



E-ISSN: 2583-1755

The Agriculture Magazine

VOLUME-1, ISSUE-9

JULY 2022

A Monthly Peer Reviewed Magazine for Agriculture and Allied Sciences

<https://theagricultureonline.com/>



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Volume 1, Issue 9, July 2022

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
Website: theagricultureonline.com

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ISSN: 2583-1755

Volume : 1, ISSUE : 9

July, 2022

Publication Schedule : Monthly

All Correspondence Should be Address to

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Dr. Kartikeya Choudhary

The Agriculture Magazine

<https://theagricultureonline.com/>

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Role of Trichoderma in Pest Management

Pooja Sharma, Sushila Choudhary and Bhawani Singh Meena

Introduction

Insects are the main pest in agricultural systems, causing significant losses in crop productivity and storage. During the last decades the control of pest insects has been carried out through the uncontrolled and massive use of chemical insecticides, very harmful to the environment and health, which requires the development of new efficient and safe alternatives. Numerous fungal species have been described as entomopathogens of insect pests, as well as plant endophytic fungi. In this sense, *Trichoderma* is a genus of filamentous fungi widely studied and used as a biocontrol agent in agriculture on pathogenic fungi due to its ability to parasitize them (mycoparasitism), among other mechanisms of action. In recent years, the possibility of using *Trichoderma* as a biocontrol agent for insect pest has been considered, both directly and indirectly. The studies carried out to date have reported that *Trichoderma* is capable of controlling insect pest directly through parasitism and the production of insecticidal secondary metabolites, antifeedant compounds and repellent metabolites. And indirectly through the activation of systemic plant defensive responses, the attraction of natural enemies or the parasitism of insect-symbiotic microorganisms.

Therefore, the use of *Trichoderma* in agriculture is not only effective against plant pathogens, but also against insect pests, representing a future alternative in the development of sustainable agriculture.

Trichoderma: a very beneficial mycoparasite fungus in agriculture

The fungal genus *Trichoderma* includes about 100 described species widely distributed throughout the world due to their rapid growth, their ability to use different substrates and to tolerate the presence of different contaminants and environmental conditions (Mishra *et al.*, 2016). In its interaction with the plant, *Trichoderma* mainly behaves as a root endophyte, colonizing only the outermost layers of the root, due to a plant defense response mediated by salicylic acid, which prevents the fungus from reaching the vascular bundles and behaving like a systemic pathogen (Alonso-Ramírez *et al.*, 2014). In this way, *Trichoderma* is also capable of activating systemic plant defenses against the attack of pests (Poveda *et al.*, 2020). The ways in which *Trichoderma* spores can be applied to crops include pre-planting applications to seed or propagation material, incorporation in the soil during seeding or transplant, watering by irrigation or applied as a root drench or dip, the greatest success

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colonization has been quantified by direct application to seeds and roots (Woo *et al.*, 2014).

Direct control of insects by *Trichoderma*

Trichoderma acts directly as an entomopathogen through parasitism and the production of insecticidal secondary metabolites, antifeedant compounds and repellent metabolites. In the same way that it has been reported for other different entomopathogen fungi, *Trichoderma* is capable of actively parasitizing the bodies of insects, using them as a source of nutrients for the formation of new conidia. The vast majority of the studies carried out have been based on the topical application of fungal spores in laboratory, reporting different percentages of mortality according to the insect pest and the study time. *T. longibrachiatum* and *T. harzianum* parasitize adult hemipterans of the silverleaf whitefly (*Bemisia tabaci*) and the tropical bed bug (*Cimex hemipterus*), causing mortality rates of 40% in 5 days (Anwar *et al.*, 2016) respectively. Similarly, after 15 days of assay, different species of *Trichoderma* provoke percentages close to 100% of mortality in adult coleopterans such as the coconut palm rhinoceros beetle (*Oryctes rhinoceros*) (Nasution *et al.*, 2018). When applied to feed (wheat grains), *T. album* causes mortality rates of 94% in 7 days in adults of the lesser grain borer (*Rhyzopertha dominica*). Moreover, in field, *T. longibrachiatum* is capable of increasing the crop yield of egg plants by 56% thanks to the foliar application of fungal spores, causing up to 50% mortality of the lepidopteran eggplant/brinjal borer

(*Leucinodes orbonalis*) (Ghosh and Pal, 2016).

