Market Access and Value Chains:** Supportive policies should aim at integrating women into agricultural value chains. This involves creating market linkages, establishing fair pricing mechanisms, and ensuring that women have equitable access to markets for their agricultural produce.
- ✓ **Gender-Responsive Extension Services:** Governments can develop and implement gender-responsive agricultural extension services. Tailored programs that address the specific needs and challenges faced by women in agriculture can enhance their capacity to make informed decisions and improve productivity.
- ✓ **Technology Adoption:** Policies encouraging the adoption of agricultural technologies that benefit women can have a transformative impact. This includes promoting the use of precision farming, mobile applications, and other innovations that enhance efficiency and sustainability in agriculture.
- ✓ **Legal Protections and Rights:** Legislation that safeguards the rights of women in agriculture is essential. Governments can enact and enforce laws that protect women from discrimination, ensure equal pay, and address issues related to inheritance and property rights.
- ✓ **Childcare Support:** Recognizing the dual roles of women as caregivers and farmers, governments can implement policies that provide childcare support. Accessible and affordable childcare services enable women to allocate more time and energy to agricultural activities.
- ✓ **Health and Safety Measures:** Implementing and enforcing health and safety regulations in agriculture is crucial. Policies that prioritize the well-being of women engaged in farming, including protection from exposure to harmful agrochemicals, contribute to a safer working env-

ironment.

- ✓ **Representation in Decision-Making:** Governments can encourage the active participation of women in agricultural decision-making bodies and institutions. Promoting gender diversity in policy formulation ensures that the unique perspectives and needs of women are taken into account.

Conclusion

In conclusion, recognizing and empowering women in agricultural economics is not merely a pursuit of gender equality but a strategic imperative for fostering sustainable and inclusive economic growth. The multifaceted roles of women, from decision-makers and entrepreneurs to agents of community development, underscore their indispensable contributions to the agricultural sector. Despite the challenges they face, women in agriculture exemplify resilience, innovation, and a commitment to sustainable practices. It is imperative for policymakers, agricultural institutions, and communities to actively support and implement policies that address gender disparities, ensure equitable access to resources, and promote women's participation in decision-making processes. By unlocking the full potential of women in agriculture, we not only enhance the sector's productivity and resilience but also contribute to the overall well-being of rural communities and global food security. As we strive for a more equitable future, valuing and investing in the empowerment of women in agricultural economics will remain pivotal for a thriving and sustainable agricultural landscape.

References

Mehra, R. (1997). Women, empowerment, and economic development. *The Annals of the American Academy of Political and Social Science*, 554(1): 136-149.

Adefare, T., Adeola, O., Mogaji, E., Nguyen, N. P. and Mogaji, S. A. (2024). Empowering women agriculture entrepreneurs: banks' role in achieving sustainable development goals. *International Journal of Bank Marketing*.

Sraboni, E., Malapit, H. J., Quisumbing, A. R. and Ahmed, A. U. (2014). Women's empowerment in agriculture: What role for food security in Bangladesh?. *World Development*, 61: 11-52.

Duflo, E. (2012). Women empowerment and economic development. *Journal of Economic Literature*, 50(4): 1051-1079.

Sharma, A., Dua, S. and Hatwal, V. (2012). Micro enterprise development and rural women entrepreneurship: way for economic empowerment. Arth Prabhand: *A Journal of Economics and Management*, 1(6): 114-127.

Boserup, E., Kanji, N., Tan, S. F. and Toulmin, C. (2013). Woman's role in economic development. Routledge.

The Palatable Paradigm: Unravelling the Rich Tapestry of Pasta

Shubham Gangwar

Pasta a culinary marvel that has captivated taste buds worldwide for centuries. From the bustling streets of Rome to the cozy trattorias of Tuscany, pasta embodies the essence of Italian cuisine and has transcended borders to become a beloved staple in kitchens across the globe. But behind its simple facade lies a complex history, a myriad of shapes, textures, and flavors, and a cultural significance that extends far beyond the dinner table. Join us on a journey as we delve deep into the world of pasta, uncovering its origins, evolution, and enduring allure.



Origins and Evolution: The story of pasta traces back thousands of years to ancient civilizations such as the Etruscans and Greeks, who crafted rudimentary versions of pasta by mixing water and flour into dough. However, it was the Italians who perfected the art of pasta-making, transforming it into the culinary masterpiece we know today. Historical records indicate that pasta gained widespread popularity in Italy during the Middle Ages, with dried pasta emerging as a convenient and durable foodstuff favored by sailors, soldiers, and travelers. One of the most iconic moments in pasta history occurred in the 13th century when Marco Polo purportedly introduced pasta to Italy upon his return from China. While the veracity of this claim remains a subject of debate among historians, there is no denying the profound impact that pasta had on Italian cuisine and culture in the ensuing centuries.

Over time, pasta evolved from a humble peasant dish to a symbol of Italian identity and gastronomic excellence. Regional variations emerged, each boasting its own unique shapes, sauces, and preparations. From the long, slender strands of spaghetti in Naples to the tube-shaped rigatoni of Sicily, the diversity of pasta reflects the rich tapestry of Italian culinary heritage.

Types of Pasta: The world of pasta is vast and diverse, encompassing hundreds of shapes, sizes, and textures. While some varieties are well-known staples like spaghetti and penne, others are more obscure, offering a tantalizing glimpse into the boundless creativity of Italian pasta artisans.

Long Pasta

- ✓ **Spaghetti:** Perhaps the most famous pasta shape, spaghetti consists of long, thin strands that are perfect for twirling around a fork.
- ✓ **Linguine:** Similar to spaghetti but slightly wider, linguine pairs beautifully with seafood-based sauces.
- ✓ **Fettuccine:** Ribbon-like strands of pasta that are ideal for rich and creamy sauces like Alfredo.

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Short Pasta

- ✓ **Penne:** Short, tube-shaped pasta with angled ends, penne is versatile and pairs well with a wide range of sauces.
- ✓ **Fusilli:** Corkscrew-shaped pasta that holds sauce exceptionally well, making it a favorite for pasta salads and baked dishes.
- ✓ **Farfalle:** Also known as bowtie or butterfly pasta, farfalle's whimsical shape adds visual appeal to any dish.

Stuffed Pasta

- ✓ **Ravioli:** Small pockets of pasta dough filled with savory fillings such as cheese, meat, or vegetables, ravioli is a true comfort food classic.
- ✓ **Tortellini:** Ring-shaped pasta filled with a mixture of meat, cheese, or both, tortellini is a beloved specialty of the Emilia-Romagna region.
- ✓ **Cannelloni:** Large pasta tubes typically stuffed with a ricotta and spinach filling, cannelloni is often baked with tomato sauce and cheese for a hearty meal.

Speciality Pasta

- ✓ **Orzo:** Resembling grains of rice, orzo is a versatile pasta shape that is commonly used in soups, salads, and pilafs.
- ✓ **Cavatappi:** Spiral-shaped pasta with ridges that capture sauce, cavatappi is perfect for hearty baked dishes and casseroles.
- ✓ **Orecchiette:** Translating to "little ears" in Italian, orecchiette's concave shape makes it ideal for trapping chunky sauces and ingredients.

The Art of Pasta-Making: At its core, pasta-making is a deceptively simple process that requires just a few basic ingredients: flour, water, and sometimes eggs. Yet, within this seemingly straightforward framework lies a world of nuance and skill. The quality of the ingredients, the precise ratio of flour to water, and the technique used to knead and shape the dough all play a crucial role in determining the final outcome.

Once the dough is prepared, it is time to shape the pasta. This step requires precision and dexterity, as each pasta shape has its own distinct method of formation. From the intricate folds of tortellini to the effortless twirl of spaghetti, mastering the art of pasta-making is a labor of love that pays homage to centuries of culinary tradition. After shaping, the pasta is left to dry, either naturally or through a mechanical drying process, which helps preserve its texture and flavor. Once dried, the pasta can be stored for extended periods, making it a convenient pantry staple for busy home cooks and professional chefs alike.

The Role of Pasta in Italian Cuisine: In Italy, pasta is more than just a meal it is a cultural institution that embodies the values of family, community, and tradition. From Sunday dinners with Nonna to festive gatherings with friends, pasta plays a central role in the fabric of Italian social life, bringing people together in celebration of food and fellowship. Italian cuisine is renowned for its emphasis on fresh, seasonal ingredients, and pasta is no exception. Whether tossed with ripe tomatoes, fragrant herbs, and extra-virgin olive oil or simmered in a rich, slow-

cooked ragù, pasta showcases the bounty of Italy's fertile land and vibrant culinary heritage.

Beyond Italy: Pasta Goes Global: While pasta may have originated in Italy, its influence knows no bounds, transcending geographical and cultural barriers to become a beloved staple in kitchens around the world. From the bustling streets of New York City to the tranquil villages of Southeast Asia, pasta has found its way into the hearts and stomachs of people from all walks of life.

The globalization of pasta has led to an explosion of creativity and innovation, with chefs and home cooks alike putting their own unique spin on classic recipes. In Japan, ramen a type of noodle soup that originated in China has become a culinary phenomenon, with shops specializing in gourmet variations of this beloved dish popping up in cities around the globe. Likewise, in India, dishes like masala pasta a fusion of Italian pasta and traditional Indian spices have gained popularity among adventurous eaters seeking new flavor experiences.

Health Considerations and Dietary Trends: While pasta is undeniably delicious, its reputation as a health-conscious choice has been subject to scrutiny in recent years. Concerns about carbohydrates, gluten, and processed ingredients have led many people to question whether pasta can fit into a balanced diet. However, when enjoyed in moderation and as part of a well-rounded meal, pasta can be a nutritious and satisfying choice. Whole-grain pasta varieties offer additional fiber and nutrients, while gluten-free options cater to those with dietary restrictions or sensitivities. Additionally, incorporating lean proteins, vegetables, and healthy fats into pasta dishes can enhance their nutritional profile and contribute to a balanced diet.

Conclusion

In conclusion, pasta is much more than just a dish it is a cultural phenomenon, a culinary canvas, and a timeless symbol of conviviality and comfort. From its humble origins in ancient civilizations to its global ubiquity in modern kitchens, pasta has captivated the hearts and palates of people around the world, uniting us in our shared love of food and fellowship. As we continue to explore the diverse and dynamic world of pasta, let us savor each moment, each bite, and each shared experience, knowing that the true essence of pasta lies not just in its taste and texture, but in the stories and traditions that it brings to life with every forkful. So let us raise our glasses or perhaps our forks and toast to the enduring legacy of pasta, a culinary treasure that has stood the test of time and continues to inspire and delight us all.

Modern Production Technology of Grapes: Enhancing Quality and Yield in Sustainable Viticulture

Anushi and Abhishek Singh

Abstract

This article, titled "Modern Production Technology of Grapes: Enhancing Quality and Yield in Sustainable Viticulture," explores the dynamic landscape of grape production technology. Focusing on both traditional practices and cutting-edge innovations, the article investigates the multifaceted components that shape the viticulture sector. Topics covered include soil management, vineyard design, irrigation techniques, pest and disease control, harvesting methods, and the integration of advanced technologies such as precision viticulture and data analytics. With a commitment to sustainability, the article seeks to unravel the complexities of grape cultivation, providing valuable insights for viticulturists, researchers, and industry stakeholders. The objective is to create a comprehensive guide that not only showcases the evolution of grape production methods but also addresses the current challenges and future prospects in this essential aspect of agricultural technology.

Introduction

Grape production holds a position of unparalleled global significance, epitomizing a versatile and economically vital facet of agriculture. The cultivation of grapes resonates across three principal domains: wine production, table grapes, and a spectrum of grape-derived products. In the realm of oenology, grapes are the quintessential raw material for crafting an extensive array of wines, contributing to a multi-billion-dollar industry with profound cultural and social implications. The appeal of table grapes transcends borders, offering a delectable and nutritious fruit for direct consumption, enriching diets around the world. Moreover, grape-derived products, from the rich sweetness of raisins to the culinary versatility of grape seed oil, further amplify the impact of grape cultivation on global food industries. The economic significance of grape production extends to employment, trade, and tourism, especially in regions renowned for their vineyards. Furthermore, grapes play a role in environmental conservation through their ability to adapt to diverse climates, supporting biodiversity and preventing soil erosion. In essence, grape production stands as a linchpin in global agriculture, intertwining cultural heritage, economic prosperity, and culinary innovation. The importance of technological advancements in grape cultivation is pivotal,



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particularly in meeting the burgeoning demand for high-quality grapes and fostering sustainable viticulture practices. Technology has emerged as a catalyst, enabling viticulturists to optimize every stage of grape production, from vineyard management to harvest. Precision viticulture, utilizing technologies such as remote sensing, GPS, and data analytics, allows for precise monitoring of vineyard conditions. This not only enhances resource efficiency but also facilitates the identification of optimal conditions for grape growth. Sustainable viticulture practices, including organic farming and reduced chemical use, have been advanced through technology by providing alternative solutions for pest control and disease management. Additionally, modern irrigation techniques, informed by technological insights, contribute to water conservation and efficiency. The integration of climate-monitoring tools aids in adapting to changing environmental conditions, ensuring vineyards are resilient in the face of climate change. In essence, technological advancements play a transformative role, not only in meeting the growing demand for high-quality grapes but also in ushering in an era of viticulture that is both economically viable and environmentally sustainable.

Historical Perspective on Grape Production

- ✓ The historical perspective on grape production unveils a rich tapestry that spans millennia, depicting the evolution of viticulture from ancient times to the sophisticated practices observed today. Grape cultivation has deep roots in various cultures, and its historical trajectory showcases the development of techniques and traditions that have shaped the viticulture landscape.
- ✓ In the cradle of civilization, ancient Mesopotamia, evidence suggests that grape cultivation and winemaking existed as early as 6000 BC. The ancient Egyptians recognized the significance of grapes and wine, attributing them to religious rituals and daily life. The Greeks, with their god Dionysus dedicated to wine, further elevated viticulture to an art form, emphasizing grape varieties and terroir.
- ✓ The Roman Empire significantly influenced the spread of grape cultivation throughout Europe, introducing advanced agricultural practices and grape varieties to regions such as Gaul (modern-day France) and Hispania (modern-day Spain). The role of grapes and wine in Roman culture was so integral that vineyards were often considered a symbol of prosperity.
- ✓ During the medieval period, monasteries took up the mantle of grape cultivation, contributing to the preservation of viticulture knowledge. The middle Ages saw the emergence of distinct wine regions, each developing its unique grape varieties and winemaking techniques.
- ✓ The Renaissance witnessed a revival of interest in science and agriculture, influencing advancements in grape cultivation. The Age of Exploration further propelled the global dissemination of grapevines, with varieties like the Mission

grape arriving in the Americas with Spanish colonizers.

- ✓ The 19th century marked a turning point with the development of modern ampelography (the study of grapevines) and the classification of grape varieties. This era also saw the devastating impact of the phylloxera epidemic, leading to the grafting of European vines onto American root-stocks to combat the pest.
- ✓ The 20th century ushered in technological innovations, with the advent of mechanized farming, chemical inputs, and controlled viticulture practices. New World regions, such as California, Australia, and South America, rose to prominence, challenging the dominance of traditional European wine-producing countries.
- ✓ Today, grape production reflects a harmonious blend of ancient traditions and cutting-edge technology. Precision viticulture, sustainable practices, and genetic advancements are reshaping the industry. The historical perspective on grape production underscores not only its economic importance but also its cultural and societal significance, illustrating how viticulture has been an integral part of human civilization, evolving through the ages.

Soil Management in Grape Production

Soil management is a critical aspect of grape production, significantly influencing vine health, grape quality, and overall vineyard sustainability. The success of grape cultivation is intricately tied to the characteristics of the soil, its composition, structure, and nutrient content. Here's an exploration of key considerations in soil management for grape production:



- ✓ **Soil Types and Composition:** Understanding the soil type is fundamental to grape production. Different grape varieties thrive in specific soil types, such as loam, sandy loam, or clay soils. Soil composition, including the balance of sand, silt, and clay, affects drainage, aeration, and nutrient availability.
- ✓ **Soil Health and Nutrient Management:** Maintaining soil health is essential for sustained grape production. Regular soil testing helps assess nutrient levels, allowing growers to adjust fertilization practices accordingly. Common nutrients crucial for grapevines include nitrogen, phosphorus, potassium, and micronutrients like zinc and iron.
- ✓ **Organic Practices and Cover Crops:** Many grape producers adopt organic practices to enhance soil fertility and reduce environmental impact. Cover crops, such as clover or grasses, are planted between rows to prevent erosion, improve soil structure, and contribute organic matter through decomposition.

- ✓ **pH Regulation:** Soil pH significantly influences nutrient availability to grapevines. The ideal pH range for grape cultivation is typically between 6.0 and 7.0. Lime may be applied to raise pH in acidic soils, while sulphur can be used to lower pH in alkaline soils.
- ✓ **Irrigation Management:** Efficient irrigation practices contribute to soil health and grape quality. Proper irrigation ensures consistent moisture levels, preventing both water stress and waterlogged conditions. Drip irrigation systems are often favoured for their precision in delivering water directly to the root zone.
- ✓ **Soil Conservation and Erosion Control:** Implementing soil conservation practices helps prevent erosion, especially on sloping vineyards. Cover crops, contour ploughing, and the use of mulch are effective measures to protect the topsoil from erosion, preserving its structure and nutrient content.
- ✓ **Organic Matter and Compost Application:** Regular incorporation of organic matter, such as compost or well-rotted manure, enhances soil structure, water retention, and microbial activity. These organic materials contribute to long-term soil fertility and support a healthy ecosystem in the vineyard.
- ✓ **Soil Moisture Monitoring:** Monitoring soil moisture levels is crucial for preventing over-irrigation or water stress. Modern technologies, including soil moisture sensors, help viticulturists assess water needs more accurately, promoting efficient water use.
- ✓ **Vineyard Floor Management:** Management of the space between vine rows, known as the vineyard floor, is vital. Ground cover crops, mulching, or using alternative ground covers contribute to weed control, prevent erosion, and enhance water retention.
- ✓ **Rootstock Selection:** The choice of rootstock influences the interaction between vines and soil. Rootstocks may be selected based on their resistance to pests, diseases, or tolerance to specific soil conditions, contributing to the overall health and longevity of the grapevines.

Vineyard Design and Layout

Vineyard design and layout are critical components of grape production, influencing everything from vine health and grape quality to overall vineyard efficiency. A well-thought-out design considers factors such as sun exposure, airflow, and accessibility for vineyard management. Here's an exploration of key considerations in vineyard design and layout:



- ✓ **Row Orientation and Vine Spacing:** The orientation of vine rows impacts sun exposure and airflow. North to south rows maximize sunlight exposure, while east to west rows can help mitigate extreme temperatures. Vine spacing is carefully determined based on the grape variety, soil type, and desired canopy density, balancing optimal sunlight penetration

and airflow.

- ✓ **Terracing and Slope Management:** In hilly or sloped vineyards, terracing helps manage water runoff and erosion while providing a more even distribution of sunlight. Terraced vineyards also facilitate easier access for vineyard workers and machinery, contributing to overall vineyard sustainability.
- ✓ **Trellis Systems:** Trellising supports the growth of grapevines, ensuring proper canopy management and sunlight exposure. Common trellis systems include vertical shoot positioning (VSP), Scott Henry, and Geneva Double Curtain (GDC). The choice depends on factors like climate, grape variety, and vineyard goals.
- ✓ **Canopy Management:** Canopy management involves controlling the growth of grapevine foliage to optimize sunlight exposure, air circulation, and grape ripening. Techniques such as shoot thinning, leaf removal, and hedging are employed based on the vineyard's specific needs.
- ✓ **End Posts and Anchoring:** Sturdy end posts and anchoring systems are essential for supporting trellis structures. These components provide stability to the vines and prevent damage from strong winds, ensuring the longevity of the vineyard infrastructure.
- ✓ **Headlands and Access Aisles:** Well-planned headlands and access aisles allow for easy navigation of vineyard machinery and facilitate efficient vineyard management tasks such as pruning, harvesting, and pest control. Adequate spacing also minimizes soil compaction.
- ✓ **Vineyard Blocks and Microclimates:** Dividing the vineyard into blocks based on factors like soil composition, elevation, or exposure allows for targeted management practices. This approach recognizes microclimates within the vineyard, enabling viticulturists to tailor cultivation techniques to specific conditions.
- ✓ **Disease Management Considerations:** Vineyard layout should account for disease management strategies. Optimal vine spacing and row orientation can enhance airflow, reducing humidity levels and minimizing conditions conducive to diseases like mildew.
- ✓ **Wildlife and Biodiversity Considerations:** Integrating biodiversity and wildlife-friendly features into vineyard design contributes to ecological balance. Hedgerows, cover crops, and bird-friendly structures can create habitats that support beneficial organisms and contribute to sustainable pest control.
- ✓ **Future Expansion and Adaptability:** Forward-thinking vineyard design considers the potential for expansion and adapts to changing circumstances. Flexibility in layout allows growers to respond to evolving market trends, technological advancements or alterations in climate conditions.

Irrigation Techniques in Grape Cultivation

Effective irrigation is a crucial aspect of grape cultivation, influencing vine growth, grape quality and overall vineyard productivity. Grapevin-

es require a consistent and well-managed water supply, and the choice of irrigation technique plays a significant role in achieving optimal results. Here's an exploration of key irrigation techniques employed in grape cultivation:

- ✓ **Drip Irrigation:** Drip irrigation is a widely used and efficient technique in grape cultivation. It involves delivering water directly to the base of each vine through a network of tubes or pipes with emitters. This method conserves water, minimizes weed growth, and provides precise control over the amount of water each vine receives. Drip irrigation is particularly beneficial in regions where water availability is a concern.
- ✓ **Surface Irrigation:** Surface irrigation methods, such as furrow or flood irrigation, involve flooding the vineyard rows with water. While cost-effective, these methods can be less water-efficient and may result in uneven water distribution. They are commonly used in flat or gently sloping vineyards where water can flow across the surface.
- ✓ **Subsurface Drip Irrigation:** Subsurface drip irrigation involves placing drip lines beneath the soil surface, delivering water directly to the root zone. This method minimizes water evaporation, reduces weed growth, and ensures a more uniform distribution of water. It is particularly suitable for vineyards with challenging surface conditions.
- ✓ **Sprinkler Irrigation:** Sprinkler systems disperse water over the vineyard in a manner similar to natural rainfall. While they provide good coverage, they can be less water-efficient due to evaporation and wind drift. Sprinkler irrigation is suitable for frost protection, and some vineyards use overhead sprinklers during critical periods.
- ✓ **Fertigation:** Fertigation involves combining irrigation with the application of fertilizers. Through this method, nutrients are delivered directly to the root zone along with water. Fertigation enhances nutrient uptake by grapevines and allows for precise control over fertilization practices.
- ✓ **Regulated Deficit Irrigation (RDI):** RDI is a strategic approach where water availability is intentionally limited during specific growth stages. This controlled stress induces moderate water deficit in vines, leading to improved grape quality and concentration. RDI is often employed to manage vine vigor and enhance wine characteristics.
- ✓ **Precision Irrigation Technologies:** Modern technologies, including soil moisture sensors and weather stations, enable precision irrigation. These tools provide real-time data on soil moisture levels and weather conditions, allowing growers to optimize irrigation schedules and conserve water resources.
- ✓ **Mulching:** Mulching involves covering the soil around grapevines with organic or synthetic materials to conserve soil moisture. Mulches reduce evaporation, suppress weed growth, and regulate soil temperature. This technique compl-

ements other irrigation methods by promoting water retention.

- ✓ **Rainwater Harvesting:** Some vineyards integrate rainwater harvesting systems to capture and store rainwater for later use in irrigation. This sustainable approach helps reduce reliance on traditional water sources.
- ✓ **Seasonal Adjustments:** Irrigation practices are often adjusted based on the grapevine's growth stages and seasonal water requirements. Tailoring irrigation schedules to meet the specific needs of vines during critical periods, such as flowering and verasion, is essential for optimizing grape quality.

Pest and Disease Control Strategies

Pest and disease control strategies are paramount in grape cultivation to safeguard vine health, ensure grape quality, and sustain vineyard productivity. Grapevines are susceptible to various pests and diseases that can compromise yields and impact wine quality. Implementing integrated and sustainable pest management practices is essential. Here's an exploration of key strategies employed in pest and disease control in grape cultivation:

- ✓ **Integrated Pest Management (IPM):** IPM is a holistic approach that combines various strategies to manage pests and diseases efficiently. It includes biological controls (predators and parasites), cultural practices (crop rotation, cover cropping), physical methods (traps, barriers), and judicious use of chemical controls. IPM aims to minimize environmental impact while maintaining effective pest and disease control.
- ✓ **Biological Controls:** Beneficial organisms such as predatory insects (ladybugs, lacewings) and parasitoids (wasps) can be introduced to control pest populations. This natural approach helps maintain a balanced ecosystem in the vineyard.
- ✓ **Cultural Practices:** Practices such as crop rotation, cover cropping, and maintaining proper spacing between vines contribute to pest and disease prevention. These practices disrupt the life cycles of pests and create an environment less favourable for the development of diseases.
- ✓ **Disease-Resistant Grape Varieties:** Planting grape varieties with inherent resistance to specific diseases reduces the reliance on chemical treatments. Breeding programs focus on developing varieties with natural resistance to common grape diseases like powdery mildew and downy mildew.
- ✓ **Monitoring and Early Detection:** Regular scouting and monitoring of vineyards for signs of pests and diseases allow for early detection. Early intervention is crucial in preventing the rapid spread of infestations. Employing technology such as pheromone traps and disease monitoring tools enhances detection accuracy.
- ✓ **Chemical Controls:** Judicious use of pesticides, fungicides, and herbicides is part of a comprehensive pest and disease management strategy. It is essential to select products that target specific pests or diseases while minimizing the impact on beneficial organisms and the environment.

- ✓ **Copper and Sulphur Sprays:** Copper and sulfur-based sprays are traditional fungicides used in organic grape cultivation. They are effective against fungal diseases like downy mildew and powdery mildew. However, their use requires careful consideration to prevent potential negative effects on soil health.
- ✓ **Resistant Rootstocks:** Some grape varieties are grafted onto rootstocks that are resistant to soil-borne pests such as nematodes. This strategy helps protect the vine's root system from damage.
- ✓ **Cultural Controls for Insects:** Practices like pheromone disruption and the use of insect traps can help control populations of specific insect pests. By disrupting mating patterns and capturing insects, these methods reduce the need for chemical interventions.
- ✓ **Genetic Modification (GM):** Ongoing research explores the development of genetically modified grapevines with enhanced resistance to pests and diseases. While controversial, this approach holds potential for creating more resilient grape varieties.
- ✓ **Quarantine Measures:** Implementing quarantine measures can prevent the introduction and spread of pests and diseases. This is especially crucial in regions with strict regulations to protect against invasive species.
- ✓ **Education and Outreach:** Educating vineyard managers, workers, and the community about best practices in pest and disease management fosters awareness and compliance with recommended strategies. Outreach programs help disseminate information and encourage sustainable practices.

Harvesting and Post-Harvest Practices

Harvesting and post-harvest practices are pivotal stages in grape cultivation, marking the culmination of meticulous vineyard management efforts and the onset of the winemaking process. The timing of the harvest is a critical decision, balancing factors such as grape ripeness, sugar levels, acidity, and flavour development. In traditional vineyards, hand harvesting remains a common practice, allowing skilled workers to selectively pick grapes at their optimal maturity. Modern vineyards may employ mechanized harvesters for efficiency. Post-harvest, grapes undergo a series of meticulous practices to preserve their quality. Sorting tables are often used to remove any under ripe or damaged grapes before they enter the winery. For white wine production, grapes are typically destemmed and crushed before pressing, while red wine grapes may undergo fermentation with skins to extract colour and tannins. Post-harvest activities extend to barrel aging, malolactic fermentation, and eventual bottling. Each step in harvesting and post-harvest practices is a delicate dance between preserving the integrity of the grape and unlocking the potential for exceptional wines. The decisions made during these stages profoundly influence the flavour profiles and characteristics of the final product, underscoring the importance of skilled craftsmanship in the art of winemaking.

Mechanized vs. hand harvesting methods and their impact on grape quality

The choice between mechanized and hand harvesting methods in grape cultivation is a nuanced decision that significantly influences grape quality and the subsequent winemaking process. Mechanized harvesting, involving the use of specialized machines equipped with grape harvesters, has gained popularity for its efficiency and cost-effectiveness. Mechanized harvesters can swiftly traverse vineyards, mechanically shaking vines to dislodge grapes, and collecting them in bins. This method is particularly advantageous for large vineyards with flat terrain, allowing for rapid grape collection. However, the mechanical process lacks the discernment of human hands, potentially leading to the inclusion of leaves, stems, or unripe grapes in the harvest. Hand harvesting, on the other hand, involves skilled labour meticulously picking grapes by hand. This method allows for a selective harvest, ensuring that only fully ripe and undamaged grapes are collected. The human touch minimizes the risk of bruising or damaging delicate grape clusters. While hand harvesting is more labour-intensive and costly, it is favoured in vineyards with uneven terrain or premium grape varieties that require special care. Ultimately, the choice between mechanized and hand harvesting methods involves a careful balance of factors such as vineyard size, topography, grape variety, and the desired level of grape quality. Many winemakers believe that hand harvesting preserves grape integrity, contributing to nuanced and superior wines, while mechanized methods offer efficiency and cost savings on a larger scale. The decision reflects a delicate interplay between technology and tradition, emphasizing the impact of harvesting techniques on the ultimate expression of grape character in the bottle.

Post-harvest technologies for grape preservation and processing

Post-harvest technologies play a pivotal role in grape preservation and processing, ensuring that the quality of harvested grapes is maintained and enhanced for the production of high-quality wines, raisins, or other grape-derived products. One key technology in grape preservation is cold storage, where grapes are promptly cooled to slow down enzymatic and microbial activities, preserving freshness and flavor. Controlled atmosphere storage further extends the shelf life of grapes by managing oxygen and carbon dioxide levels in storage rooms. Additionally, post-harvest technologies include sorting and destemming machines that efficiently remove unwanted materials like leaves and stems, ensuring that only premium grapes enter the winemaking process. Gentle pressing machines extract juice without damaging grape skins, crucial for white wine production. For red wines, modern crushers and destemmers delicately separate grape skins from the pulp. Flash pasteurization and cold stabilization techniques control microbial activity and prevent spoilage, contributing to wine stability. Furthermore, advancements in vacuum evaporation and freeze concentration enable the production of

concentrated grape juices and extracts. Overall, these post-harvest technologies not only facilitate the preservation of grape quality but also offer diverse processing options, allowing winemakers to explore a spectrum of styles and products derived from this versatile fruit.

Precision Viticulture and Technology Integration

Precision viticulture represents a transformative paradigm in grape cultivation, integrating advanced technologies to optimize vineyard management with unprecedented precision. This approach relies on the strategic use of data, sensors, and technology to tailor viticulture practices to the specific needs of individual vines or vineyard blocks. The integration of technology in precision viticulture has several key components:

- ✓ **Remote Sensing and Imaging:** Satellite imagery, drones, and other remote sensing technologies capture high-resolution images of vineyards. These images provide valuable insights into variations in vine health, vigor, and stress levels. By analysing these images, viticulturists can identify specific areas that require targeted interventions.
- ✓ **GPS and GIS Mapping:** Global Positioning System (GPS) technology, coupled with Geographic Information System (GIS) mapping, enables precise mapping of vineyard topography and variability. This information is crucial for creating site-specific management plans and accurately applying inputs like water, nutrients, and pesticides.
- ✓ **Sensor Technologies:** In-field sensors, such as soil moisture sensors and weather stations, provide real-time data on environmental conditions. These sensors help optimize irrigation schedules, ensure water efficiency, and prevent over-watering or water stress in specific vineyard zones.
- ✓ **Data Analytics and Decision Support Systems:** Advanced analytics and decision support systems process large volumes of data collected from various sources. This enables viticulturists to make informed decisions on irrigation, nutrient management, pest control, and other practices, enhancing overall vineyard efficiency.
- ✓ **Variable Rate Technology (VRT):** VRT allows for the variable application of inputs based on specific needs identified through data analysis. This targeted approach optimizes resource use, reduces waste, and maximizes the effectiveness of interventions.
- ✓ **Precision Pruning and Harvesting:** Robotics and automated systems are being developed for precision pruning and harvesting. These technologies streamline labour-intensive tasks, ensuring that each vine receives tailored attention while improving overall operational efficiency.
- ✓ **IoT and Smart Sensors:** The Internet of Things (IoT) facilitates the integration of smart sensors throughout the vineyard. These sensors monitor vine health, soil conditions, and microclimates in real-time, providing a continuous stream of data for timely decision-making.

- ✓ **Machine Learning and Artificial Intelligence (AI):** Machine learning algorithms and AI applications analyse historical data to predict future trends and identify patterns. This predictive capability aids in anticipating pest outbreaks, disease risks, and optimizing management practices.
- ✓ **Smart Vineyard Management Apps:** Mobile applications and software platforms provide viticulturists with user-friendly interfaces for accessing and interpreting data. These apps enhance real-time monitoring, decision-making, and collaboration among vineyard management teams.

Challenges and Opportunities

Precision viticulture, while promising tremendous advancements, is not without its challenges and opportunities. One of the significant challenges lies in the initial investment required for adopting precision technologies. The cost of sensors, imaging equipment, and data analytics tools can be prohibitive for smaller vineyards. Additionally, there is a learning curve associated with integrating and interpreting the vast amounts of data generated by these technologies.

Another challenge is the need for skilled personnel who can effectively use and interpret the data collected. Viticulturists must develop expertise in data analytics, remote sensing, and technology management to fully leverage the potential of precision viticulture. Furthermore, the rapid pace of technological advancements poses a challenge in keeping up with the latest tools and ensuring compatibility with existing systems. Despite these challenges, precision viticulture presents numerous opportunities. One of the most significant benefits is the potential for resource optimization. By precisely tailoring inputs such as water, nutrients, and pesticides to the specific needs of individual vines or blocks, vineyards can reduce waste, conserve resources, and improve overall sustainability.

The ability to make informed, data-driven decisions is another opportunity afforded by precision viticulture. Viticulturists can gain deeper insights into the variability within their vineyards, enabling them to implement targeted interventions. This, in turn, can lead to improved grape quality, increased yields, and enhanced overall vineyard performance. Precision viticulture also opens doors to innovation and research. The data collected over time can be analysed to uncover patterns, trends, and correlations that were previously difficult to discern. This knowledge can contribute to advancements in grape growing practices, disease management, and climate resilience. Additionally, precision technologies enable a shift towards proactive rather than reactive management. By predicting and preventing issues before they arise, vineyard managers can reduce the need for reactive interventions, resulting in more efficient and sustainable vineyard operations.

In conclusion, the challenges associated with precision viticulture should be viewed as opportunities for growth and improvement. As the technolo-

gy continues to evolve, addressing these challenges will pave the way for more accessible, user-friendly, and cost-effective solutions. The potential benefits of resource optimization, informed decision-making, and innovation position precision viticulture as a transformative force in the future of grape cultivation.

Future Trends and Prospects

The future of viticulture is poised for exciting developments as technological advancements and sustainability initiatives continue to shape the industry. One prominent trend is the increasing integration of artificial intelligence (AI) and machine learning into vineyard management. These technologies will enhance predictive analytics, allowing viticulturists to anticipate disease outbreaks, optimize irrigation schedules, and make data-driven decisions for precision viticulture. Climate change resilience is another critical focus for the future of grape cultivation. Vineyards are adapting by exploring new grape varieties, altering planting practices, and implementing innovative irrigation strategies to cope with shifting climate patterns. The development of drought-resistant rootstocks and climate-specific grape varieties will become paramount in ensuring the sustainability and resilience of vineyards worldwide. Innovations in sustainable and organic practices will continue to gain prominence. From regenerative agriculture to the use of cover crops and natural predators for pest control, vineyards are embracing environmentally friendly approaches to reduce their ecological footprint. This aligns with consumer preferences for eco-friendly products and practices.

The convergence of technology and traditional winemaking is evident in the rising popularity of smart wineries. These facilities leverage automation, sensor networks, and data analytics to optimize production processes, monitor fermentation, and ensure wine quality. The use of blockchain technology is also emerging, providing transparency in the supply chain, from vine to bottle, to meet consumer demands for traceability. The exploration of alternative winemaking methods and styles is on the horizon. Amphora aging, concrete egg fermentation, and natural winemaking practices are gaining attention as winemakers seek to express the unique terroir and characteristics of their vineyards. Experimentation with lesser-known grape varieties and revival of ancient winemaking techniques contribute to the diversity and innovation in the world of wine. As the industry evolves, collaborative initiatives and knowledge-sharing platforms will play a crucial role. Viticulturists, winemakers, and researchers will increasingly collaborate to address common challenges, share best practices, and collectively contribute to the sustainability and advancement of grape cultivation.

Conclusion

In conclusion, the landscape of grape cultivation and viticulture is undergoing a transformative journey marked by a convergence of tradition and cutting-edge innovation. As we navigate the challenges of climate change, resource

optimization, and the ever-evolving demands of consumers, the industry is responding with resilience and adaptability. Precision viticulture, with its integration of technology, is redefining the way vineyards are managed, offering unprecedented insights into the intricacies of grape growth and vine health. The pursuit of sustainability is not merely a trend but a fundamental ethos guiding viticulturists towards environmentally conscious practices. From organic farming and regenerative agriculture to the use of alternative energy sources, the industry is forging a path towards a more harmonious coexistence with nature. As climate patterns shift, grape cultivators are exploring new varieties and resilient rootstocks, safeguarding the future of vineyards and the diversity of the wines they produce. Technological advancements, such as artificial intelligence and machine learning, are empowering viticulturists with predictive analytics and data-driven decision-making capabilities. The smart winery concept, integrating automation and blockchain technology, reflects a forward-looking approach to enhance efficiency, transparency, and traceability in the winemaking process. In this era of exploration and experimentation, winemakers are rediscovering ancient techniques, embracing alternative styles, and cultivating lesser-known grape varieties. This creative spirit adds a rich tapestry of diversity to the world of wine, offering consumers a broader spectrum of flavours and experiences. As we move forward, collaboration and knowledge-sharing will be key drivers of success. Viticulturists, winemakers, and researchers are joining forces to tackle common challenges, share insights, and contribute to the continuous evolution of the industry. The future of grape cultivation is not just about producing exceptional wines; it is about fostering a sustainable, resilient, and innovative ecosystem that respects the land, the traditions and the ever-evolving preferences of wine enthusiasts around the globe. In the ever-growing vineyards of possibility, the journey of viticulture continues, promising a future as robust and diverse as the vines themselves.

References

Cataldo, E., Fucile, M., & Mattii, G. B. (2021). A review: Soil management, sustainable strategies and approaches to improve the quality of modern viticulture. *Agronomy*, 11(11): 23593.

Howell, G. S. (2001). Sustainable grape productivity and the growth-yield relationship: A review. *American Journal of Enology and Viticulture*, 52(3): 165-174.

Litskas, V., Mandoulaki, A., Vogiatzakis, I. N., Tzortzakis, N. and Stavrinides, M. (2020). Sustainable viticulture: First determination of the environmental footprint of grapes. *Sustainability*, 12(21): 8812.

Bramley, R. G. V. (2022). Precision Viticulture: Managing vineyard variability for improved quality outcomes. In managing wine quality (pp. 541-586). Woodhead Publishing.

Unveiling the Enigmatic World of Honeybees: Nature's Finest Pollinators

Gaurav Saxena, Ravi Prakash and Pavan Kumar

Introduction



In the world of nature, there's something special about honeybees. They're not just ordinary bugs buzzing around flowers; they're like a little community all on their own. Imagine a bustling hive filled with bees working together like a big team. That's what makes honeybees so interesting to study.

When you look closely, you'll see that honeybees have a neat way of living together. At the top of the bee hierarchy is the queen bee. She's like the boss, responsible for laying lots of eggs to keep the colony going. Then there are the worker bees, which are most of the bees you'll find in a hive. They're the busy ones, doing all sorts of jobs like taking care of baby bees, finding food, and protecting the hive. Lastly, there are the drones. They're like the few guys hanging around, waiting to help the queen mate. But what's really cool about honeybees isn't just their different roles; it's how they work together. They talk to each other using dances and smells to share important information. This helps them do things like find food and build their hive efficiently. Outside of their home, honeybees are super important for nature. They're great at pollinating flowers, which means they help plants make more seeds and fruits. This helps crops grow and gives us food to eat. So, when we learn about honeybees, we're not just learning about bugs; we're learning about a whole community that helps keep our world healthy and tasty.

Caste System



In honeybee colonies, a well-defined caste system governs the roles and responsibilities of each member, contributing to the colony's overall success and resilience. At the apex of this system is the queen bee, distinguished by her size and reproductive capabilities. The queen's primary function is to lay eggs, a task she performs with remarkable efficiency, ensuring the colony's continuous growth and sustainability. Moreover, the queen emits pheromones that regulate the behavior and development of other colony members, fostering harmony and cohesion within the hive.

Beneath the queen are the worker bees, the industrious females that form the majority of the colony's population. Worker bees undertake a multitude of tasks critical for the hive's functioning, including nursing. The brood, foraging for food and maintaining the hive's structure and cleanliness. The adaptability versatility allow them to seamlessly transition between roles, ensuring the colony's needs

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are met promptly and efficiently. Completing the honeybee caste system are the drones, the male bees whose existence revolves around reproduction. Drones emerge from unfertilized eggs and have no stinger or pollen baskets, limiting their role within the colony. However, their sole purpose is to mate with virgin queens from other colonies, thereby contributing to genetic diversity and the colony's long-term viability. The honeybee caste system exemplifies the power of specialization and collaboration in achieving collective success. Each member, from the queen to the lowliest worker, plays a crucial role in maintaining the hive's health and productivity. Understanding the intricacies of this caste system provides valuable insights into insect social behavior and underscores the importance of biodiversity and ecosystem resilience.

Organization and Coordination

Communication and coordination are essential aspects of honeybee society, facilitating efficient organization and collaboration within the hive. Honeybees employ a variety of sophisticated communication methods to convey vital information to their colony members, ensuring the successful operation of the hive. One notable form of communication is the waggle dance, performed by forager bees to communicate the location and quality of food sources to their nestmates. Through precise movements and vibrations, forager bees convey information about the direction, distance, and richness of a food source, enabling other bees to locate and exploit valuable resources. Additionally, honeybees utilize chemical signals known as pheromones to communicate and maintain social cohesion within the hive. These pheromones play a crucial role in regulating various colony activities, including brood care, foraging behavior, and defense responses.



Reproduction and Queen Bee

Reproduction and queen behavior are pivotal aspects of honeybee colonies, governing their social structure and sustainability. The queen bee, a central figure in the colony, possesses remarkable reproductive capabilities, laying up to 2,000 eggs per day during peak seasons. Additionally, the queen emits pheromones that regulate the behavior and development of other colony members, maintaining order and cohesion within the hive. Factors such as environmental conditions and hive population influence the queen's behavior, with swarming being a common response to overcrowding or declining resources. Swarming involves the queen and a portion of the colony leaving the hive to establish a new nest, ensuring the propagation of the colony's genetic lineage and preventing overcrowding.



Worker Bee Dynamics

Worker honeybees are the backbone of a hive, undertaking a myriad of tasks essential for its

survival and prosperity. These industrious females exhibit remarkable adaptability and versatility throughout their lives. As young adults, worker bees start their journey as nurse bees, caring for the developing brood within the hive. They meticulously attend to the larvae, feeding them a mixture of pollen and nectar known as "royal jelly" to ensure their healthy growth. As they mature, worker bees transition into roles as foragers, venturing out of the hive in search of vital resources such as nectar, pollen, and water. Foraging bees utilize their keen senses of sight, smell, and taste to locate and collect these resources, often traveling several kilometers from the hive in their quest. Furthermore, worker bees engage in various tasks within the hive to maintain its functionality and cleanliness. They participate in comb building, constructing intricate hexagonal cells from beeswax produced by their bodies. Worker bees also undertake the critical responsibility of hive sanitation, removing debris and dead individuals to uphold hygienic conditions. Moreover, they serve as sentinels, guarding the hive entrance against potential threats such as predators and robbers. The coordination and cooperation among worker bees are essential for the overall productivity and survival of the colony.



Ecological Importance

Honeybees play a vital ecological role as pollinators, facilitating the reproduction of numerous plant species and contributing to ecosystem health and biodiversity. As they forage for nectar and pollen, honeybees inadvertently transfer pollen grains from the male reproductive organs (anthers) of one flower to the female reproductive organs (stigma) of another, thereby enabling fertilization and seed production. This process, known as pollination, is essential for the reproduction of flowering plants, including many crops that humans rely on for food, fiber, and medicine. Beyond agricultural ecosystems to natural habitats, where they contribute to the diversity and stability of plant communities. By pollinating a wide range of plant species, honeybees facilitate the production of fruits, nuts, and seeds that serve as food sources for countless other organisms, including birds, mammals and insects. Moreover, honeybees play a critical role in maintaining the genetic diversity of plant populations, thereby enhancing their resilience to environmental changes and disturbances. Understanding the ecological significance of honeybees underscores the importance of conserving and protecting their populations. By ensuring the health and abundance of honeybee colonies, we not only safeguard essential ecosystem services but also support the overall health and resilience of natural and agricultural landscapes.



References

Crane, E. (1999). The World History of Beekeeping and Honey Hunting. Routledge.

Seeley, T. D. (1992). The Wisdom of the Hive: The Social Physiology of Honey Bee Colonies. Harvard University Press.

Winston, M. L. (1987). The Biology of the Honey Bee. Harvard University Press.

Seeley, T. D. (1985). Honeybee Ecology: A Study of Adaptation in Social Life. Princeton University Press.

Biogas: A Renewable Energy Source and Its Potential Applications

Rajinder Kumar and D. K. Vatsa

Introduction

Energy is a fundamental requirement for man's comfort and basic needs of everyday life. A vast majority of countries especially developing countries have energy crises with over reliance on fossil fuels. The national energy drivers of all countries globally are energy security, environmental protection, and economic growth. It is predicted that fossil fuel sources like coal, gas, and oil are headed for depletion within the next 10 decades, hence the need for alternative sources of energy. Additionally, international treaties like Agenda 21 and Kyoto Protocol advocate for a transition to renewable and low car bon sources of energy due to high green house gas emissions associated with fossil fuels and the related climate change caused.

Biogas has proved to have significant potential as a renewable energy source for industrial as well as domestic applications and an efficient solution to the global energy crisis. The increasing use of fossil fuel s and environ mental concerns over greenhouse gas emissions and climate change has generated interest in bio-gas as an alternative renewable energy resource. Increasing environmental and policy concerns and measures have generated increasing interest in the use of biomass resources as renewable feedstock for electricity generation, fuel production, chemical processing, and hydrogen production. This has been further compounded by depletion of fossil reserves, growing organic waste production, and global warming threats have combined to increase interest in anaerobic digestion and biogas fuel resources. The main application for biogas is electricity generation, thermal applications like cooking, heating and lighting, and production of biofuels. Over 7000 MW of electric power is generated from biogas annually (Topolewski, 2021). From the 1980s onward, the remarkable hike in global energy consumption has been mainly extracted through fossil energy resources. Approximately, 85% of the world's primary energy consumption has been supplied by fossil fuels in 2018. The conversion of biomass to energy has been promoting from 65 GW in 2010 to 120 GW in 2019 due to climate change, reasonable energy prices, distributed generation increase, and environmental aspects, in recent years. Wastes with high moisture content are more compatible with conversion by anaerobic digestion, landfill, and digestion technologies. The global amount of biogas plant capacity was about 19.5 GW at the end of 2019. Organic wastes are the most common feedstocks to produce biogas from wastes, including domestic wastes (food, fruits, and vegetables) or public moist wastes (cafes and restaurants, daily markets, and companies' biological wastes), due to significant

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moisture content and high degradability. These input materials are classified as organic fraction of municipal solid waste (OFMSW). Biogas is inherently renewable generated from biomass, practically a reserve of the solar energy via photosynthesis process. Anaerobic digestion biogas will not only enhance a country's energy basket status but also contribute significantly in conserving natural resources and protecting the environment. Biogas is naturally composed of biogenic material. This biogas, which occurs naturally, spreads into the environment and its major component, methane, plays a serious damaging role in global warming Methane has been used as important fossil fuel and converted to generate power, transportation, and heating, over the past decades. Nowadays, the major portion of methane consumption and utilization comes from natural gas resources, but the production of bio-methane from waste recovery approaches has been meaningfully increased. Its production potential has been improved by 4% over 9 years (from 2010 to 2018). At present, about 3.5 Mtoe (million or mega tonnes of oil equivalent) of bio-methane is produced around the world and the potential for bio-methane production today is over 700 Mtoe (Edenhofer *et al.,* 2011). Of course, this does not mean that methane conversion is feasible from all kinds of natural resources. In other words, infrastructures for biogas development extremely rely on specific equipment and the availability of control and management systems. Therefore, a sustainable industry can be installed and implemented to generate bio-energy from renewable and green natural resources. Developed countries use advanced large-scale plants for utilizing biogas. Biogas is regularly applied to generate heat, power, and electricity. Also, several industrial applications for its utilization in biogas plants as a substitute to natural gas are being progressed. Based on the analyzed data, a continuous increase in biogas production has been observed due to the global policies and programs. Since 0.5% proportion of renewable energies contribution that is about 12.8 GW (IRENA RES, 2015) is supposed to be achieved in 2020 for transportation sectors, bio-fuel production has been considered as the main source of this plan in different regions. It is noteworthy that biogas production should not be developed as a food production threat. For this reason, biofuels are mainly generated from cellulosic and lignin wastes.