T. atroviride produces insecticidal secondary metabolites to avoid being consumed by the common fruit fly (*Drosophila melanogaster*). Similarly, different species of *Trichoderma* are capable of producing and releasing secondary metabolites with great insecticidal potential into the environment. The most studied species in this sense is *T. harzianum*, by producing metabolites such as peptaibols, capable of causing mortality rates of 100% in 15 days in coleopterans, such as the mealworm (*Tenebrio molitor*) (Shakeri and Foster, 2007). Hemiptera such as the wheat aphids (*Schizaphis graminum* and *Diuraphis noxia*) the cotton aphid (*Aphis gossypii*) or the cotton jassid (*Amrasca bigutulla bigutulla*). *Trichoderma* can also produce secondary metabolites of volatile nature, such as 6-pentyl- α -pyrone, capable of causing 100% mortality in 48 h in the red spider mite (*Tetranychus urticae*). While the mortality percentages due to the production of insecticidal secondary metabolites by *Trichoderma* are reduced to 50% in 3 days in orthopterans such as the migratory locust (*Locusta migratoria*) and Lepidopterans such as the Egyptian stem-borer (*Earias insulana*) or the pink bollworm (*Pectinophora gossypiella*). On the other hand, the species *T. viride* and *T. citrinoviride* have been reported with the ability to produce different compounds or molecules with antifeedant activity against different insects. Chitinases have mainly been described against lepidoptera, which act on the peritrophic membrane of the larvae, drastically

reducing their feeding. In this sense, mortality rates of 50% in 7 days have been reported in the rice moth (*Corcyra cephalonica*) (Vijayakumar *et al.*, 2016), the cotton bollworm (*Helicoverpa armigera*) and the silkworm (*Bombyx mori*). While other compounds with antifeedant activity have been identified against hemiptera, such as the free fatty acids methyl linoleate and linoleic acid against *M. persicae* (Kaushik *et al.*, 2020), or different bisorbicillinoids (bislolongiquinolide, trichodimerol and dihydrotrichodimerol) (Evidente *et al.*, 2009) against *S. graminum*.

Furthermore, there are several species of *Trichoderma* (*T. harzianum*, *T. viride* and *T. citrinoviride*) whose volatile organic compounds (VOCs) act as repellants for pest insects, reducing the damaging effects on plant resources. Through the application of fungal spores to the soil, it was possible to verify how, in those areas where *Trichoderma* is present, the termites *Odentotermes formosanus* do not form tunnels. Similarly, the application of *Trichoderma* spores in stored bean seeds is able to reduce their consumption by the beetle *A. obtectus* to 10%, due to its repellent action against one of the major storage pests affecting stored common beans.

Indirect control of insects by *Trichoderma*

Trichoderma can also act indirectly as a plant-endophyte or as a mycoparasite, through the activation of systemic plant defensive responses, the attraction of natural enemies or the parasitism of insect-symbiotic microorganisms.

Through the colonization of the roots, *Trichoderma* is able to activate plant defenses against the attack of pathogens and pests, not only locally, but also systemically, responses mediated by the plant-hormones salicylic acid (SA) and jasmonic acid (JA), mainly (Poveda *et al.*, 2020). The leaves inoculation of *Cirsium arvense* and *Arabidopsis thaliana* by *T. viride* and *T. gamsii*, respectively, activates systemic plant defenses, reducing the feeding of the thistle tortoise beetle (*Cassida rubiginosa*) respectively, up to 25%. In the case of the hemiptere *B. tabaci*, the activation of the SA-mediated defenses in tomato plants (*Solanum lycopersicum*) colonized by *T. harzianum* caused mortality rates of up to 35%. Activation of JA-mediated systemic defensive responses in tomato plants colonized by *T. atroviride* leads to proteinase inhibitors production in leaves, causing 100% mortality in the cotton leafworm lepidopteran in 25 days. Similarly, in *Lansium domesticum* plants the JA-mediated response provokes tannins, phlobatannins, flavonoids, steroids, glycosides and alkaloids production in leaves, preventing the mealybugs *Unaspis mabilis* from feeding.

It has been proven how the activation of systemic defensive responses in the plant by *Trichoderma*-roots colonization causes the accumulation of secondary defense metabolites in plant-tissues. Some of these metabolites may be VOCs with repellent activity, such as terpenes (1-octen-3-ol and 6-pentyl- α -pyrone), reducing 75% consumption of maize leaves by the fall armyworm