A wide global market of biogas has been clearly promoted for the previous decades in various countries. Moreover, the advanced biogas production technologies have been supported by domestic or international supportive rules, such as research, design, and development (RD&D) financial funds, subsidization, and guaranteed electricity purchase contracts to make a competitive market against conventional energy suppliers. As per Fig. 1, the different utilizations of the biogas technology offer a multi-purpose solution to generate the required energy of the industrial or social sectors. Biogas is mainly consumed for combined heat and power (CHP) plants, hydrogen production units and advan-

ced energy systems such as fuel cells. Generally, in the European Union and North America, biogas plants came to be developed more than in other continents for the last 40 years. The main advantages of the units located in the mentioned regions are industrial scale, energy efficiency, and high complexity level. Biogas production was considered by academic centers and governments owing to its potential in response to different global challenges. It should also be pointed out that using biogas technologies allows industries to eliminate greenhouse gases (GHGs) emissions and waste disposal pollutions, while it provides a broad spectrum of energy utilization such as heat, electricity, and transportation purposes, based on its renewable nature.

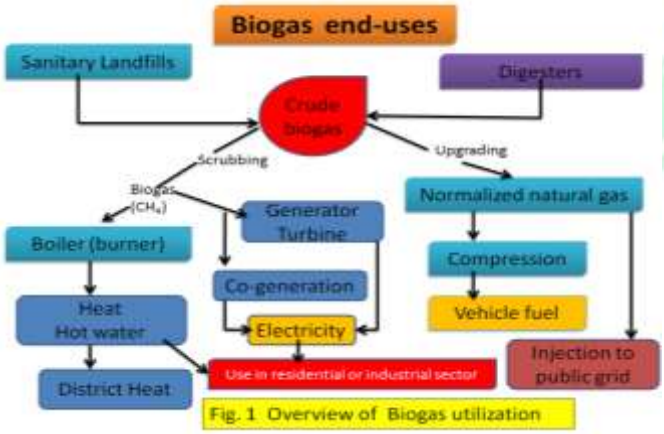


Fig. 1 Overview of Biogas utilization

There are various strategies around the world for producing biogas from agricultural products. In Germany, for example, the production of cheap agricultural products that require low processing (with no outcomes for consumers) provides feedstock for biogas plants. New policies recommend the use of crops and plant residents, life stocks remaining and landfll use (IRENA RES., 2015).

Biogas applications

Biogas is globally considered as traditional off-grid energy. Biogas can also be utilized to generate electricity. The various applications of biogas are described below:

Electricity generation: Power generation from biomass is currently the most popular and growing market worldwide, due to technological improvements, decreasing reliance on fossil-based energy, and reduction of greenhouse gases (GHG) emissions. Biogas has the potential for electricity generation in power plants by internal combustion engines (ICEs) or gas turbines (GTs) as the two most commonly used power generation methods. Micro gas turbines are also an attractive method due to lower NOx emissions and flexibility to meet various load requirements. Multiple microturbines sizing from 70 kW to over 250 kW can be employed to meet low/medium power load demands. The electricity can provide the required power to the adjacent industries and companies. With the development of electric cars, another state-of-the-art application, especially in developed countries like Germany, is the utility of electricity for e-vehicles of a connected car-sharing association. The major benefit of on-site electricity generation is to prevent transport losses and to increase reliability due to the independence from a centralized grid mostly run by traditional fossil fuels. It also brings extra economical profit by providing the required in-house power demand and selling the extra electricity.

Heat generation: Biogas can be directly combusted

in boilers for heat generation only. It is feasible to slightly modify natural gas boilers to operate with biogas. As farm biomass is a major biogas production source, the generated heat can be used for heating the digesters, farm buildings like housing units for pigs/sties, greenhouses, as well as aqua-farming, cooling/refrigeration of farm products, and drying purposes. The drying process in agricultural businesses, such as drying of digestate, wood-chip, grain, herbs, and spices, is a remarkable added value to the farm economy. Available heat for external use, representing nearly 30-50% of generated heat, can be sold to a nearby district to be used for district heating/ cooling like heating swimming pools. Also, an absorption chiller can be a potential candidate to better use heat through combined heat and power (CHP), in addition to cooling power (tri-generation). It can convert heat into cooling power with high efciencies of up to 70%.

Combined heat and power (CHP) generation: Concurrent generation of heat and electricity by combined heat and power systems is an operational approach to upgrade the energy conversion efficiency of biogas. When only converting biogas to electricity or heat, just a minor fraction of energy contained in biogas is used. Characteristically, in these types of systems, associated power conversion productivity is some-where in the region of 30 to 40%, while it is diminished by employing biogas as an alternative for refined and purely natural gas. CHP plants suggest the advantage of high-temperature exhaust gas from the electricity generation subsyst-em (ICEs or GTs) as a source of valuable heat for many heating purposes. Although the electricity generation efficiency of simple plants is only 20-45%, a larger portion of energy (around 60% of the utilized energy) is converted to heat that is reused by heat recovery systems; making it more attractive when there is a high heat demand. This considerably enhances the system efficiency and improves the payback period of plants, making the distributed generation the most common biogas application. The extra electricity could be supplied for the national grid and the extra heat can be sold to the local district utilization. A CHP cycle has sufficient productivity that has efficiency up to 90%, while it can produce 35% and 65% of the generated electricity and heat, respectively. In this case, some thermal energy is used to heat the process and about 2/3 is used for external uses. In some proposed models for biogas-based power plants, the use of generated heat is ignored and the focus is only on generating electricity. Without any doubt, this approach has no economic justification and must use all its thermal potential. There are three common ways to produce heat and power from biogas including Gas-Otto engines, Pilot-injection gas motor, and Sterling motors. In EU, four-stroke engines and ignition oil diesel engines contributed roughly the same in CHPs at somewhere in the vicinity of 50%, each. Biogas is also employed in gas turbines, microturbines, and fuel cells for CHP applications. CHP plants offer the advantage of high-temperature exhaust gas from the electricity generation subsystem (ICEs or GTs) as a

source of valuable heat for many heating purposes. Although the electricity generation efficiency of simple plants is only 20-45%, a larger portion of energy (around 60% of the utilized energy is converted to heat that is reused by heat recovery systems; making it more attractive when there is a high heat demand. This considerably enhances the system efficiency and improves the payback period of plants, making the distributed generation the most common biogas application. The extra electricity could be supplied for the national grid, and the extra heat can be sold to the local district utilization. Also, an absorption chiller can be a potential candidate to better use the extra heat through CHP, in addition to cooling power (tri-generation). It can convert heat into cooling with high efficiencies of up to 70%. A CHP cycle has sufficient productivity that has efficiency up to 90%, while it can produce 35% and 65% of the generated electricity and heat, respectively. In some proposed models for biogas-based power plants, the use of generated heat is ignored and the focus is only on generating electricity. Without any doubt, this approach has no economic justification and must use all its thermal potential.

Conclusion

With the new applications of biogas, the worldwide biogas industry has increased by more than 90% between the years 2010 and 2018, while further growth is still expected. However, the biogas industry varies significantly in different locations over the entire world. Different countries have developed several types of biogas systems which are mainly dependent on different environments as well as on energy demand and supply chain. In present scenario of energy exploration, the exploitation of biogas and the expansion of its potential applications have gained popularity due to factors like climate change, reasonable energy prices, and an increase in distributed generation. Biogas also traditionally known as an of-grid energy resource and can be used in various applications consisting of electricity production and CHP systems

References

Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Seyboth, K., Kadner, S., Zwickel, T. *et al.* (2011). Renewable energy sources and climate change mitigation: special report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge

IRENA RES. (2015). International Renewable Energy Agency. Renewable energy target setting, Abu Dhabi, UAE

Topolewski, L. (2021). Relationship between Energy Consumption and Economic Growth in European Countries: Evidence from Dynamic Panel Data Analysis. *Energies*, 14(12): 3565.

Role of Boron in Groundnut: A Review

Amit Bhadu and Rajendra Kumar Jat

Abstract

Groundnut, king of oilseeds is an important food crop, feed used for oil extraction and confectionery. Boron an essential micronutrient has significant impact over groundnut growth, yield and quality. Boron deficient is found widespread in groundnut growing areas. Boron plays a significant role in the concentration and uptake of nutrients by groundnut. Boron deficiency can cause hollow heart, stubby plants, rosetted branching, split stems and roots, leaves with a yellow-green mosaic appearance, and shell deformity. Among micronutrients, boron deficiency is one of the most crucial constraints limiting nutrient use efficiency and crop yields. The deficiency of boron on groundnut causes low pod filling, shriveled seeds and hollow darkening or off-colour in the center of the seed causing 10-50% yield losses in groundnut. Research evidences has shown positive trend on growth, yield increment and quality enhancement thereby increasing the overall productivity of groundnut.

Introduction

Groundnut (*Arachis hypogea* L.) is an important annual legume endowed with different names such as peanut, earth nut, monkey-nut and goobers. It is a valuable cash crop cultivated by millions of small farmers throughout the world due to its economic and nutritional value. Groundnut kernels are rich source of edible oil and protein. Groundnut contains average 45-50% oil, 25-30% protein, 20% carbohydrate, 5% fiber and ash. It is also a rich source of Ca, Fe, vitamins A, B, E, and K, highly substantial for human nutrition. Boron (B) deficiency has been reported from many groundnut growing areas of India. Boron seems to be the next in importance after Zn for micronutrient management. Only minimum quantities of B are needed for optimum production of groundnut. Boron has an important role in plant metabolism and found to play a significant role in the translocation of sugar molecules. Boron's high water solubility, high plant availability, low nutrient requirement, and potential to be a toxic element at a relatively low soil concentration make it a challenge to manage for groundnut production on sandy soils. Boron is an essential micronutrient for better growth and to avoid "hollow heart" in groundnut that reduces value of crop. The detection of field symptoms either boron toxicity or boron deficiency is the cause for groundnut yield loss and low quality of kernels. Boron is critical to groundnut quality hence gains momentum in management. The first adverse effects is on flowering and fruiting and therefore, on the yield and quality of the crops (Sathya *et al*., 2009). It needs a constant supply of boron during all stages of growth,

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but especially from flowering to harvest. In groundnut crop, fertilizing with boron will help to improve root nodule development for more nitrogen fixation and protein production, produce and retain more flowers and pegs, enhance calcium utilization, move sugars and protein from leaves to nuts. The positive effect of boron has been documented by eminent research scientist in groundnut leading to sustenance of groundnut yield and quality of groundnut cultivators. Soil parent material and texture are considered to be major soil factors associated with the occurrence of B deficiency that can readily be prevented and corrected by soil and foliar applications (Shorrocks, 1997). Thus the study on B nutrition of groundnut was initiated at different research center about a decade ago and some of the findings are summarized here.

Deficiency Symptoms in groundnut

- ✓ The B deficiency caused retarded growth in groundnut plant particularly of the apical portion, death of the stem apex, and regeneration from the lateral bud, malformation of the leaf vein, chlorosis, necrosis of basal margins in emerging leaves are commonly observed.
- ✓ Boron deficiency also causes thickened and stiff growing bud at terminal end, young leaves turn pale green starting at basal end, leaves deformed, twisted, and brittle, shortened internodes and bushy or rosette appearance of the plant **(**Singh *et al.*, 2004).
- ✓ The deficiency of B causes low pod filling and hollow darkening or off- colour area develop in the center of the seed known as 'hollow heart' of groundnut reducing the quality of seed. In which the inner faces of the cotyledons are depressed and discolored reducing the quality of seed (Cox and Reid, 1964).



Fig. 1: Hollow heart in Groundnut Seed

Research Evidences for Boron positive effect on Groundnut

- ✓ Positive effect of boron in quality enhancement by synthesis of protein and amino acids further increased the pod yield of groundnut (Chitdeswari and Poongothai, 2003).
- ✓ Application of 0.25 to 0.50 kg B ha^{1} gave a significant increase in pod yield of groundnut (Maheshkumar and Sen, 2004).
- ✓ The protein content of groundnut pod increased with 1.0 ppm and increasing levels decreased (Muthukrishnan, 2007).
- ✓ Boron application gave significant increase in growth, yield parameters and yield compared to control. Application of boron reduced days to 50% flowering by 4-5 days over control (Ansari *et al.*, 2013).
- ✓ Application of boron increased yield to the magnitude of 8.9% over the control which might be due to B that enhanced germination, pollen tube formation, photosynthetic activity and also

protein and nucleic acid metabolism (Saha *et al.*, 2015).

Management of Boron Deficiency

- ✓ **Soil Testing:** Before planting groundnuts, it's important to conduct a soil test to assess the boron levels in the soil. Based on the results, you can determine if boron supplementation is needed. If the soil test indicates a boron deficiency, you can apply boron through fertilizers. However, it's crucial to follow recommended application rates, as excessive boron can be toxic to plants.
- ✓ **Boron Application:** Apply 10 kg of borax and 400 kg of gypsum ha^{-1} at 45 days after sowing, treat seeds with Rhizobial culture TNAU 14, Azospirillum, and Phosphobacteria, apply 5.8 kg of boric acid ha^{-1} in black calcareous soil, apply 0.5 kg of boron ha^{-1} to increase pod yield.
- ✓ **Foliar Application:** In cases where groundnut plants are showing signs of boron deficiency during the growing season, foliar application of boron-containing products may be necessary to address the deficiency quickly.
- ✓ **pH Management:** Soil pH can influence the availability of boron to plants. A pH level that is too high or too low can affect the plant's ability to uptake boron. Therefore, managing soil pH within the optimal range can help improve boron availability.
- ✓ **Crop Rotation:** Rotation with non-boron-sensitive crops can help mitigate potential issues with excessive boron levels in the soil, especially in areas where boron-containing fertilizers have been used consistently.

Conclusion

In conclusion, effective management of boron is crucial for successful groundnut cultivation. Maintaining optimal boron levels in the soil is essential for promoting healthy plant growth, maximizing yield, and preventing the negative impact of boron deficiency or toxicity. Boron an essential micronutrient has positive effect on groundnut growth, yield and quality sustaining the standard of living of groundnut cultivator's hence proper diagnosis and management is need of present hour.

References

Ansari, M. A., Prakash, N., Singh, I. M., Sharma, P. K. and Punitha, P. (2013). Efficacy of boron sources on productivity, profitability and energy use efficiency of groundnut (*Arachis hypogaea*) under North East Hill Regions. *Indian Journal of Agricultural Sciences*, 83 (9): 959-63.

Chitdeshwari, T. and Poongothai, S. (2003). Yield of groundnut and its nutrient uptake as influenced by zinc, boron and sulphur. *Agricultural Science Digest*, 23(4): 263-66.

Cox, F. R. and Reid, P. H. (1964). Calcium-boron nutrition as related to concealed damage in peanuts. *Agronomy Journal*, 56: 173- 176.

Muthukrishnan, A. (2007). M.Sc. (Ag.) Thesis, Agricultural College and Research Institute, Madurai.

Maheshkumar and Sen, N. L. (2004). *Agriculture Science Digest*, 24(4): 307-308.

Saha, B., Saha, S., Saha, R., Hazra, G. C. and Mandal, B. (2015). Influence of Zn, B and S on the yield and quality of groundnut (*Arachis Hypogea* L.). *Legume Research*, 38 (6): 832-836

Sathya, Pitchai, S., James, G. and Indirani, R. (2009). Boron nutrition of crops in relation to yield and quality. *Agricultural Review*, 30(2): 139-144.

Shorrock, V. M. (1997). The occurrence and correction of boron deficiencies. *Plant and Soil*, 193: 121-148.

Singh, A. L., Basu, M. S. and Singh, N. B. (2004). Mineral Disorders of Groundnut. National Research center for groundnut (ICAR), Junagadh, India, p. 85.

Impact of Indoctrinate Use of Chemical Fertilizers on Soil Properties

Britan Rahman, Ipsita Ojah and Shadad Md. Khayer

Many issues plague modern agriculture, including low levels of soil organic carbon, inefficient use of fertilizers, and an imbalance between the addition and removal of nutrients from the soil. Sustaining the soil ecosystem and ensuring sustainable crop output depend on managing soil fertility. Today's agriculture is primarily dependent on a variety of inputs, including mechanization, irrigation, agrochemicals, chemical fertilizers, and quality seeds. These inputs have increased production to feed the growing population, but their careless application has a detrimental effect on the soil ecosystem and productivity, which is concerning. When we talk about chemical fertilizers, we mean compounds that have a high concentration of nutrients that are necessary for plant growth. These are synthetic materials that give plants nourishment. In today's agriculture, fertilizers are an essential component. It has a vital role in increasing soil fertility and crop productivity. In addition to essential nutrients chemical fertilizers also consists metals such as cadmium, arsenic, nickel, lead, copper, natural radio nuclide such as U_{218}, Th_{232}, Po_{210} etc. Therefore, fertilization can be responsible for the accumulation of heavy metals in soil system and through food chain may get into human body. Extended and careless application of chemical fertilizers can lead to a decrease in the amount of organic matter in the soil and potentially raise its acidity. Since salt is a major component of chemical fertilizers, they are harmful to agriculture in long run. They reduce essential nutrients and minerals in the soil.

Impact of Chemical fertilizers on soil

Soil quality: In an effort to boost crop yield, more chemical fertilizers particularly Urea, MOP, and SSP may be applied, which could degrade the quality of the soil. Since soil is the primary source of essential nutrients, it is necessary to control them completely. Numerous factors, including compaction, acidification, alkalization, erosion, pollution, salinization, and a decrease in soil organic matter can occur due to injudicious application of fertilizers which can negatively impact the amount of nitrogen, phosphorus and sulphur content in soil by its losses to atmosphere and water.

Physiochemical properties of soil: Maintaining healthy soil and consistent soil productivity requires careful management of soil nutrients. Frequent fertilizer application changes the soil's organic N and

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C content, aggregation, and structure, which in turn affects the amount of nitrogen and carbon in the soil. It significantly affects the biochemical characteristics of the soil, which could lead to a change in the microbial community. As a result, variations in N and OM may impact pH and nutrient availability, which in turn may impact the microbial community. The bulk density of the soil changes as a result of fertilization. Higher root development may result in increased soil organic carbon, which would then add additional root residues to the soil after they decompose.

Soil Enzyme activity: Numerous soil enzymatic activities, including those of phosphatases, dehydrogenases, proteases, glucosidases, and others, are crucial markers of soil microbial activity and health. Long-term usage of chemical fertilizer and indoctrination have no beneficial impacts on dehydrogenase activity or microbial biomass, but organic amendments such as residues in soil from roots after decomposition do have beneficial impact. Similarly, the administration of organic N promotes several soil enzymatic activities such as saccharase and urease. Copper, a common contaminant of chemical fertilizers, directly influences the activity of soil dehydrogenase.

Soil Compaction: The development of dense, well-filled layers on cultivated fields is known as soil formation. This is mostly because of the compressive stresses that agricultural machinery wheels apply to the soil, which is malleable. Reduced usage of organic fertilizer, heavy gear use, continuous application of chemical fertilizer, and continuous ploughing at a constant depth all contribute to soil compaction. Compacted soil also leads to extreme soil strength, inadequate aeration, poor drainage, erosion, runoff, and degradation of the soil. The permeability, hydraulic conductivity, and groundwater recharge all decrease as a result of these modifications. One of the main components of the land degradation syndrome is soil compaction. It poses a serious risk to agriculture and has an adverse effect on almost all soil qualities. It modifies the structure of soil by fracturing aggregate units, lowering the porosity

Soil Salinization: Salts are the major content of chemical fertilizers and are believed to be destructive to soil. The dissolution of chemical fertilizer applied to soil affects many soil properties, in particular the soil salinity. The salinity induced by N can adversely influence the nitrification process in soil, resulting in accumulation of NO_2 in the soil. Upon applying phosphatic fertilizer such as DAP, the concentration of soluble salts gets increased which causes soil salinity. This increased salinity may inhibit nitrification process, resulting in lesser transformation of NH_3 to NO_3-N, therefore, an enormous amount of N was present in the form of NH_4^+ at the highest level of salinity. Potassic fertilizer usually have significant effects on soil salinity. Application of Potassic fertilizers containing sulphate and chloride salts may lead to salinization of soil because of their large salt index.

Soil Acidification: The degree to which nitrogenous

fertilizers, especially reduced nitrogen (NH_3, NH_4^+), work as acidifiers determines how much of an impact they have on soil health when applied consistently and sparingly. Ammonium ions, nitrate ions, and urea ions are the three types of nitrogen molecules that change the pH of soil. The conversion of nitrogen into other forms and plant absorption have an impact on the acidity of the soil. A nitrogenous fertilizer's ability to cause acidification of the soil depends on the type of nitrogen given, the soil's ability to act as a buffer, and the overall balance between processes that produce and consume protons. Ammonium sulphate, a nitrogenous fertilizer, binds with water to the sulphuric acid in the soil. The acid releases hydrogen ions, which causes a loss of soil nutrients that are replaced.

Soil acidity is influenced by phosphatic fertilizers through the gain or release of H^+ ions, depending on the type of P fertilizer used as well as soil pH. When phosphoric acid is added to the soil with pH less than 6.2, it releases one H^+ ion, and two H^+ ions will be released when the pH of soil is greater than 8.2. SSP, MAP, and TSP all can acidify the soil if the soil pH is above 7.2.

Effect on soil biota: Soil microbial activity is a vital part of soil health. Bacteria, algae, fungi, protozoa, actinomycetes and viruses constitute soil microflora which form an important part of the soil ecosystem. They play important role in soil like maintaining soil fertility, nutrient cycling, degradation of organic nutrients etc. The impact of fertilizer on micro-organisms in the soil may be beneficial or harmful, and vary in duration relying on time-period considered, the amount, quality, and the way of application of fertilizer. More recently, it has been pointed out that diversity in microbial culture collection (MCC) is crucial in maintaining the health of soil because of their role in the formation of soil structure, soil organic matter (SOM) decomposition, and the biogeochemical cycling of nutrients.

Soil Organic Matter (SOM): Numerous studies have revealed that farming and the use of nitrogenous fertilizers affect SOM; this is an increasingly controversial issue. When nitrogen fertilizer is not applied during cultivation, SOM decreases; however, this can improve with N fertilizer application. By encouraging plant development and increasing the amount of litter and root biomass delivered to the soil, fertilizer can help enhance soil organic matter (SOM) relative to unfertilized soil. By decay or microbial litter transformation (straw, leaves, etc.), as well as native kinds of organic carbon already present, it can enhance the loss of SOM. With water, ammonium sulphate binds to sulphuric acid in the soil. Because of the acid's release of hydrogen ions, soil nutrients are lost, and alkaline components are replaced.

Conclusion

Chemical fertilizer application is a standard practice in modern agriculture. Its long-term use negatively affects the biological and physiochemical characteristics of the soil. In terms of the dominating soil species and the diversity of their structures and functions, they disturb the microorganisms.

The addition of inorganic fertilizer affected the pH and electrical conductivity of the soil. Applying NPK fertilizer seems to primarily inhibit the activities of different soil enzymes. Applying chemical fertilizers at the right times and in the right quantities is important. Only fertilizers should be applied based on the soil's fertility status, which is determined by conducting soil tests. It will result in a loss of money, effort, and time otherwise.

Shoot and Fruit Borer: Notorious Pest of Brinjal

Desh Raj Choudhary, Ajay Kumar and Rajesh Kumar

Shoot and Fruit Borer (*Leucinodes orbonalis*)

Host range: Brinjal, potato, other wild plants belonging to solanaceous crop

Shoot and fruit borer, *Leucinodes orbonalis*is regarded as most serious insect pest of brinjal crop. Its infestation is among the major limiting factors responsible for poor brinjal fruit yield. Larvae of this insect bore into the stem, leaves and fruit of brinjal. The severity of any particular insect depends on the season and the region in which the crop is grown. Majority of insect causes damage only in exception years, but few pests are prevalent in every area, every year and cause varying levels of damage. The incidence of this insect is facilitated further with intercropping of other solanaceous crops, in which these crops acted as alternate hosts.

This article is expected to enlighten readers about the damage potential and management of this major pest of brinjal crop. The severity of this pest on brinjal crop necessitates growers to apply repeated sprays of broad spectrum insecticides, which significantly reduces the net return from this crop and deteriorates environment in the longer run. Apart from this borer, aphid, leafhopper, ash weevil, and other polyphagous insects also contribute to yield losses in this crop. This insect pest is cosmopolitan as it is reported from Congo, South Africa, Burma, Sri Lanka, Bangladesh, Malaysia, Thailand, apart from India. It is estimated to damage up to 30 to 50% of brinjal fruits.