(*Spodoptera frugiperda*) (Contreras-Cornejo *et al.*, 2018a). In addition, these metabolites can attract the natural enemies of insect-pests, as has been verified with the 6-pentyl- α -pyrone, the attractant VOC of the parasitoid wasp of the fall armyworm *Camoletis sonorensis* (Contreras-Cornejo *et al.*, 2018). By inducing a SA-mediated systemic resistance by colonizing the roots of tomato plants, *T. harzianum*, *T. longibrachiatum* and *T. atroviride* cause the death of 100% of the individuals of the potato aphid (*Macrosiphum euphorbiae*) in 25 days. This is due to the production by the plant of VOCs, such as methyl salicylate, which attract the specific parasitoid wasp *Aphidius ervi* together with the predator aphid *Macrolophus pygmaeus* (Battaglia *et al.*, 2013). However, in the case of other aphids, the root colonization of maize plants (*Zea mays*) by *T. harzianum* in field caused a JA-mediated systemic resistance, which produced the release of the VOC (Z)-3-hexen-1-ol, attracting the aphid predator *Harmonia axyridis* and reducing the insect pest population by 22%. Similarly, against different species of Auchenorrhyncha and Coccoidea in vineyards in field, *Trichoderma* causes the JA-mediated production of VOCs that attract hemipterans parasitoid wasps of the Mymaridae family.

To combat insect pest, the ability of *Trichoderma* as a mycoparasite can also be used effectively, specifically against insect-symbiotic fungi. The alnus ambrosia beetle (*Xylosandrus germanus*) represents a pest of great importance for

the hazelnuts (*Corylus*) of Turkey, the biggest hazelnut producer in the world. The female of these beetles make tunnels in the xylem of their host trees, which they inoculate with spores of the fungal genera *Ambrosiella* and *Raffaelea*. Both larvae and adults can only feed on these wood-degrading fungi, therefore, they require this symbiotic nutritional relationship to survive. Inoculation of hazelnut branches with spores of *T. harzianum*, *T. asperellum* and *T. atroviride* has been shown to drastically reduce the beetle population by directly mycoparasiting the beetle-symbiotic fungi (Kushiyevev *et al.*, 2020).

The leaf-cutting ants represent an economically important pest in tropical and subtropical agricultural and forestry ecosystems. These hymenopterans use leaf fragments to cultivate different fungi on which they feed, therefore, nutritional symbiotic fungi. In this sense, the mycoparasitism exerted by *Trichoderma in vitro* on the fungi *Leucoagaricus gongylophorus*, an *Acromyrmex pubescens* symbiont and *Attamyces* sp., an *Atta Cephalotes* symbiont has been verified. From the *in vitro* results, spores of *T. viride* were applied to wheat bran, also used by *A. cephalotes* as a growing substrate for their symbiont fungus, reporting the mortality of 100% of the ants in 40 days due to starvation. Based on this mechanism of action, it has been suggested that there are plant species that favor the colonization of their tissues by *Trichoderma* so that, when they are taken to the nest by the leaf-cutting ants *Atta sexdens*, *Trichoder-*

ma mycoparasites the symbiont fungi, acting like Trojan-horse management strategy.

Furthermore, *Trichoderma* can act as an effective antagonist of the gut microbiota of insects. The oral application of *T. koningi* spores to grass moth larvae (*Ostrinia furnacalis*) caused the mortality of 30% of the specimens in 12 days, as a consequence of the reduction of the gut microbiota.

Conclusions

Insect pests can cause serious losses in crop productivity. For this reason, the use of chemical insecticides that will help reduce losses has become essential, although their massive use has caused serious damage to the environment. The development of an agriculture that respects the environment requires the implementation of new strategies in the control of insect pests, such as the use of biopesticides. There are many mycopesticides on the market today that are used effectively to control insect pests, although the market share is still very small. This is possibly due to the use by farmers of chemical insecticides during the last decades, making it difficult to establish new alternatives more dependent on environmental and biological factors, such as biopesticides. Despite this, year after year the percentage of use of mycopesticides increases, and that of chemical pesticides decreases.

Trichoderma is a genus of filamentous fungus that includes several species widely studied and used as biocontrol agents in agriculture, due to mechanisms of action such as mycoparasitism on plant pathogenic fungi.

Furthermore, *Trichoderma* shows great persistence in the agrosystem, due to its different ways of obtaining resources, and it can be beneficially related to a great variety of different crops in a generalist way. In recent years, several studies have been developed on the use of *Trichoderma* as a biological control agent for insect pests, reporting results of up to 100% mortality, both in the laboratory and in the field. In this sense, it is worth highlighting the ability of *Trichoderma* to act against the insect pest in different ways, directly (parasitism and the production of insecticidal secondary metabolites, antifeedant compounds and repellent metabolites) and indirectly (activation of systemic plant defensive responses, attraction of natural enemies and parasitism of insect-symbiotic microorganism), increasing its effectiveness and possibility of use in the agrosystem. However, it is important to note that the vast majority of the studies carried out with *Trichoderma* as mycopesticide are under controlled greenhouse or laboratory conditions, requiring a greater number of investigations in the field to corroborate the results obtained. This absence of studies could be because field trials often produce non-significant results and such results are not frequently published. In this sense, laboratory experiments could do not accurately reflect field conditions, with significant soil and epiphyte microbiota. Furthermore, parallel studies should be developed to determine the possible negative effects of the use of *Trichoderma* on natural enemies or non-

pest insects, and in indigenous entomopathogenic endophytic fungi.