Damage symptoms

Fruits are severely damaged by the larvae of shoot and fruit borer, which drastically reduces the yield. Fruits are damaged shortly after transplantation and continue to be damaged until fruit harvest. Eggs are laid by the adult female on the ventral side of leaves, flower buds, and juvenile fruits. Early stage pinkish larva first bores into the terminal shoots, thereby causing the shoot to wither and dry thereafter; it bores into the young fruits thus, rendering it unfit for marketing. These damaged fruits rot owing to the fungal and bacterial growth.



Fruit Damage Shoot Damage

ETL: Control measures should be initiated if 1-5% of the brinjal fruits were found damaged.

Life Cycle: Egg period lasted for three-four days. On leaves, delicate shoots, blooms and developing fruits, 50-350 creamy white eggs are placed singly. The ro-

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bust pink larva has brown head, with warts on the body cove red in widely spaced hairs. A total of five larval instars with overall larval period of 15 days are observed in this insect. Tough, grayish-coloured, boat-shaped pupae are formed on the plant surface, which varies from six to eight days. The adult exhibit medium-sized white fore wings with trap ezoidal brown and red patterns. The entire life cycle is completed of insect in 17-50 days depending upon the environmental conditions.


Adult


Egg Larva Pupa

Preventative (Prophylactic) measures of pest control

- ✓ It is suggested to cultivate borer tolerant varieties of brinjal, if available.
- ✓ It is recommended to carry out synchronous planting with neighboring brinjal fields to reduce the spread of infestation. It is also suggested to grow them away from known areas of infestation and under netting to prevent egg lying by female moths.
- ✓ Thoroughly monitor brinjal crop for infestation and destroy borer infested shoot and fruit, if found.
- ✓ Remove brinjal crop stubbles from the previous season that can help reduce carry over pest population.
- ✓ Rotate brinjal with root crops or pulses to reduce infestation.

Intercropping

- ✓ Intercropping can be tried to reduce infestation of *L. orbonalis*.
- ✓ Use maize as a barrier crop and intercrop it with non-host crops viz. cowpea, coriander, black gram and green gram.

Control

- ✓ Avoid rationing of brinjal crop.
- ✓ Cultivate resistant varieties like Arka Kusumakar, Pusa Purple Round, Pusa Purple Long, Pant Samrat and Annamalai.
- ✓ To suppress population growth, collect and eliminate any injured tender shoots, fallen fruits and fruits with boreholes.
- ✓ Collect and destroy adult moths using light traps which is installed at the rate of one ha^{-1}.
- ✓ Biological control of this pest can be done by introducing of hyper parasites like *Pristomerus testaceus*, *Cremastus flavoorbitalis*, *Bracon* sp., *Pseudo perichaeta* sp. These hyper parasites parasitize and feed upon the larvae of this pest. Release parasitic eggs 1.0 lakh ha^{-1} *Trichogramma chilonis.*
- ✓ Spray *B. thuringiensis* var. kurstaki Bt formulations, such as Dipel @ 1.5 to 2.0 ml L^{-1} of water.
- ✓ Spray any pesticide at intervals of 15 days beginning a month after planting. Quinalphos 25 EC 1.5 L + Neem oil 1.0 L, NSKE 5 percent, Azadirachtin 1.0 percent 1.0-1.5 L or Carbaryl 50 WP 2 kg + Wettable Sulphur 50 WP 2 kg, Endosulfan 35EC 1.5 L + Neem oil 1.5 L, Fenpr-

opathrin 30 EC 250-340 ml or Thiodicarb 75 WP 625-1000 g Flubendiamide.

- ✓ When fruit is maturing and being harvested, avoid applying pesticide.
- ✓ Before planting new plants, uproot and destroy any old ones to prevent the spread of pest sand infection.

Vermicomposting: Role of Earthworm in Soil Formation

Ajay Kumar Yadav, Charu Sharma and Shivali Rana

Introduction

Vermicomposting, the transformation of organic waste into vermicompost, is a bio oxidative mesophilic process in which detritivorous earthworm species interact with microorganisms, strongly affecting decomposition processes, accelerating the stabilization of organic matter and greatly modifying its physical, chemical, and biological properties. This is an essential part in organic farming today. It can be easily prepared, has excellent properties, and is harmless to plants. The earthworms fragment the organic waste substrates, stimulate microbial activity greatly and increase rates of mineralization. These rapidly convert the waste into humus-like substances with finer structure than thermophilic composts but possessing a greater and more diverse microbial activity. Vermicompost being a stable fine granular organic matter, when added to clay soil loosens the soil and improves the passage for the entry of air. The mucus associated with the cast being hydroscopic absorbs water and prevents water logging and improves water-holding capacity. The organic carbon in vermicompost releases the nutrients slowly and steadily into the system and enables the plant to absorb these nutrients. The soil enriched with vermicompost provides additional substances that are not found in chemical fertilizers. Vermicomposting offers a solution to tonnes of organic agro-wastes that are being burned by farmers and to recycle and reuse these refuse to promote our agricultural development in more efficient, economical and environmentally friendly manner.

Role of earthworms in Soil

The earthworms are the biological indicator of the soil ecosystem as they indicate the health and fertility of the soil for proper cropping. The main activity of earthworms involves the ingestion of soil, mixing of different soil components and production of surface and sub surface castings thereby converting organic matter into soil humus. By the intensive mixing of organic matter with inorganic soil particles and microorganisms and by slime secretion, earthworms create stable soil crumbs, which enhance soil structure. In the soil for proper aeration, rich nutrient contents earthworms are very essential organisms. It play an important role in the decomposition of organic matter and soil metabolism through feeding, fragmentation, aeration, turnover and dispersion. They are biological indicators of soil

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quality, as a good population of earthworms indicates the presence of a large population of bacteria, viruses, fungi, insects, spiders and other organisms and thus a healthy soil. Soil structure is greatly influenced by two major activities of earthworms: Ingestion of soil, partial breakdown of organic matter, intimate mixing of these fractions and ejection of this material as surface or subsurface casts. Burrowing through the soil and bringing subsoil to the surface. During these processes, earthworms contribute to the formation of soil aggregates, improvement in soil aeration and porosity. Earthworms contribute to soil aggregation mainly through the production of casts, although earthworm burrows can also contribute to aggregate stability since they are often lined with oriented clays and humic materials.

Earthworms bring about mineralization of organic matter and thereby release the nutrients in available forms that can be taken up by the plants. Microbial activity in earthworm casts may have an important effect on soil crumb structure by increasing the stability of the worm-cast-soil relative to that of the surrounding soil. Earthworms digest organic matter and convert them into the humus. Humus has a high value of inorganic salts like N, P, K, and Ca these are the main integrant that enhances the crop productivity. The earthworm found in the different layer of the soil like epigeic earthworm found in the upper layer of the soil and not built the permanent burrow so this species is not involved in the mixing nutrients and aeration in the soil but the composting process is very fast as it decomposes biodegradable organic matter into the nutrient-rich manure. Vermicast or earthworm manure changes the soil profile, texture, and stabilization of the microbial community in the soil. Endogeic earthworms live in the horizontal burrow and feed on soil and some plant litter and help in the mixing of nutrients in the soil and change the texture of the soil.

Effect of earthworms on soil quality

Earthworms, known for enhancing soil productivity and fertility, play a crucial role in shaping soil structure. Their activities lead to physical, chemical, and biological alterations in the soil, earning them recognition as soil managers.

Effects on physical properties of soil

Soil structure undergoes significant influence from two primary activities of earthworms: Firstly, they ingest soil, partially break down organic matter, mix these fractions intimately, and then eject this material as surface or subsurface casts. Secondly, they burrow through the soil, bringing subsoil to the surface. Throughout these processes, earthworms aid in the formation of soil aggregates and enhance soil aeration and porosity. Earthworms primarily contribute to soil aggregation by producing casts, although their burrows can also bolster aggregate stability as they often contain oriented clays and humic materials. It's widely acknowledged that earthworm casts contain more water-stable aggre-gates than the surrounding soil, thereby affecting both water drainage from the soil and its moisture retention capacity, both crucial factors for plant productivity.

Effect on chemical properties of soil

Earthworms play a vital role in mineralizing organic matter, thereby releasing nutrients in forms readily available for plant uptake. When organic matter passes through the earthworm gut, it is ejected in their casts, which undergo further breakdown into finer particles, exposing a greater surface area to microbial decomposition. Consequently, earthworms significantly influence nutrient cycling processes across various ecosystems. This influence manifests across four stages: during transit through the earthworm gut, in freshly deposited casts, in aging casts, and during the long-term development of the entire soil profile. Earthworms contribute nutrients such as nitrogenous wastes, with their casts exhibiting higher concentrations of base-exchangeable bases, phosphorus, exchangeable potassium and manganese, and total exchangeable calcium. Additionally, earthworm activity promotes nitrification by increasing bacterial populations and soil aeration. A crucial effect of earthworms is their stimulation of microbial activity in casts, which enhances the conversion of soluble nitrogen into microbial protein, thereby preventing nitrogen loss through leaching into lower soil horizons. Moreover, the carbon-to-nitrogen ratios of casts are lower than those of the surrounding soil, summarizing the influence of earthworms on soil nitrogen and nitrogen cycling. Nitrogenous byproducts resulting from earthworm metabolism, including casts, urine, mucoproteins, and dead tissues, are returned to the soil, further enriching its nutrient content.

Earthworms and microorganisms

The relationship between earthworms and microorganisms is intricate. The majority of microorganism species found in the digestive tracts of earthworms are the same as those inhabiting the soils where the earthworms reside. In earthworm casts, the microbial population is significantly higher compared to the surrounding soil. These casts typically harbor a greater abundance of fungi, actinomycetes, and bacteria, along with heightened enzyme activity compared to the surrounding soil. The microbial activity within earthworm casts may play a crucial role in shaping soil crumb structure by enhancing the stability of the worm-cast-soil complex relative to the surrounding soil. Earthworms serve as vital agents for introducing microorganisms into soils. Many soil microorganisms remain dormant with low metabolic activity, awaiting suitable conditions such as the environment of the earthworm gut or its mucus to become active. Studies have demonstrated that earthworms increase overall microbial respiration in soil, thereby promoting microbial degradation of organic matter.

Earthworms and plant growth

Earthworms effectively prepare the soil for optimal plant growth. Darwin's observations regarding the positive impact of earthworms on soil fertility, crucial for plant development, have been widely recognized. Many researchers have endeavored to showcase the beneficial effects of earthworms on soil, with a particular focus on enhancing plant growth and crop yields. Earthworms

release substances such as auxins and cytokinins, which are beneficial for plant growth. Besides the presence of essential macronutrients and micro-nutrients in earthworm casts and their secretions, which are plentiful, the beneficial effects of earthworms on plant growth may stem from various other factors. It's possible that certain metabolites produced by earthworms play a role in stimulating plant growth.

Benefits of earthworms

- ✓ It helps in water infilteration, soil aereation.
- ✓ It helps in soil compaction and maintain soil health.
- ✓ It maintains soil organic matter
- ✓ It maintains soil pH.
- ✓ It helps in providing beneficial microbes.



Conclusion

The green organic waste is turned into a dark, nutrient-rich soil through the process of vermi-composting. This is primarily due to microorganisms breaking down the soil and keeping it in a healthy state for plant growth. One of the very few environmentally beneficial methods for recycling biomass and organic matter wastes into compost that contains important nutrients is vermicomposting. Globally, there should be encouragement for environmentally responsible waste management practices.

Zero Budget Natural Farming (ZBNF)

Anup Gajanan Gadekar

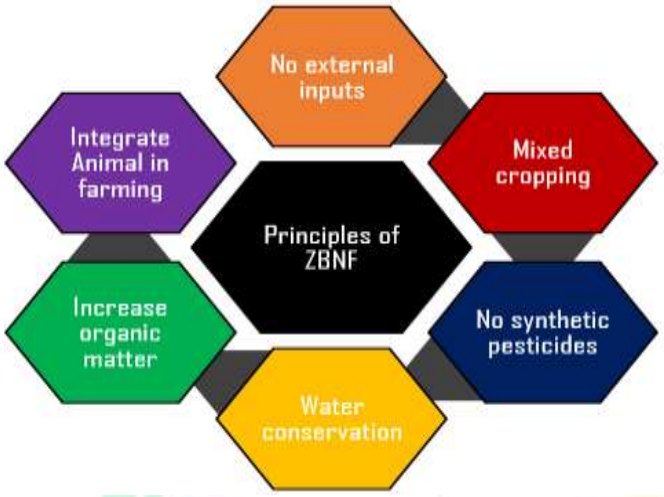
Introduction

In ancient time farmer's target was only on growing food to feed burgeoning population. As population increase it become difficult to raise organic food for all. This had led to the adoption of unsustainable agricultural practices to ensure the food security. The use of pesticides, fungicides, herbicides in conventional agriculture, ensued food produce for all. But there were followed by many harmful consequences. Major obstacle emerged about quality of food. Moreover, initially India had subsistence type of farming but as the dependence on food grains increased with increasing population it had automatically shifted to commercial farming. Pesticides, fertilizers, and inorganic chemicals are used excessively in modern agriculture. Consequently, a farmer with modest holdings who invests in costly inputs runs a significant financial risk and ultimately becomes enmeshed in the debt cycle. Given the wide range of detrimental effects of commercial farming, it is now crucial to find alternative approaches that can produce superior results with minimal depletion of natural resources.

Thus, the issue that now has to be answered is: What are some strategies for using low-input farming to produce high-quality results? "Zero Budget Natural Farming" is the answer to this query (ZBNF). ZBNF, as the name suggests, is a place where there is no cultivation or harvesting costs. It implies that farmers may produce crops healthily without having to buy pesticides and fertilizers, and that this farming method also enhances the nutritional value of crop production and ultimately economy of country. The grassroots movement known as Zero Budget Natural Farming (ZBNF) was first successful in South India, specifically in Karnataka. Today, it is practiced throughout India by peasants. Farmers that are plagued by high farming costs find relief from the farming methods. Zero Budget Natural Farming (ZNBF) is the practice of growing crops without the use of pesticides, fertilizers, or other outside resources. The term "Zero Budget" describes all crops having zero cost of production. The movement in Karnataka state was born out of collaboration between Mr Subhash Palekar in the mid-1990s as an alternative to the Green Revolution methods such as the adoption of high yielding variety seeds and use of chemical based fertilisers and pesticides, who put together the ZBNF practices, and the state farmers association Karnataka Rajya Raitha Sangha (KRRS), a member of La Via Campesina (LVC). He said that the rising expense of these external inputs was a leading source of farmer indebtedness and suicide, while the impact of chemicals on the environment and long-term fertility was disastrous. Addressing the United Nati-

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ons conference on desertification (COP-14), Indian PM told the global community that India is focusing on Zero-Budget Natural Farming (ZBNF). ZBNF was also highlighted in budget 2019 in the bid to double farmer's income by 2022.



Subhash Palekar's Zero Budget Natural Farming

Subhash Palekar's Budget of Zero Natural farming is a special kind of farming where you can get essential inputs from the market, such as seeds, fertilizer, and plant protection chemicals, with absolutely no financial outlay. Farmers don't need to use pesticides or fertilizers to cultivate resilient native crop varieties. Since it is a zero-budget farming no institutional credit would be required and dependence on hired labour is also reduced to bare minimum. All that the system requires is native breed of cattle which is any case forms an integral part of farming families in rural areas. It is claimed that one cow is sufficient to take up this method of farming on thirty acres of land.

Four principles of ZBNF: There are four basic principles of ZBNF which must have been followed during this method.

- ✓ **Jeevamrutha:** It is a mixture of cow dung, cow urine, jaggery, pulse flour, water and soil and this mixture is applied in the field. It is a fermented microbial culture. It provides nutrients, but most importantly, acts as a catalytic agent that promotes the activity of microorganisms in the soil, as well as increases earthworm activity.
- ✓ **Bijamrita:** A composition of neem leaves and pulp, tobacco and green chillies, which is prepared for management of insect and pests. Seed treatment can be done with this mixture.
- ✓ **Mulching:** It is used to protect the topsoil during cultivation and it saves the topsoil from tilling.
- ✓ **Wafsa condition:** It is the condition where air molecules and water molecules both are present in the soil. Thus, providing water to maintain the required moisture-air balance is necessary.

Target impacted by ZBNF

- ✓ Put an end to hunger and guarantee that every-one, especially the weak and impoverished, has access to enough food that is healthy and sufficient.
- ✓ Increase the agricultural output and incomes of small-scale food producers by twofold by providing equitable and safe access to land, useful resources, inputs, expertise, financial services, value-adding possibilities, and non-farm jobs.
- ✓ Make sure that food production systems are sustainable and put in place resilient techniques that boost output, support ecosystem mainten-ance, fortify climate change resilience and enha-

nce the quality of the land and soil.

- ✓ Maintain genetic diversity of seeds, cultivated plants and farmed and domesticated animals, and promote access to and equitable sharing of benefits from the use of genetic resources.

Advantages of ZBNF

- ✓ Zero budget natural farming reduces the initial cost of farmers.
- ✓ Farmer's income automatically increases.
- ✓ The soil ecosystem improves.
- ✓ Cow dung adds soil value. It is full of nutrients value and available locally.
- ✓ Bacteria of cow dung decompose the organic matter in soil and make soil for the plants.
- ✓ It required less electricity and water.
- ✓ ZBNF improves the productivity of the soil.
- ✓ It decreases the disease attack risk on the crop.

Government initiatives

With the Paramparagat Krishi Vikas Yojana (PKVY), which has been in effect since 2015-16, and the Rashtriya Krishi Vikas Yojana (RKVY), the Indian government is encouraging organic farming. The goal of the Paramparagat Krishi Vikas Yojana (PKVY) is to use low-cost, environmentally friendly technologies to create agricultural goods free of chemicals and pesticide residues. This program encourages organic farming and the consumption of organic food while discouraging the use of chemical pesticides and fertilizers. Organic farming or natural farming model components are supported by the relevant State Level Sanctioning Committee (SLSC) in accordance with the RKVY system. Andhra Pradesh unveiled an ambitious goal in June 2018 to become the first Indian state to practice 100% natural farming by 2024, citing the benefits of ZBNF. Scientists from the National Academy of Agricultural Sciences, however, had argued that government promotion of ZBNF should wait until it receives the appropriate scientific endorsement.



Source: IARI, New Delhi

Conclusion

India is one of the largest agrarian economy in the world, where, about 44 per cent of the workforce are employed in agriculture contributing 14 percent of the GDP and about 10 percent of the country's exports. The Zero Budget Natural Farming (ZBNF) can help to eliminating rural indebtedness and degradation of natural resources in India. No Spending Cap Natural farming has benefits and drawbacks of its own, but with the right execution, it may be a dependable part of Indian agriculture. To establish a knowledge bridge between farmers and his farming system, the government should take the lead. The government should prioritize addressing the situation, which includes growing labor costs, by raising the price at which produce is sold.

Seed Treatment: First Step of Plant Disease Management

Kuntilesh Fal Dessai, Sheetal and Gayatri Sinha

Introduction

According to United Nations estimates from 2019, there could be 9.7 billion people on the planet by the year 2050. In order to secure global food security in a sustainable manner, global agriculture will confront significant obstacles in increasing its output by at least 50% (Searchinger *et al*., 2019). A key factor in promoting food security is seeds: Roughly 90% of the food crops farmed worldwide are seed-grown. For this reason, planting nutritious, high-quality seeds is crucial to ensuring agricultural yields and food production. On and in seeds exist numerous pathogens, such as fungus, bacteria, viruses, and nematodes, which cause serious diseases in a number of crops. One significant method for the large-scale spread of pathogens is the link between the infection and seed. One typical method for pathogen persistence is seed association (Denancé and Grimault, 2022). It is frequently advised to utilize seeds that have been verified as disease-free or as having contamination levels below a certain threshold as the main management tactic. Seed treatment can also encourage healthy crops by improving their immunity and promoting uniform germination. Seed treatment enhances the resistance of the seeds, making them stronger against pathogens and pest attacks and stresses in their environment. Chemical or biological seed treatments can provide critical protection since the germination stage, protecting the emergence out of the soil and during the first stage of the crop cycle by preventing seeds against seed and soil-borne pathogens, seed-borne insects, diseases, and pests.



Fig.1: Categories of seed treatment

Advantages of seed treatment

- ✓ More alternatives available to chemical in effective manner.
- ✓ Protection of seed during storage and after planting in soil.
- ✓ Reduction in initial inoculum.
- ✓ Reduce the danger to non-target organisms, eliminate drift issues, and lessen the amount of land exposed to active ingredients with optimum efficacy in order to minimize the negative effects on the environment. Application per hectare, resulting in outstanding control of soil-borne, foliar, and seed-borne diseases and a reduction in

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the cost of disease control per hectare.

- ✓ Boost seed vigor, as this is essential for field emergence and establishment to be successful.
- ✓ Even and uniform application of the chemical.
- ✓ Combination of treatment can be applied more precisely.
- ✓ Breaking of seed dormancy and improve seed germination.

Types of seed treatment

Physical methods of seed treatments: Physical treatments include hot-water treatment (for loose smut of wheat at 52 ℃ for 10 minutes), solar-heat treatment (loose smut of wheat), and the like.

Biological methods of seed treatments: A wide range of biotic, abiotic, and physiological stresses are lessened in seed and seedlings when beneficial microorganisms, such as fungus and bacteria (species of *Trichoderma, Pseudomonas, Bacillus, Rhizobia* etc.,), are applied to the seed (Mastouri *et al*., 2010). Biological treatment includes, seed treatment with bio-control agents like *Trichoderma* spp. (fungal bio-agents), *Bacillus* spp. (Bacterial bio-agents) and *Pseudomonas* spp. etc.

Radiation treatment: Chemical pesticides applied to seeds have a variety of unfavorable impacts, chief among them being the persistence of the harmful principles in the environment and plant system. Although radioactive irradiation has been shown to be effective in a few cases as well (Bagegni *et al*., 1990), it has not been applied extensively since seeds are frequently killed by exposures high enough to control infections. Different types of electromagnetic radiation such as gamma, high energy electrons, ultrasonic radiation, microwave and UV radiation have been used as alternative seed treatment agents for management of microbial infestations. Inactivation or control of microorganisms and insect pests by gamma irradiation on various plant products have been reported. Gamma irradiation at non-harmful doses (0.10-0.50 kiloGray) decreases microbial infestation in seedlings of all kinds, according to Singh and Singh's 2005 study. The four rice cultivars that were studied showed that the seeds that were exposed to 0.10 kilo Gray (kGy) had the highest rate of germination, but low doses of gamma radiation enhanced root growth. Although laser light has many uses in agriculture, more research is needed to substantiate its promise as a substitute for controlling illnesses that start in the seed, particularly those caused by internal fungi.

Chemical methods of seed treatments: Today, a wide variety of homemade and commercial seed treatments are accessible. Farmers may choose to use a single chemical seed treatment or a combination of seed treatments containing biocontrol agents, depending on the needs of their particular crops for different problems. The various seed treatments are described here.

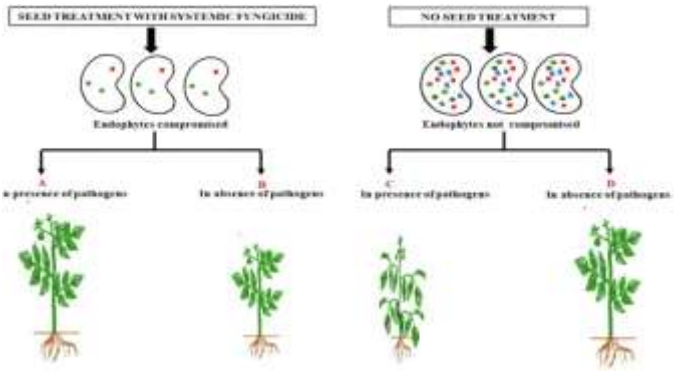
- ✓ Fungicide seed treatment can provide them protection and prevent fungal diseases. Seeds are especially highly susceptible to soil borne pathogens in the early stages of growth and some fungi can be hard to combat on their own.
- ✓ Insecticide seed treatments can provide protecti-

on against such pests with the added benefit of having a lower concentration of chemicals than the pesticides applied to fully grown crops.

- ✓ Fertilizer seed treatments are another type of seed treatment that helps with plant growth.
- ✓ Seed treatments with bio-fertilizers can enhance fertilizer performance or supply micro-nutrients to the soil to enrich the growth environment for the seeds.

Precautions in seed treatment

- ✓ In addition to being toxic to humans, the majority of compounds used in seed treatment can also be damaging to seeds. It takes great caution to guarantee that treated seed is never fed to people or animals.
- ✓ Additionally, it's important to treat seed at the proper dosage rate using too little or too much material might have the same detrimental effects as applying none at all.
- ✓ If the seeds are to be treated with bacterial cultures also, the order in which seed treatments should be done shall be as follow: FIR (Fungicides, Insecticides and Rhizobium).



Conclusion

Management of seed and soil-borne pathogenic fungi using fungicides is important for ensuring food security. Systemic fungicide pre-sowing seed treatment is a widely accepted method for the majority of agricultural crops grown worldwide. The goal of the treatment is to shield the crop from illnesses that are spread by soil and seeds. More crops should be researched to compare the benefits of seed treatment in managing diseases vs the possible loss in crop performance caused by disruption of the seed endobiome. This can be achieved by using fungicides with varying modes of action.

References

Bagegni, A. M., Sleper, D. A., Kerr, H. D. and Morris, J. S. (1990). Viability of *Acremonium coenophialum* in tall fescue seed after ionising radiation treatments. *Crop Science*, 30: 1272-1275.

Mastouri, F., Björkman, T. and Harman, G. E. (2010). Seed treatment with *Trichoderma harzianum* alleviates biotic, abiotic, and physiological stresses in germinating seeds and seedlings. *Phytopathology*, 100(11): 1213-1221.

Searchinger, T., Waite, R., Hanson, C., Ranganathan, J., Dumas, P., Matthews, E. and Klirs, C. (2019). Creating a sustainable food future: A menu of solutions to feed nearly 10 billion people by 2050.

Singh, M. T. and Singh, M. S. (2005). Effect of gamma irradiation on seed micoflora seed germination and seedling growth of rice. *Oryza*, 42(2): 129-132.

Role of Bioinformatics in Agriculture

Munmun Mitra, Rishita Kapoor and Meena Wankhade

Introduction

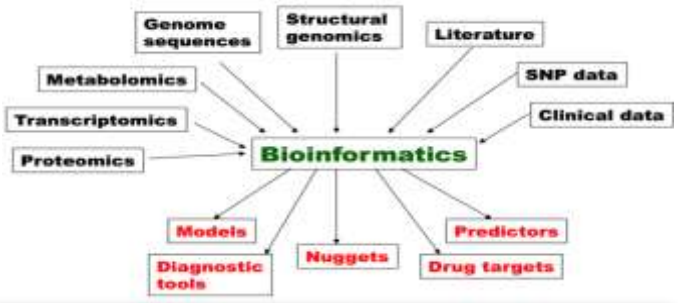
Bioinformatics is a crucial subdiscipline that bridges biology and computer science, focusing on the acquisition, storage, analysis, and dissemination of biological data. This interdisciplinary field utilizes a combination of biology, chemistry, physics, computer science, programming, mathematics, and statistics to analyze and interpret biological data. The primary goal of bioinformatics is to extract knowledge from biological data through the development of algorithms and software tools. Bioinformatics, a discipline that combines biology and computer science has significantly transformed the agricultural sector by providing powerful tools for understanding and manipulating plant genomes, improving crop yield, and enhancing food security. This article explores the applications of bioinformatics in plant biotechnology and agriculture, highlighting its impact on stress resistance, disease management, and the development of new crop varieties.

Historical Perspective: The term "bioinformatics" was first coined in 1960 by Dutch biologists Paulien Hogeweg and Ben Hesper to describe the study of information processes in biotic systems. The field experienced significant growth in the mid-1990s due to advancements in DNA sequencing technology driven by projects like the Human Genome Project.

Key Aspects of Bioinformatics

Data Analysis: Bioinformatics involves analyzing DNA, RNA, protein sequences, and other biological data to understand genetic and genomic information.

- ✓ **Computational Biology:** It encompasses computational, statistical, and computer programming techniques for analyzing biological queries and simulating biological processes.
- ✓ **Applications:** Bioinformatics finds applications in genomics, proteomics, protein structure modeling, image analysis, drug design, gene therapy, evolutionary studies, microbial applications, and more.
- ✓ **Role in Medicine:** In the medical field, bioinformatics aids in precision medicine by developing measures to prevent and cure infectious diseases through advanced data analysis techniques.



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Applications of Bioinformatics in Agriculture

Bioinformatics has revolutionized the agricultural sector. It plays a crucial role in the agriculture sector by providing tools and techniques to analyze and interpret biological data related to plants and crops. Some key applications of bioinformatics in agriculture include:

- ✓ **Genomics and Metabolomics:** Bioinformatics helps in understanding the genetic and molecular basis of plant processes, which is fundamental for efficient exploitation of plants as biological resources.
- ✓ **Genome sequencing and analysis:** Next-Generation Sequencing (NGS) technologies have enabled the rapid sequencing of plant genomes, providing valuable insights into gene function and regulation.
- ✓ **Plant Breeding:** Bioinformatics tools are used to identify and manipulate genes related to specific traits, such as pathogen and abiotic stress resistance, quality characteristics, and reproductive characteristics, to improve crop yields.
- ✓ **QTL Analysis and Mapping:** Quantitative Trait Locus (QTL) analysis and mapping help in identifying the genetic basis of complex traits, which is crucial for crop improvement.
- ✓ **Genome-wide association studies (GWAS):** GWAS identify loci and allelic variations associated with valuable traits, facilitating crop modification and improvement.
- ✓ **Genotype Building Experiments:** Bioinformatics tools are used to build genotypes and analyze their effects on plant traits, which is essential for crop breeding
- ✓ **Agriculturally Important Databases:** Bioinformatics databases store and manage large amounts of biological information related to plants and crops, which is crucial for research and development.
- ✓ **Molecular Plant Breeding:** Bioinformatics tools are used to develop molecular markers for plant breeding, which helps in selecting plants with desired traits.
- ✓ **Rational Plant Improvement:** Bioinformatics tools are used to identify and manipulate genes related to specific traits, which helps in improving plant performance.
- ✓ **Sustainable Agricultural Development:** Bioinfor-matics tools are used to study the impact of genome sequencing on agriculture, which helps in developing sustainable agricultural practices
- ✓ **Plant Genomics:** Bioinformatics tools are used to study the genetic and molecular basis of plant processes, which is fundamental for efficient exploitation of plants as biological resources.
- ✓ **Model Organism:** Bioinformatics tools are used to study model organisms, which helps in understanding plant biology and improving crop yields.
- ✓ **Managing and Distributing Plant Genome Data:** Bioinformatics tools are used to manage and distribute plant genome data, which is crucial for research and development.

- ✓ **Molecular Plant Breeding:** Bioinformatics tools are used to develop molecular markers for plant breeding, which helps in selecting plants with desired traits.
- ✓ **Rational Plant Improvement:** Bioinformatics tools are used to identify and manipulate genes related to specific traits, which helps in improving plant performance.
- ✓ **Genotype Building Experiments:** Bioinformatics tools are used to build genotypes and analyze their effects on plant traits, which is essential for crop breeding.
- ✓ **Nutritional Genomics:** Bioinformatics tools aid in developing biotechnology tools for genetically modifying crops to enhance nutritional content, addressing food supply challenges for a growing population.
- ✓ **Modeling Plant Growth:** By predicting and manipulating plant growth patterns using bioinformatics tools, researchers can optimize agricultural practices for improved crop yields and sustainable agriculture practices

In summary, bioinformatics plays a vital role in the agriculture sector by providing tools and techniques to analyze and interpret biological data related to plants and crops, which ultimately leads to improved crop yields and sustainable agricultural practices.

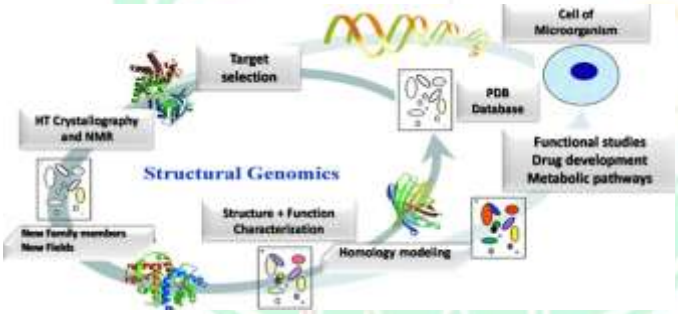
Challenges and Limitations

Despite the significant progress made in bioinformatics, there are several challenges and limitations:

- ✓ **Data integration and management:** The massive, complex datasets generated by agricultural systems require sophisticated analytical techniques and effective data integration and communication across public and private sectors.
- ✓ **Digital disparities:** Subsistence farmers often lack the skills and resources to utilize sophisticated digital. Subsistence farmers often lack the skills to utilize sophisticated digital technologies, and there is a need for improved and efficient data integration and communication across public and private sectors
- ✓ **Algorithm Development:** Developing sophisticated algorithms and methods to derive meaningful insights from diverse data sources, such as genomic, soil nutrient profiles, and climate patterns, is crucial but challenging.
- ✓ **Interdisciplinary Approach:** Bioinformatics in agriculture requires an interdisciplinary approach, integrating expertise in biology, computer science, engineering, and social sciences. This can be challenging due to the diverse backgrounds of researchers and stakeholders.
- ✓ **Data Privacy and Security:** Ensuring the privacy and security of agricultural data is crucial, as it often contains sensitive information about crops, farmers, and the environment.
- ✓ **Economic Viability:** Deploying big data solutions on a large scale requires tackling pervasive digital disparities and making precision agriculture tools economically viable and accessible.

Future Outlook

As genome sequencing capabilities continue to expand rapidly, bioinformatics will play a crucial role in developing advanced algorithms to handle massive datasets efficiently. The development of large centralized databases of genome sequences is a key focus for future growth in bioinformatics to aid scientific research effectively. In conclusion, bioinformatics plays a vital role in advancing our understanding of biological processes by leveraging computational tools to analyze complex biological data. Its interdisciplinary nature makes it a powerful tool for researchers in various fields such as genetics, genomics, medicine, and evolutionary biology.



Conclusion

An interdisciplinary field of study that combines computer science, mathematics, and biology is called bioinformatics. Information technology is used in bioinformatics to handle biological data, which aids in the deciphering of plant genomes. In biological science, a vast amount of data has been generated over the past 20 years. This began with the emergence of two things: first, the fast implementation of high throughput experimental techniques in laboratory research; and second, the sequencing of model organisms' genomes.

Concept of CRISPR Cas Technology

Oksana Mandal, Rishita Kapoor and Manjula

Understanding the Concept of CRISPR-Cas Technology

CRISPR-Cas technology is a revolutionary gene-editing tool that has transformed the landscape of genetic engineering. It is based on the natural immune system of bacteria, where CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) sequences serve as a genetic memory bank to recognize and combat viral infections. In recent years, the field of genetics and biotechnology has witnessed a revolutionary advancement with the emergence of CRISPR-Cas technology. This groundbreaking tool has transformed the landscape of genetic engineering, offering unprecedented precision, efficiency, and versatility in manipulating DNA. From its humble beginnings as a bacterial immune system to its current status as a powerful gene-editing tool, CRISPR-Cas has captured the imagination of scientists and the public alike. This article delves into the intricacies of CRISPR-Cas technology, exploring its origins, mechanisms, applications, ethical considerations, and future prospects.

Origin

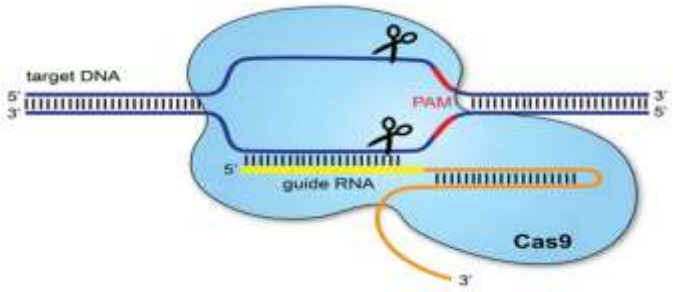
CRISPR-Cas technology traces its roots back to a fundamental biological process found in bacteria known as Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR). Initially discovered in the late 1980s, CRISPR was identified as a peculiar genetic sequence in bacterial genomes that played a role in their immune defense against viral infections. This system essentially acts as a molecular memory bank, storing snippets of viral DNA to recognize and combat future invasions. The CRISPR system operates in conjunction with CRISPR-associated (Cas) proteins, which act as molecular scissors capable of precisely cutting DNA at specific locations. The marriage of CRISPR sequences with Cas proteins led to the development of the CRISPR-Cas technology that revolutionized genetic engineering. In 2012, researchers demonstrated that guide RNAs could direct a Cas nuclease (such as Cas9) to any DNA sequence, enabling precise gene editing in various cells, including human cells (Asmamaw and Zawdie, 2021).

Mechanism

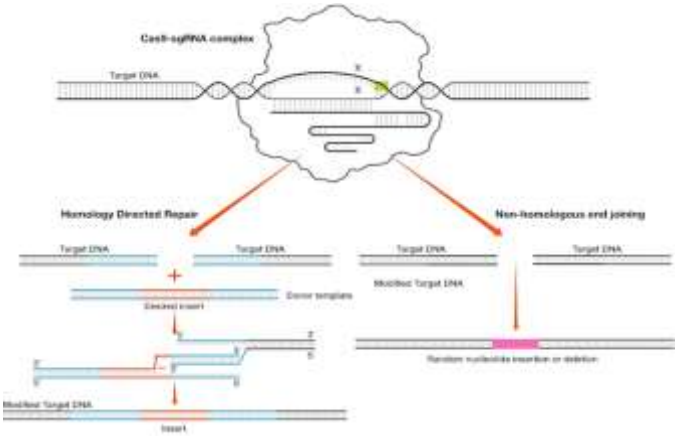
At the core of CRISPR-Cas technology lies its ability to target specific DNA sequences with remarkable accuracy. The technology involves two essential components: a guide RNA (gRNA) that

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matches a desired target gene, and Cas9 (CRISPR-associated protein 9) an endonuclease that causes a double-stranded DNA break, allowing modifications to the genome (Redman *et al*., 2016).



The process of CRISPR-Cas gene editing can be divided into three steps: recognition, cleavage, and repair. First, the gRNA recognizes the target DNA sequence and the process begins with the design of a guide RNA that is complementary to the target DNA sequence. This guide RNA leads the Cas protein to the desired location on the DNA strand, where it initiates a double-strand break. Then, Cas9 binds to the DNA and cuts it, effectively shutting off the targeted gene or activating it if a modified version of Cas9 is used. Finally, the cell's repair machinery fixes the DNA break, either by introducing precise genetic modifications such as gene knockouts, insertions or removing genetic material or by replacing an existing segment with a customized DNA sequence (Wang *et al*., 2023). The simplicity and efficiency of CRISPR-Cas technology have made it a preferred tool for genetic manipulation in various organisms ranging from bacteria to plants and animals. Its versatility extends beyond traditional gene editing to applications in gene regulation, epigenome editing, and even potential therapeutic interventions for genetic disorders.



DNA repair via homology directed repair and non-homologous end joining

Applications

The impact of CRISPR-Cas technology spans across diverse fields, offering innovative solutions to longstanding challenges. In agriculture, CRISPR-Cas has been utilized to develop crops with enhanced nutritional value, increased resistance to pests and diseases, and improved yields. The precision of gene editing allows for targeted modifications without introducing foreign genes, addressing concerns related to genetically modified organisms (GMOs). In medicine, CRISPR-Cas holds immense promise for treating genetic diseases by correcting faulty genes responsible for conditions like sickle cell anemia, cystic fibrosis, and muscular dystrophy. Researchers are exploring the potential of using CRISPR-Cas for cancer therapies, immunotherapy advancements and personalized medicine approaches tailored to individual genetic profiles.

Limitations

CRISPR/Cas is an extremely powerful tool, but it has important limitations:

- ✓ Difficult to deliver the CRISPR/Cas material to mature cells in large numbers, which remains a

problem for many clinical applications. Viral vectors are the most common delivery method.

- ✓ It is not 100% efficient, so even the cells that take in CRISPR/Cas may not have genome editing activity.
- ✓ It is not 100% accurate, and "off-target" edits, while rare, may have severe consequences, particularly in clinical applications.

Ethical Considerations and Challenges

Despite its transformative potential, CRISPR -Cas technology raises significant ethical considerations and challenges that warrant careful deliberation. One of the primary concerns revolves around off-target effects, where unintended genetic modifications may occur at sites similar to the target sequence. Ensuring the safety and accuracy of gene editing procedures is paramount to prevent unforeseen consequences. The ethical implications of germline editing making heritable changes to an individual's DNA that can be passed on to future generations have sparked debates about the boundaries of genetic manipulation and the potential for designer babies. Regulatory frameworks must be established to govern the responsible use of CRISPR-Cas technology and mitigate risks associated with misuse or unintended outcomes.

Future Prospects and Innovations

Looking ahead, the future of CRISPR-Cas technology holds exciting possibilities for advancing scientific research, healthcare practices and biotechnological innovations. Ongoing research efforts are focused on refining gene editing techniques, enhancing specificity, and developing novel applications in areas such as synthetic biology and regenerative medicine. The convergence of CRISPR-Cas technology with other cutting-edge technologies like artificial intelligence and nanotechnology opens up new frontiers for interdisciplinary collaborations and transformative discoveries. As scientists continue to unravel the complexities of the genome and harness the power of genetic manipulation, we stand at the cusp of a new era defined by unprecedented capabilities to shape life at its most fundamental level. In conclusion, CRISPR-Cas technology represents a paradigm shift in our ability to manipulate genetic information with precision and efficiency. From its humble origins in bacterial immunity to its current status as a game-changing tool in genetics and biotechnology, CRISPR-Cas has redefined our understanding of DNA editing and opened up a world of possibilities for addressing pressing challenges in agriculture, medicine, and beyond. As we navigate the ethical considerations and technical challenges associated with this revolutionary technology, we are poised on the brink of a genetic revolution that promises to reshape our world in ways we are only beginning to comprehend.

References:

Asmamaw, M. and Zawdie, B. (2021). Mechanism and Applications of CRISPR/Cas-9-Mediated Genome Editing. *Biologics*, 15: 353-361.

Redman, M., King, A., Watson, C. and King, D. (2016). What is CRISPR/Cas9? *Arch. of dis. in childh. Edu. and Practice*, 101(4): 213-215

Organic Farming: A Scenario and Vision towards Sustainability

Roniujjaman Shaikh, Shivali Rana and Aditi Sharma

Introduction

Addressing the challenge of sustaining India's expanding population with ample food has been a significant obstacle since the nation gained independence. To tackle this issue, methods like introducing irrigation water, nutrients, and pesticides into high-yield crop varieties have been employed. While this strategy has raised concerns regarding soil health, environmental pollution, pesticide toxicity, and the long-term viability of agricultural practices, it has also led to a surplus of food. Consequently, scientists and policymakers are revaluating agricultural systems to prioritize biological inputs over heavy reliance on chemical fertilizers and pesticides, prompting a shift towards more sustainable farming methods. Among these methods, organic farming emerges as a promising approach that not only addresses these concerns but also presents a pathway towards long-term sustainability. Recently, organic farming as a cultivation process has been gaining popularity. Organically grown foods have become a preferred choice for both consumers and farmers, aligning with the "go green" lifestyle. However, the question arises: what does organic farming entail? The term 'organic' was initially coined by Northbourne in 1940 in his book titled 'Look to the Land'. Northbourne proposed that the farm itself should have biological completeness; it must function as a living entity, maintaining a balanced organic life within itself. Additionally, Northbourne defined organic farming as 'an ecological production management system that encourages and enhances biodiversity, biological cycles, and soil biological activity'. Organic farming focuses on cultivating land and growing crops in a natural manner, emphasizing ecologically based pest control and the use of biologically derived fertilizers, primarily sourced from animal and plant wastes, along with nitrogen-fixing cover crops. Originating as a response to the environmental harm caused by chemical pesticides and synthetic fertilizers in conventional agriculture, modern organic farming offers numerous ecological benefits. In comparison to conventional methods, organic farming employs fewer pesticides, reduces soil erosion, minimizes nitrate leaching into groundwater and surface water, and promotes the recycling of animal wastes within the farm.

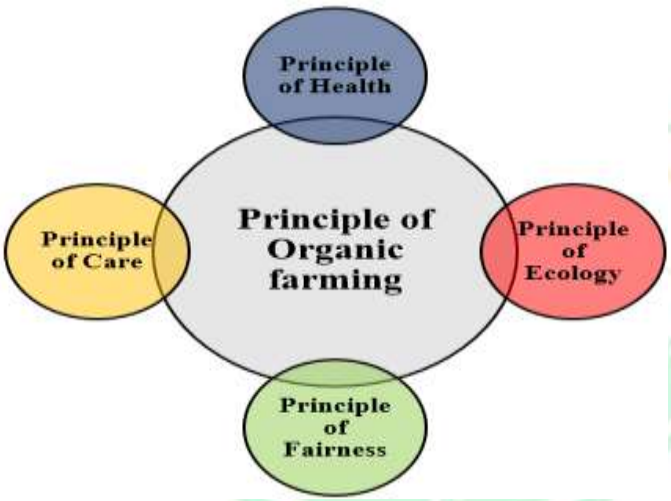
Organic farming embodies a holistic and ecologically friendly approach to agriculture. It adv-

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ocates for the use of natural inputs, crop rotation, and biodiversity conservation to improve soil health, safeguard the environment, and produce nutritious food. By avoiding synthetic chemicals and embracing sustainable practices, organic farming presents a viable solution to many of the challenges associated with conventional agriculture.

Principles of Organic Farming

The four main principles of organic production given by IFOAM in 2005 (IFOAM, founded in 1972) are:



- ✓ **The Principle of Health:** Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.
- ✓ **The Principle of Ecology:** Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.
- ✓ **The Principle of Fairness:** Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.
- ✓ **The Principle of Care:** Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Objectives of Organic Farming

These are major objectives of sustainable organic farming:

- ✓ A high crop yield
- ✓ Synchronization between nature and agriculture system by rejuvenation of soil and nutrient recycling
- ✓ Increasing microflora and microfauna of soil, thus enhancing fertility
- ✓ Enhancing soil quality without compromising biological diversity in the ecosystem
- ✓ Promoting alternative energy resource usage
- ✓ Developing equilibrium between crop farming and animal husbandry
- ✓ Keeping animals in an environment which is close to their natural habitat
- ✓ Preserving and applying traditional knowledge in farming and management

Benefits of organic farming

Nutritional benefits and health safety: The increasing demand for organically cultivated fresh produce has sparked interest among both consumers and producers regarding the nutritional composition of organic versus conventionally grown foods. According to research conducted by AFSSA (2003), organically grown foods, particularly leafy vegetables and tubers, exhibit higher dry matter content

compared to conventionally grown counterparts. While organic cereals and their products may contain lower protein levels than conventional cereals, they boast higher-quality proteins with superior amino acid profiles. Organic wheat, for instance, has been observed to contain 25-30% more lysine compared to conventional wheat. Moreover, organic produce tends to contain higher levels of essential nutrients such as magnesium, iron, and phosphorus, as well as major elements like calcium, sodium, and potassium, along with trace elements including manganese, iodine, chromium, molybdenum, selenium, boron, copper, vanadium, and zinc.

Environmental impact: Organic farming plays a crucial role in environmental preservation. Extensive research has examined the impact of organic and conventional agriculture on the environment, with indications suggesting that organic farming poses fewer environmental risks. This is attributed to its prohibition of synthetic pesticides, many of which pose potential threats to water sources, soil health, as well as local terrestrial and aquatic ecosystems. Moreover, organic farms excel in promoting biodiversity compared to conventional counterparts, primarily due to the implementation of crop rotation practices.

Furthermore, organic farming enhances the physico-biological characteristics of soil by increasing organic matter content, biomass, enzyme activity, soil stability, water percolation, and water-holding capacities. It also mitigates erosion, both water and wind-induced, more effectively than conventional farming methods. Additionally, organic farming demonstrates a lower energy footprint and generates less waste per unit area or yield compared to conventional practices.

Socioeconomic impact: Organic farming necessitates a higher level of labor, thus generating more income-generating opportunities/farm. Typically, organic products command a premium of 10-40% compared to similar conventionally grown crops, contingent upon various factors affecting both input and output. On the input side, factors contributing to the higher price of organic foods include the expenses associated with obtaining organic certification, the elevated cost of labor in agricultural operations, and the absence of subsidies for organics in India, unlike chemical inputs. However, consumers are increasingly willing to pay higher prices due to growing health consciousness. Additionally, some organic products face a shortage in supply relative to high demand, resulting in increased costs. Moreover, locally produced biofertilizers and pesticides contribute to lower yearly inputs for farmers. Furthermore, laborers employed in organic farms are less exposed to agricultural chemicals, thereby experiencing improved occupational health. Organic foods also boast a longer shelf life compared to conventional counterparts, attributed to lower nitrate content and higher antioxidant levels. Nitrates accelerate food spoilage, while antioxidants contribute to prolonging the shelf life of foods. The organic farming sector is experiencing significant growth due to the profitability of organic produce,

leading to an increasing inclination towards organic agriculture among farmers.

Organic agriculture and sustainable development

The concept of sustainable agriculture encompasses three primary objectives: environmental health, economic profitability, and social and economic equity. Sustainability is based on the principle that we must meet present needs without compromising the ability of future generations to meet their own needs. The fundamental principles of organic farming for environmental sustainability include:

- ✓ Enhancing and preserving the natural landscape and agro-ecosystem.
- ✓ Preventing the overexploitation and contamination of natural resources.
- ✓ Reducing the consumption of non-renewable energy sources.
- ✓ Leveraging synergies inherent in natural ecosystems.
- ✓ Promoting and maintaining soil health by encouraging the use of organic manures and avoiding harm from pesticides.
- ✓ Ensuring optimal economic returns while providing a safe, secure, and healthy working environment.
- ✓ Recognizing the value of indigenous knowledge and traditional farming systems.

Long-term economic viability is achievable through organic farming, primarily due to its ability to command premium prices in the market. The increased production costs associated with pesticides and fertilizers in conventional farming, coupled with their adverse effects on farmer health, disrupt the economic balance within communities, with benefits primarily accruing to pesticide manufacturers. The continual degradation of soil fertility caused by chemical fertilizers results in decreased productivity and elevated production costs, rendering conventional farming economically unsustainable. Implementing a comprehensive strategy that addresses food security, rural employment generation, poverty alleviation, natural resource conservation, adoption of export-oriented production systems, development of robust infrastructure, and fostering active participation from government and private-public sectors is essential to revitalizing economic sustainability in agriculture.

Conclusion

Organic farming produces food that is both more nutritious and safer. The popularity of organic food is experiencing significant growth as consumers increasingly seek out healthier and safer options. The organic farming process is known to be more environmentally friendly compared to conventional farming practices. Various government schemes are being implemented to promote organic farming. However, transitioning towards organic farming poses challenges, particularly for small-scale landholders. These challenges include declining crop productivity, lack of access to irrigation water, high labour costs, limited market availability and minimum support prices, unpredictable monsoon patterns, and temperature fluctuations. It is imperati-

ve for the government to devise policies aimed at addressing these constraints in organic crop cultivation to ensure successful planning and execution, benefiting both farmers and the economy.

Fertilizer Application for Dryland Crop Production

Hasim Kamal Mallick, Shivali Rana and Gargi Goswami

Introduction

Nearly 70% of the arable land in our country is rainfed. Roughly 70% of our nation's cultivable land relies on rainfall for irrigation. Despite covering such a significant portion, this area contributes just 42% of the overall food grain production. The scarcity of water in these regions significantly impedes the adoption of modern agricultural practices, including the utilization of high-yield varieties, pesticides, and fertilizers. Fertilizer consumption per hectare in dryland regions is significantly lower compared to irrigated areas. Surprisingly, over 80% of the nation's total fertilizer usage is concentrated in only 30% of irrigated land. Nonetheless, research has demonstrated that the productivity of dry lands can be substantially enhanced by implementing appropriate methods of fertilizer application. Dry lands have not only a thirst for water but also a hunger for nutrients. In such contexts, effective fertilizer application is vital to optimize crop yields while preserving resources and mitigating environmental impact. Nitrogen deficiency poses a common challenge in dryland areas, exacerbated by limited soil moisture and elevated temperatures, which promote nitrogen loss into the soil. Additionally, deficiencies in phosphorus, potassium, sulphur, and zinc are often observed in dryland regions, all of which are crucial for plant growth and development. Fertilizers serve a crucial function in restoring vital nutrients in dryland soils, ultimately enhancing crop productivity and resilience to drought conditions. Nonetheless, inappropriate application methods can result in nutrient loss through leaching, runoff, and wastage. Therefore, adopting precision fertilizer techniques tailored to the specific needs of dryland crops is essential for sustainable agriculture.

Nutrient availability: Nutrient availability refers to the quantity of nutrients within the soil that plants can readily absorb through their roots. A nutrient is considered available only when it is soluble in water. In regions with sufficient rainfall or irrigation, the primary focus is to enhance the solubility of nutrients in water so that plant roots can effectively uptake them. However, the situation contrasts sharply in dryland areas. These soils lack adequate moisture to dissolve plant nutrients, even if the nutrients are in a water-soluble form within the soil. Consequently, nutrients in the soil struggle to reach the plant roots. As a result, the application of fertilizers is severely

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limited in dryland regions.

Recommendation of Nutrients: Among the three primary fertilizer nutrients nitrogen, phosphorus, and potassium nitrogen holds the greatest significance for crop yield in dryland farming due to the pronounced nitrogen deficiency in these soils. Nitrogenous fertilizers consistently elicit a stronger response compared to phosphatic and potassic fertilizers. Moreover, a higher amount of nitrogen can be made accessible compared to phosphorus and potassium at a specific level of soil moisture. Nitrogen exhibits greater mobility in soil than phosphorus and potassium, with a defined level of moisture capable of transporting more nitrogen than phosphorus and potassium. Despite this, the recommended nitrogen levels for crops in dryland conditions are typically lower than those in irrigated conditions. Generally, cereal crops in dryland conditions require less fertilizer compared to irrigated conditions, whereas the disparity is not as significant for leguminous crops.

Use of organic matter: Organic matter constitutes a critical element of soil composition, comprising plant residues, animal residues, and decomposed soil organisms. Sustaining an adequate level of organic matter in the soil necessitates the use of farmyard manure, green manure, compost, and other organic materials. The size of well-decomposed organic matter particles is approximately equivalent to the finest soil particles known as clay. However, organic matter particles play a more significant role than clay in retaining soil moisture. A unit volume of organic matter particles can retain moisture at a rate 10 to 100 times greater than the same volume of clay. Therefore, it is imperative to supplement organic matter reserves in dryland soils to enhance moisture retention. Additionally, organic matter aids in the development of granular soil structure, facilitating better soil aeration. This fosters a conducive environment for root proliferation, allowing roots to extract a greater amount of moisture and nutrients from the soil.

Placement of Fertilizers: Placing fertilizers directly in the root zone of the soil is a more efficient method compared to broadcasting. In this technique, fertilizers are carefully positioned in furrows behind the desi plough at an appropriate depth and a safe distance from seeds or seedlings. This approach minimizes direct contact between the fertilizer and soil particles, thereby reducing the risk of nutrient fixation and enhancing nutrient availability to plants. Even in conditions of limited soil moisture, this method ensures that fertilizer nutrients can still reach the plant roots effectively. The process involves creating furrows on one or both sides of the crop plant rows, placing the fertilizer within these furrows, and then covering them. Furrows can be made using a bullock-drawn plough, or in some regions, specialized machines like “seed cum fertilizer drills” are utilized for this purpose. In orchards, fertilizers are placed in a ring around the tree trunk, maintaining a safe distance from the tree itself.

Spray application: The application of urea and mic-

ronutrient fertilizer through spraying is recognized as highly beneficial in arid conditions. In situations where soil moisture is insufficient for proper transportation of nutrients to plant roots, utilizing a spray solution becomes advantageous. This method is particularly effective for supplying nitrogen via urea. Specifically formulated spray-grade urea is available in our country. A solution comprising 2-3% urea in water can be sprayed onto the crop. Multiple applications of this solution, typically two to three sprays, can be administered to the standing crop. In instances where a farmer encounters challenges in timely fertilizer application due to factors such as delayed rainfall, fertilizer unavailability or financial constraints, the application of a 2-3% urea solution proves highly beneficial.

Balanced use of Fertilizers: Applying singularly either nitrogen, phosphorus, or potash is not as advantageous as utilizing their combinations. Specifically, combining phosphatic fertilizer with nitrogenous fertilizer is particularly beneficial in dryland conditions. Phosphorus plays a crucial role in extending the plant's root network, facilitating greater exploration of the surrounding soil for nutrients and moisture. With elongated roots, the plant can absorb a larger quantity of nutrients such as nitrogen, potash, and calcium from the soil. Conversely, nitrogen, when combined with other nutrients, contributes to the robust development of foliage. The collective effect of employing these nutrients in combination results in higher crop yields.

Use Of phosphorus mixed with farmyard manure (FYM): The process of preparing farmyard manure using this method results in what is known as enriched FYM. An application of approximately 750 kg of FYM ha^{-1} is deemed sufficient. To ensure optimal nutrient distribution, the entire recomm-ended dose of phosphatic fertilizer, calcul-ated based on the required phosphorus amount for the intended crop, is mixed with the farmyard manure before application to the field. This mixture is then spread in alternating layers over each other and left in a manure pit to mature for approximately one month. It's important to cover the pit with soil to create an airtight environment. Enriching FYM with phosphorus also enhances the nitrogen content of the manure. The phosphorus within the FYM prevents the gaseous loss of nitrogen by absorbing and retaining it within the manure. Utilizing enriched FYM has proven highly beneficial, particularly in dryland soils.

Use of micronutrients and amendments: Micro-nutrients play a vital role in plant growth, despite being required in minute quantities. In some cases, the absence of these micronutrients in the soil can render plant growth impossible. The deficiency of micronutrients can lead to a drastic reduction in crop yield, and traditional fertilizers may not adequately address the issue. In such scenarios, it is advisable to take a representative soil sample to a local soil testing laboratory for analysis of the soil's nutrient status.

Use of bio fertilizers: The utilization of bio-fertilizers is highly advantageous, particularly in dryland conditions. When leguminous crop seeds are

treated with Rhizobium bio-fertilizers, the crop's ability to fix atmospheric nitrogen increases significantly, reducing its reliance on soil nitrogen. Additionally, the roots and residues of legume crops left in the soil after harvest enrich the soil with nitrogen, benefiting subsequent crops. Another promising bio-fertilizer, Mycorrhiza, can greatly support phosphorus uptake in crops. This bio-fertilizer consists of fungi organisms whose body resembles a network of fine threads called hyphae. These hyphae wrap around plant roots and extend into the soil solution, absorbing nutrients and transporting them to the plant roots' vascular bundles for utilization.

Alteration in time of Fertilizer application: Crops require fertilizer at specific stages of growth, but adjusting the timing of fertilizer application based on soil moisture availability is advisable. If rainfall occurs shortly before or after the usual fertilizer application time, adjustments can be made to synchronize with nutrient availability. It's crucial to apply fertilizer when there is sufficient moisture in the soil, as this enhances nutrient uptake by plants. In dryland fields with limited irrigation, timing of fertilizer application can be calibrated accordingly.

Mulching: The method of mulching involves placing various materials such as straw, plant residues, leaves, loose soil, or plastic film onto the soil surface to minimize moisture loss through evaporation. Mulching serves to decrease soil erosion and provides protection to plant roots against significant fluctuations in soil temperature. When applied to rainfed crops, mulching aids in retaining soil moisture and enhances the efficiency of fertilizer utilization. In the case of wheat fields, the practice of mulching, especially after a preceding crop of maize, often results in notable benefits. For instance, when wheat follows mulched maize, the yields achieved with 0 and 40 kg N ha^{-1} were comparable to those obtained with 40 and 80 kg N ha^{-1} without mulching. This indicates that mulching saved 40 kg N ha^{-1} in succeeding wheat crops.

Conclusion

In the conclusion that fertilizers are applied to meet the needs of the dryland crops, there may be prolonged breaks in the monsoon in *kharif* or limited available moisture in the root zone of *rabi* crops may be exhausted before the plants reach the reproductive stage resulting in poor yields. This has to be avoided by assessing the yield potential of different regions and regulating the soil fertility levels by adding only such quantities of fertilizers as required for realizing the potential to the maximum extent possible. Hence fertilizer usage is more in irrigated agriculture than dryland agriculture.

Rice Grain Discoloration Disease: An Overview

Sharanabasav Huded, Manda Anil Mhatre and Manjula

Introduction

Rice (*Oryza sativa* L.) is a staple food and one of the most important cereal crops, especially for Asia, but recently consumption outside Asia has increased. Asian countries dominate the global rice production and China tops the list producing 1,45,500 million tons followed by India (1,03,500 million tons). The USDA projects that by 2025-26 (base year 2015-16), rice area, yield, and production will rise globally by 3.8, 7.2, and 11.3 percent, respectively. The demand for rice will grow in coming years at least to 2035 to feed the burgeoning population (FAO, 2017). It offers more than two thirds of the population have access to food security, and millions of rural households rely on it as a source of income. It is grown in hilly regions with elevations of up to 2200 meters above mean sea level, within the diverse agroecosystem. Ten thousand years ago, rice cultivation served as the cornerstone of social order and played a major role in local customs and faiths. In developing nations, rice provides 715 kcal per person per day, 27% of the dietary energy supply, 20% of the dietary protein, and 3% of the dietary fiber. The bran and rice polish that are left over after milling rice are utilized as fuel, packaging material, animal feed, industrial grinding and fertilizer manufacture. Despite the fact that rice is produced and consumed in large quantities worldwide, there are numerous obstacles that lower output. The main challenges faced by paddy farmers are high labor costs, a lack of suitable high-yielding varieties, a lackluster village-level extension program, expensive inputs, a lack of faith in the technology, insufficient power supplies, a labor shortage, pest and disease attacks, and a lack of seasonal rainfall. 76 illnesses that affect rice are brought on by nematodes, bacteria, viruses, fungus and mycoplasma like organisms. The complicated condition known as rice grain discoloration is caused by a microbial infection on the glumes, kernels, or both. Grain discoloration is an emerging yield reducing disease which is a potent threat to rice crops (Schaad, 2008). It is also referred to as “dirty panicle” or “glume discoloration.” According to reports, it was a separate illness that significantly reduced economic yield (Chandramani and Awadhiya, 2014).

Geographical Distribution and Economic Loss

Diseases are important factor for reduction in the yield of paddy worldwide heavy yield losses ranging from 50 to 90 %. According to Arshad *et al*. (2009), reports of the disease originated from a number of different global locations, including Latin

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America, the Gulf of Mexico, Guyana, Pakistan, and various regions of Asia. The disease is progressively becoming an increasingly serious problem. It has been recorded from several locations in India, including Assam, Karnataka, Andhra Pradesh, Odisha and Eastern India. The issue is getting severe every year since it can reduce rice crop yield potential by up to 6%.

Causes of Grain discoloration

Numerous causes, including panicle lodging, microbial infection, and changes in soil and climate, have been linked to rice grain discoloration. The rapid climate shift that caused the high illness incidence also increased the virulence of the once-minor pathogen(s), which in turn caused the rice crop to be devastated. Grain discoloration is mostly caused by biotic factors such as microbial infections (viral, bacterial, and fungal disorders). The disease epidemic at NRRI, Cuttack in 2019 was largely caused by the temperature range of 25 to 37 °C, moderate rainfall, high relative humidity (70-76%), and strong wind speed (Baite *et al*., 2020). The primary cause of the rice grain discoloration condition is microbial infection. While many bacteria and fungi are linked to rice grain discoloration, two significant groups-field fungus and storage molds-are implicated in the discoloration of rice grains. Field fungi like *Drechslera oryzae, Pyricularia oryzae, Alternaria padwikii, Fusarium moniliforme, Curvularia geniculata, Sarocladium oryzae* etc. whereas, storage molds, saprophytes *viz*., *Aspergillus* sp., *Penicillium* sp., *Mucor* sp., *Rhizopus* sp., etc. are more or less parasitic and infects grain before harvest. In Tamil Nadu, it was discovered that *Drechslera oryzae* and *Curvularia lunata* were primarily linked to discolored rice grains (Subramanian, 1988). Seed that is discolored can be attributed to 28-32% of bacteria. Grain discoloration in rice is also caused by bacteria such as *Pseudomonas avenae*, *P. fuscovaginae*, *P. syringae* var. oryzicola, and *P. glumae* (Suryadi and Kadir, 2009).

Symptoms

The symptoms of rice discoloration are brown or black spots on grain, hollow light weight panicle, blackish brown stripes on grain and infected panicle with unfilled grains. Grain discoloration affects the grain morphology in term of grain size and shape.

Table 1: Involvement of pathogen causing rice grain discoloration disease

Sr. No	Rice pathogen/ other effect	% of pathogens involvement	Yield Losses
1	Bacteria	18-65 %	Severe
2	Fungi	1-80 %	Severe
3	Virus	25-50 %	Moderately
4	Insect-pests	2-12 %	Severe
5	Environment	< 10 %	Low

Management

There are a number of approaches to managing this illness that have been documented by previous researchers. Schaad (2008) states that there are now no rice types that fully resist the illness or viable control strategies. Use of clean seeds not only reduces the transmission of rice seed-borne diseases but also increase the yield. It reduces 5.83-8.73% unfilled grains in the dry season and 8.32-8.65%

discolored seeds in the wet season. Farmers typically winnow and dry their seeds; they did not give much thought to treating the seeds beforehand. Therefore, seed treatments must to be taken into account when managing the illness. Numerous biological control agents, such Trichoderma, and botanical extracts, like neem, nishinda, garlic, and alamanda, can be utilized as seed treatments, leading to improved plant stand, increased germination, decreased disease incidence, and increased yield of various crops (Naher *et al*., 2016). Spraying at heading and during grain maturation can also reduce glume blotch caused by *Drechslera oryzae* (Kulkarni *et al*., 1980).

Prospects of managing rice grain discoloration

The development of resistant rice varieties, a variety of genetic germplasm resources, modern molecular techniques, and wild species will all be highly beneficial for the advancement of rice crop resistance to diseases. Gaining an understanding of the role of genes and their regulatory networks in regulating biotic and abiotic variables is one of the key goals of ongoing research in rice genomics. To overcome such type of limitations multi target mutation and gene silencing would be helpful. To determine the relationship of insertion mutants and flanking sequence tags (FSTs) are available in rice to target the genes. This could be possible by the adoption of new approaches to genome sequencing and DNA pooling.

Conclusion

Rice grain discoloration is a complex disease which develops by a range of micro-organisms. Grain discoloration is becoming recognized as a grave ailment that results in substantial crop loss. A few of the main causes of the illness are microbial infection, farming practices, and climate change. Given the damage it causes, management plans should be created that incorporate enhanced cropping techniques, the use of genetic resources, the management of pathogens through the application of cutting-edge technologies such as bio intensive practices, nanoparticles and silicon-based formulations, as well as new generation pesticide formulations.



References

Arshad, H. M. I., Khan, J. A., Naz, S., Khan, S. N., and Akram, M. (2009). Grain discoloration disease complex: a new threat for rice crop and its management. *Pakistan Journal of Phytopathology*, 21(1): 31-36.

Baite, M. S., Raghu, S., Prabhukarthikeyan, S. R., Keerthana, U., Jambhulkar, N. N. and Rath, P. C. (2020). Disease incidence and yield loss in rice due to grain discoloration. *Journal of Plant Diseases and Protection*, 127: 9-13.

Chandramani, B. and Awadhiya, G. K. (2014). Assessment of percent grain discoloration in important rice varieties. *International Journal of Current Research in Biosciences and Plant Biology*, 1(4): 61-64.

Kulkarni, S., Ramkrishnan, K., Hegde, R.K., 1980. Ecology, epidemiology and supervised control of rice brown leaf spot Iran. *Rice Research Newsletter*, 5: 13-14.

Naher, L., Ali, M. A. and Sheheli, S. (2016). Effect of seed treatment on seed borne fungi of rice. *Progressive Agriculture*, 27(1): 48-56.

Schaad, N. W. (2008). Emerging plant pathogenic bacteria and global warming. *Pseudomonas syringae Pathovars and Related Pathogens-Identification, Epidemiology and Genomics*, 369-379.

Subramanian, K. S. (1988). Studies in grain discoloration of rice caused by *Drechslera oryzae* (Breda de Hann). Subram and Jain and *Curvularia lunata* (Wakker). Boedijn. Ph. D. Thesis, Tamil Nadu Agricultural University, Coimbatore, p. 213.

Suryadi, Y. and Kadir, T. S. (2009). Effect of longevity of seedling-inoculation with *Trichoconis padwickii* on the severity of rice grain discoloration. *Journal Agrotropika*, 14(1).

Can We Eat Insects?: Concept of Entomophagy

Shruti Biradar, Harish Kumar T. S. and Parimala B.

Introduction

The relationship between humans and animals has varied throughout history and across different cultures. For centuries, humans have hunted animals for food or fur, besides using them for transportation or labor. In addition, animals have been caged for people's pleasure or tamed to be exploited in various ways. In particular, the domestication of animals such as cows, sheep, and horses enabled humans to establish settled agricultural societies, thus playing a significant role in human history by providing benefits in terms of food, transportation, farming, and companionship (Lesnik, 2018). Historically, people have frequently associated animals including insects with spiritual meaning and revered them as sacred or symbolic entities. They still serve as reminders of the natural environment and our relationship to it, even in modern times and the life-and-death cycles. Cows are revered in Hinduism and are not to be injured. To be more precise, Brahmins never handle or consume any meat, fish, or eggs, although members of the other three castes - Kshatriya, Vaisya and Shudra occasionally consume these foods as well as chicken, goat, or mutton, but never on holy days (Meyer-Rochow, 2009). Animals and humans have historically had a complicated and sometimes contradictory conne-ction. Although animals have always been necessary for human survival, overhunting, pollution, and habitat degradation have also negatively impacted animals. However, the necessity of striking a balance between meeting human needs and protecting the environment is becoming increasingly apparent these days. There are numerous things we can do to maintain the equilibrium that is essential to the planet's long-term sustainability. Entomophagy is the term used to describe the process of eating insects as food. Although 'microlivestock/mini-livestock' are not equivalent words to entomophagy, they are sometimes used to categorize the insects that can be eaten by human beings. Currently, many ethnic groups in Asia, Africa, Mexico, and South America rely on edible insects as a natural food supply. Entomophagy can be sustainable and benefits rural communities in terms of economy, nutrition, and ecology. However, due to changes in social structures, demography, and the growing use of modern foods, entomophagy is becoming less common in some areas. Different edible bug species

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are preferred depending on factors like flavor, nutritional value, ethnic customs, local laws, family history, and ease of availability.

Why Entomophagy?

- ✓ When their numbers are high, insects can be quickly and easily gathered in large quantities from forests and water sources.
- ✓ Insects can be reared and multiplied easily in small spaces and a short period due to their short life cycle and high intrinsic growth rate. The raising of edible insects is more environmentally beneficial than raising traditional livestock because they don't need to be fed grains (Oonincx *et al*., 2010).
- ✓ In low-income areas, only insects are available in the period of food shortage, particularly at the beginning of the rainy season when livestock is lean, new crops have just been sown and the stocks of stored produce from the previous crop season become limited.
- ✓ Insects are generally combined with, or frequently eaten as a supplement to, diets that primarily consist of grains including rice, beans, sorghum, maize, cassava, and millet. They are also used as an ingredient to make other foods.
- ✓ In addition to local markets, the food industry in developed nations have pioneered the export of insects in the form of beetle juice, canned silkworm pupae, hesperided butterfly caterpillars and immature ant stages.
- ✓ Tribes have utilized entomophagy as a medical treatment on a daily basis for ages, and certain nations still employ this method.
- ✓ Comparing insects to conventional livestock, the former produces a lot less greenhouse gases (GHG, especially methane and nitrous oxide) per kilogram of meat (Oonicx *et al*., 2010). Mealworms emit around 100 times as much greenhouse gas as pigs.

Nutritive value of insects

Apart from the reasons mentioned above, insects have been well recognized worldwide as nutritious food since insects provide proteins (amino acids including methionine, cysteine, lysine, and threonine), carbohydrates, fats, some minerals and vitamins, and have energy value (Xiaoming *et al*., 2010). Exploration on the nutritional composition of edible insects have been done according to internationally accepted guidelines. Due to their wide variety of species, edible insects have a wide range of nutritional properties. Even within the same species of insect, nutritional values can vary depending on the stage of the insect (egg, larvae, pupa, and adult for holometabolous insects, and egg, nymph, and adults for hemimetabolous insects). Diverse analytical techniques, the heterogeneity between insects from various environments, and various rearing and storage conditions can also contribute to this variation in nutrient composition.

The international network of food data systems (FAO INFOODS) has recently published a database on food composition and in version 4.0 a total of 471 edible insects, with different methods of preparation. Eggs, larvae/nymphs, pupae, and adults

Table 1: Commonly explored major edible insect species documented from India

Method of processing	Insect species	Order: Family	Insect life stage(s)	State
Baked	*Oecophylla smaragdina*	Hymenoptera: Formicidae	Egg, adult	Assam, Karnataka
	Rhynchophorus phoenicis	Coleoptera: Curculionidae	Larva	Assam
	Rhynchophorus ferrugineus	Coleoptera: Curculionidae	Larva	Assam
Cooked	*Pentatomid* sp.	Hemiptera: Pentatomidae	Adult	Arunachal Pradesh
	Locusta sp.	Orthoptera: Acrididae	Adult	Arunachal Pradesh
Dry/deep fried	*Dihammu scervinus*	Coleoptera: Cerambycidae	Larva	Assam
	Batocera rufomaculata	Coleoptera: Cerambycidae	Larva	Assam
	Meligethes aeneus	Coleoptera: Nitidulidae	Larva	Assam
	Okanagan sp.	Diptera: Asilidae	Larva	Assam
Roasted	*Gryllus campestris*	Orthoptera: Gryllidae	Nymph, Adult	Assam
	Schizodactylus monstrosus	Orthoptera: Gryllidae	Nymph, Adult	Assam
	Vespa tropica	Hymenoptera: Vespidae	Larve	Arunachal Pradesh
	Polistes sp.	Hymenoptera: Vespidae	Larva	Arunachal Pradesh

of insects all have been consumed in India, probably due to the significant variations in nutrient content that occur over the course of insect life. A high energy value is obtained from eating termites, grasshoppers, caterpillars, and crickets. Content of protein is significantly higher than or equal to animal foods such as, chicken, pork, eggs, beef or lamb. When five insects were compared for nutritive value, high protein content was found in dragon fly, *Crocothermis servilla* larva (70.48%), short horned grasshopper, *Oxyahyla hyla* adult (64.67%), surface grasshopper, *Oedaleus abruptus* adult (60.00%) and eri silkworm, Samiari cini pupa (71.9%). Maximum amino acid amounts of 100 g/100 g dry weight of silkworm pupae have been reported (Yhoung-aree, 2010). The bamboo caterpillar comes in second with 77.5 g and the house cricket comes in third with 68.7 g. Caterpillars, grubs of palm weevils (*Rhyncho-phorus* spp. (Coleoptera: Curculionidae)) and termites are rich in fat. The amount of calories found in insects can reach up to 776.9 kcal/100 g, which is frequently more than the amount found in soybeans, maize, and cattle (Ramos-Elorduy, 2005). A bread containing grubs of the African palm weevil provides the major and minor nutrients essential for body growth. Eating silkworm cater-pillars can meet daily needs for thiamin, copper, zinc, iron, and riboflavin. Eating those insects that contain riboflavin can also help supplement any riboflavin shortage. Insect protein synthesis uses less resources and is ecologically sustainable than that of animal protein. Maximum contents of calcium of 61.3, 72.4 and 76 g/100 g dry weight have been recorded, respectively, in dung beetle grubs (*Oryctes* sp.), palm weevil grubs and adult house crickets. Honeybee eggs, larvae, and pupae are rich in vitamins A, B_2, and C.

Future perspective: Further research is needed to ascertain whether the production of a kilogram of insect protein is also more environmentally friendly than conventional animal protein when the entire production chain is taken into account. Thus, in order to preserve this priceless natural resource and the indigenous knowledge for future generations, it is necessary to evaluate insect biodiversity and the role

that ethno-entomophagy plays, particularly in India. Additionally, there is opportunity to work toward increasing their commercial worth as food and feed for livestock, particularly chickens, and as readily available resources in a sustainable way.



Conclusion

There is growing interest in insects as human food in academia, food and agricultural industries, public institutions and the public at large. As the public's awareness of nutritional security has grown, insects have been and will continue to be employed as a source of nutrient-dense food. Due to their high rate of reproduction, high rate of energy conversion, high capacity for survival, short life span, and small spatial requirements, insects will offer one of the more feasible options for ensuring food security.



References

Lesnik, J. J. (2019). *Edible insects and human evolution*. University Press of Florida.

Meyer-Rochow, V. B. (2009). Food taboos: their origins and purposes. *Journal of Ethno-biology and Ethnomedicine*, 5: 1-10.

Oonincx, D. G., Van Itterbeeck, J., Heetkamp, M. J., Van Den Brand, H., Van Loon, J. J. and Van Huis, A. (2010). An exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption. *PloS One*, 5(12): e14445.

Ramos-Elorduy J. (2005). Insects: a hopeful food source, pp. 263-291. In Ecological Implications of Minilivestock: Potential of Insects, Rodents, Frogs and Snails for Sustainable Development (edited by M. G. Paoletti). Science Publishers Inc., Enfield, NH.

Xiaoming, C., Ying, F., Hong, Z. and Zhiyong, C. (2010). Review of the nutritive value of edible insects. *Forest Insects as Food: Humans Bite Back*, 85.

Yhoung-Aree, J. (2010). Edible insects in Thailand: nutritional values and health concern. *Forest Inects as Food: Humans Bite Back*, 85.

Role of Microbes in Mineral Nutrition

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Introduction

The global population is on a rapid rise, necessitating transformative changes within agriculture to sustainably meet the growing demand for food. In this twenty-first century, there is a pressing need for sustainable crop enhancements and eco-friendly agricultural practices. The focus of sustainable agronomy should shift away from reliance on chemical fertilizers and pesticides, which can have detrimental effects on plant health and the broader ecosystem, including animals and humans. Instead, preference should be given to food products derived from plants cultivated in natural conditions, aided by beneficial microorganisms. Plants exist within intricate ecosystems teeming with diverse microorganisms, many of which, like nitrogen-fixing symbiotic bacteria and mycorrhizal fungi, have long been recognized for their role in enhancing mineral nutrition and supporting plant vitality. Recent research has shed light on the rich diversity of plant-associated microorganisms and their potential to substitute artificial inputs in agriculture. Significant advancements have been made in understanding the dynamics and composition of rhizospheric microbiomes, revealing that plants influence microbiome structures through root exudates, while bacteria adapt to thrive in this niche. However, much remains unknown about the mechanisms driving these interactions and micro-biome alterations. Plants and microbes engage in various mutually beneficial interactions, presenting a significant challenge to enhance plant growth through soil microbe inoculation. Nevertheless, scientists and botanists have developed genetically improved crops with resistance to diseases and tolerance to environmental stresses such as heat, cold, light and salt. Furthermore, genetically modified crops offer improved nutritional profiles. Despite these advancements, the importance of plant growth-promoting soil microbes and their role in enhancing plant yield should not be overlooked. Soil microbes contribute to plant growth and develop-ment under stress conditions through biochemical mechanisms, providing resistance against pathogens, producing phytohormones, and regulating nutritional balance. Thus, the relationship between plants, soil, and microbes forms a tripartite interaction crucial for sustainable agricultural practices.

Plant and microbial relation

Plant growth, development, and yield are

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influenced by numerous factors, with soil being one of the most crucial. In addition to soil, various microorganisms residing within it colonize plant tissues and exert beneficial effects on plant growth and development. Plants interact with a diverse array of microorganisms, including prokaryotes and eukaryotes, many of which contribute to enhancing nutrient availability. The soil constitutes a complex ecosystem housing bacteria, fungi, protists, and animals, with plants engaging in a wide range of interactions with these soil organisms, spanning various ecological scenarios such as competitive, exploitative, neutral, commensal and mutualistic relationships.

In the realm of modern plant science, studies have predominantly focused on mitigating pathogenic effects like herbivory and infection or alleviating abiotic stress conditions. Nonetheless, there has long been interest in understanding the positive ecological interactions that foster plant growth. For instance, in the latter half of the 19th century, both mycorrhizal fungi and bacteria found in nodulated legumes were recognized as root symbionts. As early as the 1950s, bacterial cultures such as *Azotobacter chroococcum* or *Bacillus megaterium* were applied to agricultural seeds to enhance growth and yield. By the 1980s, various bacterial strains, primarily Pseudomonas but also Azospirillum, were identified for their growth-promoting effects.Since the 2000s, metagenomics has been utilized to explore the quantity and diversity of the root microbiome, with a shift away from focusing solely on specific bacterial strains.

Regarding how microbial activity promotes plant growth, three main mechanisms are typically proposed:

- ✓ Manipulating the hormonal signaling of plants.
- ✓ Repelling or outcompeting pathogenic microbial strains.
- ✓ Increasing the bioavailability of soil-borne nutrients.

This essay primarily focuses on the third mechanism, wherein soil bacteria break down resistant forms of soil-borne nutrients to release them for plant nutrition. Most nutrients, including nitrogen (N), phosphorus (P) and sulfur (S), are predominantly bound in organic molecules in natural ecosystems, making them only partially accessible to plants. Plants depend on soil microbes like bacteria and fungi, which possess the metabolic capacity to depolymerize and mineralize organic forms of N, P, and S, allowing plants to acquire these nutrients. Subsequently, the contents of these microbial cells are released through protozoic predation or turnover and cell lysis, liberating inorganic forms of N, P, and S into the soil. These inorganic forms, including ionic species like ammonium, nitrate, phosphate, and sulfate, are the preferred nutrient forms for plants. In natural settings, these microbial nutrient transformations play a crucial role in driving plant growth and can sometimes act as the rate-limiting step in ecosystem productivity.

Fertilization Techniques and Sustainability of the Environment

The majority of modern agricultural systems rely on mineral fertilizers to provide macronutrients. However, unsustainable fertilization practices contribute to soil degradation, waterway eutrophication, and greenhouse gas emissions, among other significant alterations to Earth's biogeochemical cycles. Moreover, the finite quantities of phosphate rock are depleting rapidly and are projected to be exhausted within a few decades. Additionally, the energy-intensive Haber-Bosch process used in N-fertilizer production relies on fossil fuels, further exacerbating the depletion of natural resources and exacerbating global warming.Given the scale and seriousness of these issues caused by fertilizers, a key research priority in agricultural science is to develop alternative approaches that sustain plant nutrition while significantly reducing mineral fertilizer inputs. One potential solution is to replace mineral fertilizers with organic inputs and supplement plants with specific root-associated microbes capable of depolymerizing and mineralizing organic-bound nutrients. This approach posits that organic inputs are more sustainable than mineral fertilizers because various industrial, municipal and agricultural processes generate substantial amounts of nutrient-rich "waste," which could potentially be composted and utilized as fertilizer. Additionally, nutrients bound to organic matter are less prone to leakage or volatilization, as they exhibit greater stability in the soil compared to mineral fertilizers. Organic agricultural systems already employ biofertilizers, yet there is a lack of mechanistic insight into the selection of plant cultivars and microbial inoculants. This lack of precision stems from two primary knowledge gaps:

- ✓ The strategies employed by plants to recruit beneficial microbes and the extent of genetic variation influencing this trait are unclear.
- ✓ There is insufficient understanding of which specific microbes serve as optimal partners for enhancing plant nutrition from organic sources of nitrogen (N), phosphorus (P), and sulfur (S).

Plant, soil, and microbial interactions

Soil microbes play a crucial role in bolstering the growth and development of crop plants against soil-borne pathogens in agriculture. Initially, plants release root exudates into the soil-root interface, attracting soil microorganisms towards the root hairs. Furthermore, the rhizosphere acts as a filter for endophytic microbes inhabiting it; occasionally, diverse microbes migrate into the host plant and transiently become endophytic microbes.

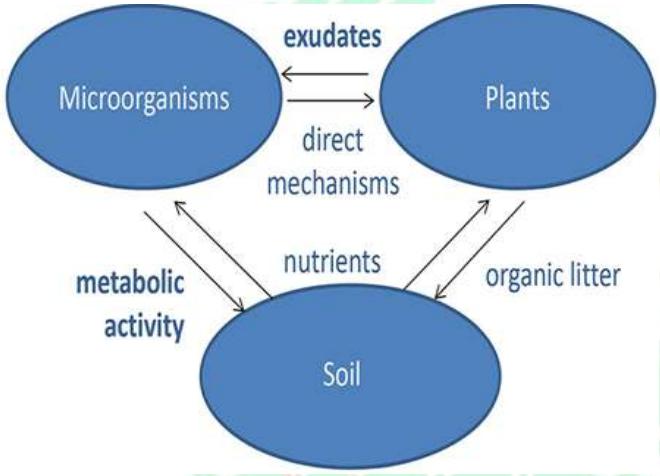
Plant growth promotion by microbes

Microbes facilitate plant growth through diverse mechanisms. Certain microorganisms have the ability to enter plant cells, where they fix atmospheric nitrogen, synthesize amino acids and other bioactive compounds, produce phytohormones, combat diseases that hinder plant growth, and enhance mineral absorption from the soil. Beneficial microbes further promote plant growth by residing as endophytes within plant tissues and also by inhabiting the rhizosphere.

Nutrient availability, uptake, depletion, mobiliza-

tion on rhizosphere and its biochemical mechanism

The rhizosphere, the soil region surrounding plant roots, exhibits biological, chemical, and physical distinctions from non-rhizosphere areas. This zone possesses unique characteristics, including temperature regulation, water retention, pH balance, detoxification of harmful substances, and the provision and upkeep of nutrients. The abundance of nutrients in the rhizosphere fosters plant growth and enhances productivity.

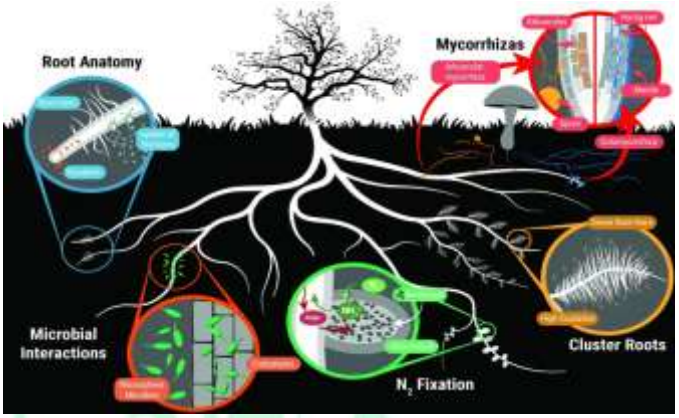


Contribution of soil microbes towards the nutrient acquisition of the plant

The soil's rhizosphere contains several microorganisms that interact with plants and act as either beneficial, harmful, or neutral.Soil agricultural productivity depends upon the beneficiary or mutual interactive relationship between microbes and plants. Rhizosphere microbes are incredibly beneficial to plants' health in nutrient uptake and soil sustainability.

Phytoremediation: an agricultural blessing

Phytoremediation is an eco-friendly method that employs both associated microorganisms and green plants, alongside agronomic practices and appropriate soil modifications, to eradicate or extract harmful environmental pollutants from the surroundings. Typically, this technique involves the use of genetically modified or indigenous plants to remediate organic pollutants or heavy metals from the soil.



Conclusion

Similar to humans, plants frequently face challenges from various beneficial and pathogenic microorganisms. While plants possess defense mechanisms that effectively counteract many disease-causing pathogens, the evolution and emergence of new pathogens can enable them to evade the host's immune defenses. In order to access nutrients that are difficult to obtain from the soil, plants rely on the metabolic activities of soil microbiota. Given the environmental harm associated with current fertilization methods, there is a pressing need in current research to enhance plant-microbe nutritional interactions for more sustainable agricultural practices. However, the specific mechanisms governing the assembly of the plant microbiome and its modulation in response to the plant's nutritional status are exceedingly complex and challenging to anticipate.

Agricultural Youth: Future Farmers with Agri-Entrepreneurship

Rutuja Madhukar Kharde

Youth represent a significant portion of the population that possesses a strong sense of passion, motivation, and willpower, making them an invaluable resource for promoting a country's political, cultural, and economic development. If the youth's enthusiasm and energy are correctly channeled, they have the power to significantly improve society and advance the country. In order to attract young people to the agricultural field, farming needs to provide both financial and intellectual satisfaction. By making agriculture profitable, Agri-entrepreneurship may be able to draw in young people from rural areas. Furthermore, ICTs are the development toolset that gives rural youth the ability to overcome the obstacles of poverty, backwardness, and illiteracy. Young people living in rural areas and ICTs have the potential to be powerful agricultural catalysts.

Accompanying youth and the journey to adulthood are opportunities, constraints and uncertainty. In this day of globalization, young people are always trying to find a balance between what they want to be and what they can become, which is stretching the essential process of youth. A number of scholars have emphasized the necessity to address the consequences of global variables that are affecting the transition into adulthood, as these countries' demographic profiles are changing due to the fact that many of them are relatively young.

Young people in today's developing world have unprecedented opportunities that have not been available to previous generations due to advancements in health, rapid urbanization, rising school enrollment and educational attainment, as well as increased opportunities for physical mobility and access to information and communication.

Food security, rural development, and employment are all facilitated by agriculture, which is essential to the Indian economy. Attracting and keeping new talent, however, is a major concern for the industry. India has an increasing number of youths; thus, the country needs to come up with creative ways to get the next generation involved in agriculture. The significance of young people getting involved in agriculture, the opportunities that are open to them, and methods for promoting their involvement will all be covered in this blog article. We can ensure the sector's and the country's sustainable future by fostering an atmosphere in which youth view agriculture as an appealing career option.

The Importance of Young People in Agriculture

India, with around 600 million people under 25, has one of the highest young populations in the world. Involving this population in agriculture is essential to tackling global food security issues and guaranteeing the country's food supply is sustainable.

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The agricultural industry may benefit from the new ideas, inventive perspectives, and desire to embrace new technologies that young people bring to the table. Encouraging young people to work in agriculture can also close the generational divide and maintain the long-term sustainability of the sector.

Openings for Youth in Agribusiness

Agriculture offers assorted career prospects for youthful individuals over different sub-sectors, counting crop production, livestock, ago-processing, and agri-inputs. Trying entrepreneurs can tap into the developing request for value-added items, organic produce, and specialty markets for exotic produce. The rise of precision agriculture and digital farming innovations gives opportunities for youth with a foundation in science, innovation, engineering, or mathematics (STEM) to apply their abilities in agriculture. Smart cultivating, drones, and data-driven decision-making are a number of imaginative innovations revolutionizing the industry. In India, youth who want to work in agriculture have access to a wide range of educational and skill-building opportunities. To give students the skills and knowledge they need, organizations like the Indian Council of Agricultural Research (ICAR), State Agricultural Universities, and several Krishi Vigyan Kendras (KVKs) offer specialized courses and training programs. Despite the prospects, Indian millennials view agriculture as a low-status and low-paying profession. This image is further exacerbated by a lack of exposure to the diverse array of job pathways and opportunities for progression within the industry. The availability of resources and land is a major obstacle for young individuals wishing to launch agribusinesses. The dispersion of agricultural holdings and the high cost of land make it challenging for aspiring business owners to obtain the capital needed to start their enterprises. Furthermore, traditional methods are frequently the center of agricultural education and training in India, with little attention paid to contemporary methods and technologies. It may be difficult for young people to acquire the necessary skills to thrive in the changing agricultural scene as a result of this schooling gap.

Approaches to Encouraging Youth Activity in Agriculture

We need to take a multifaceted approach that addresses the obstacles young people experience and emphasizes the potential in order to encourage them to seek jobs in agriculture.

- ✓ **Increasing awareness:** Hold job fairs and awareness campaigns to highlight the variety of career options in agriculture as well as the industry's potential for expansion and innovation.
- ✓ **Investing in education:** Modernizing agricultural education and training programs to include agribusiness management skills, contemporary technologies, and practices that appeal to youth interests.
- ✓ **Providing resources and support:** Putting in place policies and initiatives like the Agri-Clinics and Agri-Business Centers Scheme (ACABC) and the Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) that give young Agri-Entrepreneu-

rs access to finance, land, and other resources.

- ✓ **Leveraging technology:** Encouraging the agricultural sector to utilize cutting-edge technologies and digital tools to increase the sector's attractiveness and effectiveness for youth.

Challenges: Youth experience following challenges while opting Agriculture as profession.

- ✓ Insufficient access to knowledge, information and education.
- ✓ Limited access to land.
- ✓ Inadequate access to financial services.
- ✓ Difficulties accessing green jobs.
- ✓ Limited access to markets.
- ✓ Limited involvement in Policy dialogue.
- ✓ Lack of agricultural content in education.
- ✓ High risk in agriculture profession.

Roles of Government, Management and Educational Institutions

To encourage young engagement in agriculture, cooperation between the government, the farm sector and educational institutions is crucial.

- ✓ **Governmental programs and directives:** The Indian government ought to keep creating and enforcing laws that encourage young people to work in agriculture by providing resources, financial incentives, and programs for skill development.
- ✓ **Businesses and academic establishments:** It takes cooperation between educational institutions and the agriculture sector to create training programs and curricula that give young people the skills needed for the modern agricultural workforce.

Furthermore, for prospective Agri-entrepreneur industry-led mentorship programs and internships can offer beneficial real-world exposure as well as networking opportunities

Success Narratives: Numerous young individuals in India have effectively pursued careers in agriculture and have made noteworthy contributions to the field. Here are a few motivational instances. The Agri-Tech startup creates and markets reasonably priced agricultural equipment aimed at smallholder farmers. Their goods have increased agricultural output and given rural communities job prospects.

- ✓ **BharatAgri:** The BharatAgri Smart Farming App Aids Indian farmers in raising agricultural yields. Working directly with farmers and the entire agriculture value chain, Bharat Agri is a farming technology platform. With the goal of reaching 140 million Indian farmers, Bharat Agri is committed to bridging the technology and agricultural gaps in India. By giving important information when needed and doing routine monitoring, it helps farmers "Grow Efficient, Grow More" by systematically implementing scientific procedures.
- ✓ **TechInAg:** It is a startup, which is in the seed stage, aims to aid farmers in irrigating fields optimally. Their prototype, a smart intelligent irrigation bot, a wheeler bot, was created to save farmer's time and effort and control input costs.
- ✓ **Agri Vijay:** Empowering Farmers with Renew-

able Energy using to Fight Climate Change. AgriVijay is India's first curated Marketplace of Renewable & Green Energy products for farmers & rural households bringing all products in solar, biogas, green energy - electric under one roof and with Energy Advisory approach where farmers energy needs are understood coupled with waste availability at their end before products are recommended, sold, financed, delivered & installed along with abating GHG/CO_2 emissions mitigating Climate Change aligned with United Nations SDG's becoming Energy Independent along with increased savings & income.

- **Kheyti:** It is a social enterprise that offers affordable greenhouse solutions to small-holder farmers in order to increase crop yields and revenue.
- **Aibono:** It is an AgriTech startup that maximizes crop yield for small farmers by utilizing data-driven farming practices and artificial intelligence.

These and numerous other success stories show how young people may have a big impact on the agriculture industry and encourage others who want to work in the field.

The sustainable expansion and development of the agriculture sector in India depends on inspiring young people to seek careers in the field. For the nation's educated youth, agriculture and agri-systems offer enormous opportunities for growth and employment. We can foster an atmosphere where young people view agriculture as an appealing and feasible career option by increasing knowledge of the variety of options available, making relevant educational and training investments, and offering resources and assistance to young Agri-entrepreneur. We can ensure a prosperous future for agriculture and the country by working together, and cooperation between the government, business community, and academic institutions is crucial in these endeavors.

References

Jagat, B. (2015). A Viable Future: Attracting the Youth to Agriculture. Asian Farmers Association for Sustainable Rural Development, 7(1).

Tongia, R. (2019). The future of farming is India's largest concern, according to The India Forum.

Khan, S., Javeed, Q., Peer, A., Khuroo, B. and Farhein, H. (2023) Rural Youth in Agricultu re. Advances in Agricultural Extension book.

Application of Nanotechnology in Weed Management

N. Anthony Baite, Nitin Yadav and Basant Kumar Dadrwal

Introduction

Weed management has always been a crucial aspect of agriculture, as weeds compete with crops for nutrients, water, and light, leading to significant yield losses. Traditional weed management methods, including mechanical weeding, cultural practices, and chemical herbicides, have been effective but come with limitations such as labor intensity, environmental pollution, and the development of herbicide-resistant weed species. In recent years, nanotechnology has emerged as a promising tool in agriculture, offering innovative solutions to these challenges. This article explores the application of nanotechnology in weed management, highlighting its potential benefits and current research in this field.

What is Nanotechnology?

Nanotechnology involves the manipulation of matter at the nanoscale (1-100 nanometers), where unique physical and chemical properties emerge. These properties can be harnessed to create novel materials and devices with applications across various fields, including medicine, electronics, and agriculture. In agriculture, nanotechnology is being explored for its potential to improve crop protection, enhance nutrient delivery, and provide innovative solutions for weed management.

Nanotechnology in Weed Management: How It Works

The application of nanotechnology in weed management primarily focuses on two areas: enhancing the efficacy of herbicides and developing nanoscale materials for targeted weed control.

Nano-Herbicides: Enhancing Herbicide Efficacy

Targeted Delivery: Traditional herbicides often suffer from inefficiencies due to non-target effects, where a significant portion of the chemical may drift away from the target weed or degrade before it reaches the weed. Nano-herbicides, formulated by encapsulating active ingredients within nano-particles, offer a solution by enabling targeted delivery. These nano-carriers can be engineered to release the herbicide in response to specific environmental triggers, such as pH changes or the presence of specific enzymes, ensuring that the herbicide is released precisely where and when it is needed.

Controlled Release: Nanotechnology allows for the controlled release of herbicides over time, reducing the need for repeated applications. For example, herb

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-icides encapsulated in polymeric nanoparticles can be designed to degrade slowly, releasing the active ingredient over an extended period. This not only increases the herbicide's effectiveness but also reduces the environmental impact by minimizing runoff and leaching.

Increased Herbicide Potency: The unique properties of nanoparticles, such as their high surface area and ability to penetrate plant tissues, can enhance the potency of herbicides. By improving the solubility and stability of the active ingredients, nano-formulations can achieve the same level of weed control with lower doses, reducing chemical input and potential toxicity.

Nanomaterials for Weed Control

Nanoparticles as Herbicides: Some nanoparticles themselves have herbicidal properties. For instance, metal oxide nanoparticles, such as zinc oxide (ZnO) and titanium dioxide (TiO_2), have shown potential in inducing oxidative stress in weed species, leading to cell damage and death. These nanoparticles can be applied as a foliar spray or incorporated into the soil to target weeds selectively.

Magnetic Nanoparticles: Magnetic nanoparticles can be used for site-specific weed control. When coupled with a magnetic field, these nanoparticles can be directed to specific areas of the field, where they can deliver herbicides or disrupt weed growth through physical means, such as generating heat (hyperthermia) to kill weed seeds or seedlings.

Nanoparticle-Based Bioherbicides: Nanotechnology also holds promise in enhancing the efficacy of bioherbicides natural herbicides derived from micro-organisms, plants, or other biological sources. Encapsulation of bioherbicidal agents in nano-particles can protect them from environmental degradation, improve their stability, and enhance their uptake by target weeds.

Table 1: Example of nano-enabled herbicides for weed control

Nano herbicide	Crop	References
Zinc hydroxide nitrate intercalated with sodium dodecylsulphate and bispyri-bac anions	*Oryza sativa* L.	Sharif *et al*., 2020
Imazamox–clay complexes with chitosan and iron (III)-modified smectites	*Brassica oleracea var. botrytis* L.	Cabrera *et al*., 2016
Atrazine-loaded polymeric nanoparticles	*Brassica juncea* L.	Takeshita *et al*., 2021
Paraquat-polymeric chitosan/xantan/tripoly-phosphate nanocapsules	*Zea mays* L.	Ghaderpoori *et al*., 2020
Glyphosate along with multiwall carbon nanotubes	*Arabidopsis thaliana* L.	Ke *et al*., 2021

Advantages of Nanotechnology in Weed Management

The integration of nanotechnology into weed management practices offers several advantages:

Precision and Efficiency: Nanotechnology enables precise targeting of weeds, reducing the amount of herbicide needed and minimizing non-target effects on crops and the environment.

Environmental Sustainability: Nano-formulations can reduce the environmental impact of herbicides by minimizing runoff, leaching, and volatilization. Controlled release mechanisms also decrease the frequency of applications, further reducing the chemical load on the environment.

Combating Herbicide Resistance: By enhancing

the efficacy of herbicides and enabling the development of novel weed control mechanisms, nanotechnology can help combat the growing issue of herbicide-resistant weed species.

Cost-Effectiveness: Although the initial development of nanotechnology-based products may be costly, the long-term benefits of reduced herbicide use, improved efficacy, and fewer applications can make these technologies cost-effective for farmers.



Fig. 1: Typical illustration of nanoherbicide effect of target weeds

Challenges and Future Prospects

Despite the promising potential of nanotechnology in weed management, several challenges need to be addressed before these technologies can be widely adopted:

Regulatory Hurdles: The use of nanomaterials in agriculture is subject to stringent regulatory scrutiny due to concerns about their safety and environmental impact. Extensive research is needed to assess the long-term effects of nanomaterials on soil health, non-target organisms, and human health.

Public Perception: Public acceptance of nanotechnology in agriculture may be a challenge, particularly in regions where there is resistance to new technologies. Education and transparent communication about the benefits and risks of nanotechnology are essential to gaining public trust.

Cost and Accessibility: The development and commercialization of nano-herbicides and other nanotechnology-based weed control methods may be expensive. Ensuring that these technologies are accessible and affordable for smallholder farmers, especially in developing regions, will be crucial.

Research and Development: While research in this field is growing, more studies are needed to optimize nano-formulations, understand their interactions with plants and soils, and develop guidelines for their safe and effective use.

Conclusion

Nanotechnology offers a transformative approach to weed management, with the potential to enhance the efficacy of herbicides, reduce environmental impact, and address the challenge of herbicide resistance. While there are challenges to overcome, the ongoing research and development in this field hold promise for the future of sustainable agriculture. As nanotechnology continues to evolve, it could become an integral part of integrated weed management strategies, contributing to more productive and environmentally friendly farming practices.

References

Takeshita, V., de Sousa, B. T., Preisler, A. C., Carvalho, L. B., Pereira, Ad. E. S., Tornisielo, V. L., Dalazen, G., Oliveira, H. C. and Fraceto, L. F. (2021). Foliar absorption and field herbicidal studies of atrazine-loaded polymeric nanoparticles. *Journal of Hazardous Materials*, 418: 126350.

Cabrera, A., Celis, R. and Hermosín, M. C. (2016). Imazamox-clay complexes with chitosan and iron (III)-modified smectites and their use in nanoformulations. *Pest Management Science* , 72: 1285-1294.

Ghaderpoori, M., Jafari, A., Nazari, E., Rashidipour, M., Nazari, A., Chehelcheraghi, F., Kamarehie, B. and Rezaee, R. (2020). Preparation and characterization of loaded paraquat-polymeric chitosan/xantan/tripolyphosphate nanocapsules and evaluation for controlled release. *Journal of Environmental Health Science and Engineering*, 18: 1057-1066.

Ke, M., Ye, Y., Zhang, Z., Gillings, M., Qu, Q., Xu, N., Xu, L., Lu, T., Wang, J. and Qian, H. (2021). Synergistic effects of glyphosate and multiwall carbon nanotubes on *Arabidopsis thaliana* physiology and metabolism. *Science of The Total Environment*, 769: 145156.

Sharif, S. N. M., Hashim, N., Isa, I. M., Bakar, S. A., Saidin, M. I., Ahmad, M. S., Mamat, M. and Hussein, M. Z. (2020). Controlled release formulation of zinc hydroxide nitrate intercalated with sodium dodecylsulphate and bispyribac anions: A novel herbicide nanocomposite for paddy cultivation. *Arabian Journal of Chemistry*, 13: 4513-4527.

Herbicide Resistance and Its Management in India

N. Anthony Baite, Nitin Yadav and Basant Kumar Dadrwal

Introduction

Herbicide resistance is the ability of a weed species to withstand an herbicide that was once effective at controlling it. This resistance arises due to genetic variations within the weed population, which are selected for under continuous herbicide application. In India, the increasing reliance on herbicides for weed control in major crops like rice, wheat, soybean, and cotton has led to the evolution of resistant weed populations.

Causes of Herbicide Resistance in India

Several factors contribute to the development of herbicide resistance in India:

Monocropping Systems: The practice of growing the same crop repeatedly on the same land increases the selection pressure for specific weed species, which, in turn, become resistant to the herbicides used.

Over-reliance on Specific Herbicides: Farmers often depend on a limited number of herbicides, particularly those that are cost-effective and widely available, leading to the rapid selection of resistant weed biotypes.

Lack of Crop Rotation: The absence of diverse crop rotation systems limits the variety of weed control measures, further contributing to resistance.

Inadequate Awareness and Training: Many Indian farmers lack access to the latest information and training on integrated weed management practices, leading to improper herbicide use.

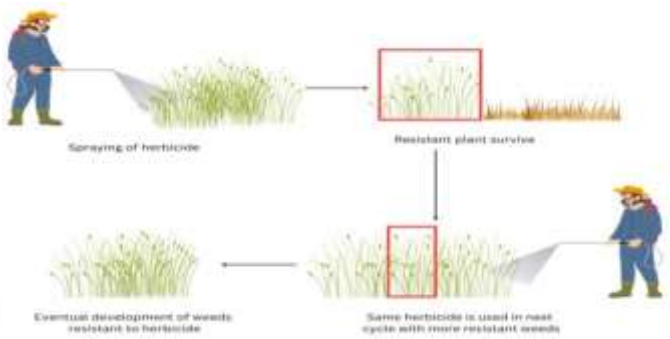


Fig. 1: Sequence of herbicide resistance in weeds

Examples of Herbicide-Resistant Weeds

India has witnessed the emergence of several herbicide-resistant weed species across various cropping systems. Some notable examples include:

Weed species	Affected crop(s)	Resistant to	References
Phalaris minor	Wheat	Isoproturon, Clodinafop	Bhullar *et al.*, 2014; Walia *et al.*, 1997
Echinochloa colona	Rice	Propanil	ICAR-weed news (2011)
Amaranthus palmeri	Cotton	Glyphosate	Culpepper *et al.*, 2006
Eleusine indica	Maize, Rice, Cotton	Paraquat	Hooda and Chauhan, 2023
Chenopodium album	Wheat, mustard	Atrazine	Bühler *et al.*, 2016

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Consequences of Herbicide Resistance

Herbicide resistance in weeds has several adverse effects on Indian agriculture:

Reduced Crop Yields: Resistant weeds compete with crops for nutrients, water, and sunlight, leading to significant yield losses.

Increased Production Costs: Farmers may need to apply higher doses of herbicides or switch to more expensive alternatives, increasing the overall cost of cultivation.

Environmental Impact: Overuse and misuse of herbicides can lead to soil and water contamination, affecting biodiversity and human health.

Threat to Food Security: The spread of herbicide-resistant weeds can threaten food security by reducing the availability of key crops.

Management Strategies for Herbicide Resistance

Managing herbicide resistance requires an integrated approach that combines chemical, cultural, mechanical, and biological methods. Key strategies include:

Integrated Weed Management (IWM): Implementing IWM practices involves the use of multiple weed control strategies, such as crop rotation, intercropping, mechanical weeding, and the judicious use of herbicides with different modes of action.

Herbicide Rotation and Mixtures: Using herbicides with different modes of action in rotation or as mixtures can reduce the selection pressure for resistance.

Cultural Practices: Adopting practices like crop rotation, cover cropping, and mulching can reduce weed pressure and the reliance on herbicides.

Mechanical Control: Utilizing tools like tillage, hoeing, and manual weeding can physically remove weeds and reduce their seed bank in the soil.

Monitoring and Early Detection: Regular monitoring of weed populations for signs of herbicide resistance can help in early detection and timely intervention.

Farmer Education and Training: Educating farmers on the proper use of herbicides, resistance management, and alternative weed control methods is crucial for sustainable agriculture.

Conclusion

Herbicide resistance is a growing challenge in Indian agriculture, with serious implications for crop production, farm income, and environmental sustainability. By adopting integrated weed management practices, rotating herbicides, and enhancing farmer education, India can mitigate the threat of herbicide resistance and ensure the long-term sustainability of its agricultural systems. This comprehensive approach will not only help in managing existing herbicide-resistant weed populations but also prevent the emergence of new resistant biotypes, securing the future of Indian agriculture.

References

Walia, U. S., Brar, L. S. and B. K. Dhaliwal. (1997). Resistance to isoproturon in *Phalaris minor* Retz. in Punjab. *Plant Protection Quarterly*, 12(3): 138-140.

Bhullar, M. S., Puma, S. S., Tomar, S. S., Singh, V. P. and Sharma, J. D. (2014). Little seed canary grass resistance to clodinafop in Punjab: farmers' perspective. *Indian Journal of Weed Science*, 46(3): 237-240.

Bühler, M., Bogenrieder, A., Sandermann, H. and Ernst, D. (2016). Heteroplasmy and atrazine resistance in Chenopodium album and *Senecio vulgaris*. *Zeitschrift für Naturforschung C*, 71(7-8): 267-272.

Culpepper, A. S., Grey, T. L., Vencill, W. K., Kichler, J. M., Webster, T. M., Brown, S. M., York, A. C., Davis, J. W. and Hanna, W. W. (2006). Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) confirmed in Georgia. *Weed Science*, 54(4): 620-626.

Hooda, V. S. and Chauhan, B. S. (2023). Herbicide response and germination behavior of two goosegrass (*Eleusine indica*) populations in the Australian environment. *Weed Science* 71(6): 584-593.

ICAR- Directorate of Weed Research. (2011). Weed news. 11(4). https://dwr.icar.gov.in/Weed_News/2011-Oct-Dec.pdf

Molecular Techniques for Plant Pathogen Detections

Archana R. Mukhedkar

Introduction

In agriculture and forestry, plant diseases result in significant productivity and financial losses. For instance, soybean rust, a fungal disease that affects soybeans, has resulted in a significant economic loss. Farmers may benefit from an estimated $11 million profit if only 20% of the infection is removed (Robert *et al*., 2006). In the United States, agricultural losses caused by plant diseases are thought to cost over $33 billion annually. Approximately 65% of this, or $21 billion, could be ascribed to non-native plant diseases. Chestnut blight fungus, Dutch elm disease, and Huanglongbing citrus disease are a few of the illnesses brought on by introduced pathogenic species (Li *et al*., 2006). Next to the economic impact of plant pathogens, the socio ecological impact cannot be underestimated, considering that the world population is set to increase to 9.7 billion by the year 2050, which goes hand in hand with an increased global food consumption. In the past, more agricultural area was used to meet the rising need for food. But other spatial arrangements, like housing, industry, and perhaps most crucially, forestry, are sacrificed in the process. The optimal approach, known as agricultural intensification, appears to be raising the yields that can be attained given that 50% of the livable area is already utilized for agriculture. However, the rapid spread of host-specialized infections is facilitated by agricultural intensification, such as the dense cultivation of broad areas with monocultures. The impact of these infections is made worse by the expansion of international trade, which speeds up the introduction of invasive pathogens and causes significant crop damage and yield loss (Baldi and La Porta, 2020). Therefore, it is of huge importance to reduce the losses associated with plant disease. More importantly, these losses need to be reduced in a sustainable manner. In the past, more agricultural area was used to meet the rising need for food. But other spatial arrangements, like housing, industry, and perhaps most crucially, forestry, are sacrificed in the process. The optimal approach, known as agricultural intensification, appears to be raising the yields that can be attained given that 50% of the livable area is already utilized for agriculture. However, the rapid spread of host-specialized infections is facilitated by agricultural intensification, such as the dense cultivation of broad areas with monocultures. The impact of these infections is made worse by the expansion of international trade, which speeds up the introduction of invasive pathogens and causes significant crop damage and yield loss.

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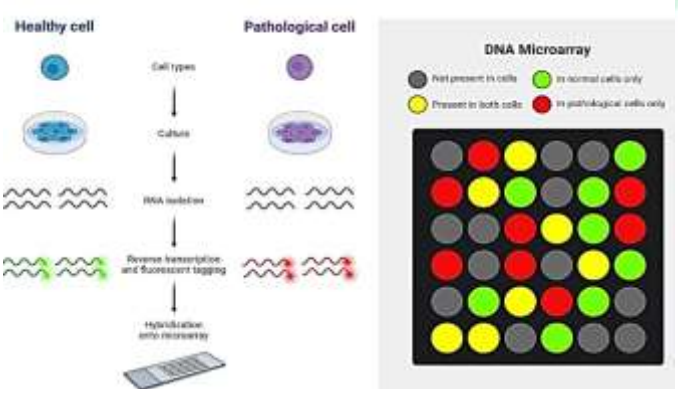
Various molecular techniques for pathogen detection

Polymerase Chain Reaction (PCR) Based Assays: Multiplex PCR assay uses one reaction mixture with various primer pairs, and allows simultaneous amplification of several pathogens. The generated amplicons can then be separated and visualized using electrophoresis. Designing primers for the multiplex assay is crucial, and specific sets of primers should have similar annealing temperatures for successful amplification. Using the multiplex PCR technique, a contemporaneous diagnostic tool was developed to identify 12 fungus linked to cranberry fruit rot pathogens caused by fungi ITS-LSU and TEF-1a gene regions were successfully used to identify *Allantophomopsis cytisporea, A. lycopodina, Phyllosticta elongate, Coleophoma empetri, Colletotrichum fiorinae, C. fructivorum, Fusicoccum putrefaciens, Monilinia oxycocci, Phomopsis vaccinia, Phyllosticta vaccinia, Physalospora vaccinia,* and *Strasseria geniculate* associated with cranberry fruit rot (Conti *et al*., 2019). Threats to the cactus industry that could have an impact on its export sector include the pathogenic fungus *Fusarium oxysporum, Bipolaris cactivora, Phytophthora nicotinae* and *Phytophthora cactorum*. Though multiplex PCR assays are quick and reliable in nature, the assays are potentially expensive and resource-intensive and decreased sensitivity associated with the multiplex methods. BIO-PCRassay is a modification of end-point PCR technique which involves a pre-assay incubation step in a diseased sample to increase the biomass of the causal agent. This technique is mainly used to concentrate target pathogens by growing the target pathogen in a growing media that prevent the growth of non-target microorganisms to improve detection.

Nucleic Acid Sequence Based Amplification: Under isothermal circumstances, nucleic acids are amplified using nucleic acid sequence-based amplification (NASBA). It frequently uses RNA for amplification, in which reverse transcriptase converts a single-stranded RNA (ssRNA) template to complementary DNA (cDNA). RNase H, T7RNA polymerase, and avian byeloblastosis virus reverse transcriptase are used in the NASBA assay, which has a temperature of about 41°C. It can produce more than 10^8 copies of the target nucleic acid sequence in 30 minutes, and amplicons are identified utilizing electro chemiluminescence in molecular beacons and probe-capture hybridization. In plant fungal pathogen detection, the use is extremely uncommon. In the future, though, it might be applied to the identification of fungal illnesses.

DNA Microarray: A DNA microarray (DNA chip, genechip or biochip) is an assemblage of micro-scopic DNA spots attached to a solid surface (usually glass) in defined positions. The microscopic spots consist of thousands of specific DNA sequences (probes) that are used to hybridize a cDNA (target) sample. Hybridized probe cDNA systems can be detected and quantified using fluorophore, silver, or chemiluminescence-labeled targets to define the comparative abundance of transcripts in the sample.

Advancement of DNA microarray technology has led high throughput and multiple detection of various phytopathogens including viruses, viroids, bacteria, and fungi. *Aphanomyces cochlioides*, *Botrytis cinerea*, *Penicillium expansum* and other sugar beet root rot pathogens were detected using a novel microarray test (ArrayTube) that used marker genes ITS, TEF-1a, and 16S rDNA with effective probes. It is quick, simple, reliable, and economical to generate DNA microarrays in batches on ordinary microscope slides. DNA macroarrays are constructed by creating species-specific probes (15-30 bases of oligonucleotides) that are arrayed into well plates and mounted on a nylon or nitrocellulose membrane. A significant disadvantage of microarrays is that they can only detect sequences that the array is intended to recognize. The target DNA sequence can then be identified using probe hybridization using PCR amplification and labeling.



DNA Microarray Technology

RNA interference: RNA interference (RNAi) is a cellular process that regulates gene expression by silencing specific genes. The steps of RNA interference are as follows:

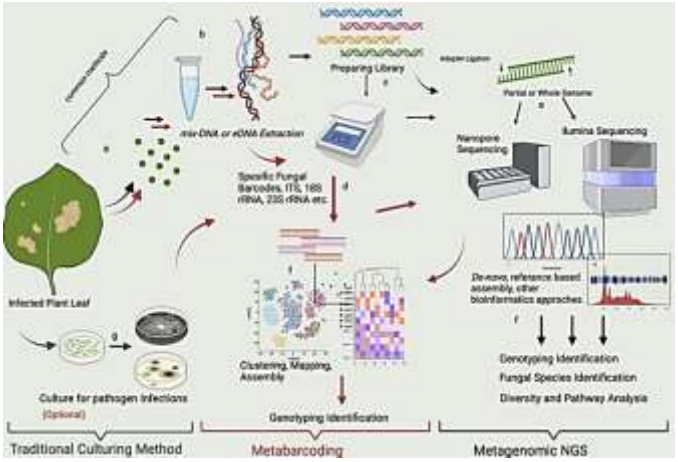
- ✓ **dsRNA Formation:** Double-stranded RNA (dsRNA) is introduced into the cell, either by exogenous delivery or through the transcription of a specific gene to produce dsRNA.
- ✓ **Dicer Cleavage:** An enzyme called Dicer recognizes the dsRNA and cleaves it into small interfering RNAs (siRNAs) that are typically 21-25 nucleotides long.
- ✓ **RISC Assembly:** The siRNAs are then loaded onto the RNA-induced silencing complex (RISC), where one of the siRNA strands, known as the guide strand, is selected.
- ✓ **Target Recognition:** The guide siRNA within the RISC complex binds to the complementary mRNA sequence of the target gene.
- ✓ **mRNA Degradation:** The binding of the guide siRNA to the target mRNA triggers its degradation or prevents its translation into a functional protein.
- ✓ **Gene Silencing:** The targeted gene effectively silenced, leading to a reduction or elimination of the corresponding protein's expression.

Genome Editing: In recent times, advanced breeding technologies like meganucleases (MNs), zinc-finger nucleases (ZFNs), transcription-activator-like (TAL) effector nucleases (TALENs), and clustered regularly interspaced palindromic repeats (CRISPR) have emerged. Among these, the CRISPR/Cas9 system has gained significant attention for enhancing disease resistance in various crops such as rice, cacao, wheat, tomato, and grape. This system enables precise editing of the genome through the activity of RNA-guided DNA endonu-

cleases. Apart from crop genome editing, this technology has also shown promise in editing the genomes of fungal and oomycete pathogens, providing novel strategies for plant disease management. Applications of genome editing in developing disease-resistant plants, overcoming disease susceptibility factors and engineering plant defense mechanisms.

Next Generation Sequencing (NGS)

Next-Generation Sequencing (NGS), also known as Massive Parallel Sequencing, is a high throughput sequencing technology known to have revolutionized the world of molecular biology. Unlike Sanger sequencing, or first generation sequencing, next-generation sequencing (NGS) is fast, affordable, and capable of sequencing millions of reads at once. Transcriptome and genomic research are impacted and advanced by the ongoing breakthroughs in NGS. Because NGS offers thorough and high-resolution genetic data, it has contributed to our understanding of the genetics of plant diseases. There are numerous NGS platforms available today, each using different technologies and processes.



Next Generation Sequencing Technology

Biosensors in the Detection of Plant Pathogens

A promising and innovative technique for rapidly and precisely identifying plant diseases with great sensitivity is provided by biosensors. These gadgets combine a transducer that converts the biological contact into a measurable signal with a biological recognition element, such as enzymes, antibodies, or nucleic acids. Biosensors are highly versatile and can recognize a wide range of pathogens in various plant tissues, including bacteria, fungus, and viruses. Biosensors provide numerous benefits compared to conventional detection techniques, such as instantaneous analysis, mobility, and the possibility of doing on-site testing without requiring specialist laboratory apparatus. The application of these technologies has been successful in detecting many plant infections, including the *Citrus tristeza virus* and *Phytophthora infestans*. This demonstrates their effectiveness in agricultural diagnostics (Maftei *et al*., 2019).

Conclusion

Recent advances in molecular biological techniques have increased detection and diagnosis of novel, emerging, previously reported, and re-emerging fungal plant pathogens. Traditional and variant polymerase chain reaction (PCR) based assays, isothermal and post amplification tools, hybridization techniques, and next-generation sequencing (NGS) approaches are well-known for diagnostics in phytofungal disease detection. These molecular-based approaches have successfully identified and diagnosed symptomatic and asympto-

matic diseases of culturable and unculturable fungal pathogens in sole and co-infections of agriculturally important field, horticultural, floricultural, ornamental and forest plant species.

References

Baldi, P. and La Porta, N. (2020). Molecular approaches for low-cost point-of-care pathogen detection in agriculture and forestry. *Frontiers in Plant Science*, 11: 570862.

Conti, M., Cinget, B., Vivancos, J., Oudemans, P. and Bélanger, R. R. (2019). A molecular assay allows the simultaneous detection of 12 fungi causing fruit rot in cranberry. *Plant Disease*, 103(11): 2843-2850.

Li, W., Hartung, J. S. and Levy, L. (2006). Quantitative real-time PCR for detection and identification of Candidatus Liberibacter species associated with citrus huanglongbing. *Journal of Microbiological Methods*, 66(1) 104-115.

Maftei, D., Eremia, S. A. V. and Cristea, C. (2019). Electrochemical biosensors for the detection of microorganisms based on nanostructured materials. *International Journal of Molecular Sciences*, 20(19): 5390.

Roberts, M. J. (2006). The value of plant disease early-warning systems. *Economic research report* (United States. Department of Agriculture. Economic Research Service).