The use of *Trichoderma* as a biocontrol agent for insect pests requires even more studies in the field and against other groups of insects, but its direct and indirect effectiveness make it a sustainable alternative for the future in agricultural plant health.

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Role of IFS in Natural Farming

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Natural farming is a chemical free alias traditional farming method. It is considered agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity (NITI, GOI). It is the system where rules of nature are applied to the agricultural practices and this method works along with the natural biodiversity from the farmed areas. Natural farming is an ecological farming approach established by Masanobu Fukuoka (1913-2008) who was a Japanese farmer and philosopher, introduced in his 1975 book. The One-Straw Revolution. Recently, natural farming was seen offering solutions to many problems viz., food insecurity, farmer's distress, and health problems arising due to pesticide and fertilizer residue in food and water, global warming, climate change and natural calamities. Basically, it is the practice of working with nature to achieve more.

Objectives of Natural farming

- ✓ To produce food of high nutritional quality in sufficient quantity.
- ✓ To work with natural system rather than seeking to dominate them.
- ✓ To encourage and enhance biological cycles within farming system-involving micro-organisms, soil flora and fauna, plants and animals.

- ✓ To maintain and increase long term fertility of soil.
- ✓ To use, as far as possible, the renewable resources. To work as much as possible, within a closed system, with regard to organic matter and nutrient elements.
- ✓ To give all livestock, conditions of life that allow them to perform all aspects of their innate behavior.
- ✓ To avoid all forms of pollution that may result from agricultural techniques.
- ✓ To maintain the genetic diversity of agricultural system and its surroundings, including the plants and wild life habitats.
- ✓ To allow agricultural producers an adequate returns and satisfaction from their work including safe drinking water.

Scope of natural farming

Natural farming has emerged as an alternative system of farming that may not only address quality and sustainability concerns, but also ensures a debt-free future, with increasing awareness about the safety and quality of food, long-term sustainability of the system and accumulating evidence of being equally productive.

Natural farming is also a sustainable and environmentally beneficial production strategy that

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benefits small-scale farmers in particular. Natural farming is appropriate for small farmers in developing countries like India. According to the available evidence. Natural agriculture helps to poverty reduction and food security through a variety of factors, including:

- ✓ Increasing yields in locations with low inputs;
- ✓ Biodiversity and natural resources conservation on the farm and in the surrounding environment;
- ✓ Increasing revenue and/or lowering costs;
- ✓ Creating food that is both safe and diverse
- ✓ Having a long-term sustainability.

Potential areas of natural farming

According to recent data about 4 lakh hectare area of India has been brought under natural farming so far as a part of a sub scheme of the Paramparagat Krishi Vikas Yojana. Andhra Pradesh, Himachal and Gujrat, parts of Haryana are gradually adopting natural farming.

Role of IFS in Natural Farming

Integrated Farming System (IFS) is the integration of different agricultural methods like crop cultivation with animal husbandry and aquaculture with pig farming. The essence of IFS is that it works like an ecosystem where all the elements are in equilibrium and interdependent. The waste of one element works as a nutrient for another. The final result is the optimum utilization of resources and nutrients, restoration of ecological balance, and increase in the income of the farmers. It relates rearing of indigenous cow because desi or

indigenous cow is the main thing of natural farming. By this farmers can produce natural products for farming in their field. However, some of the enterprises maybe just taken up to increase the farmer's income, without any interdependency with agriculture. IFS contributing to the sustainability of agriculture as follows:

Economic Profitability

The profitability of farmers is the most important aspect of sustainable agriculture. It is difficult to provide incentives to farmers without the promise of good returns. IFS has the potential to increase productivity multiple times. For example, practicing apiculture (beekeeping) with oilseed cultivation has shown the productivity gain of 2-3 times in oilseed because of pollination services provided by bees. Besides this, farmers also get additional marketable products like honey, wax, bee venom, and pollen from such mix-farming. This further enhances the profits of farmers. For this precise reason, beekeeping is being promoted under the Mission for Integrated Development of Horticulture.

As already pointed out, around 80% of farmers in India are small and marginal farmers. These farmers practice subsistence agriculture; only a few can upgrade to commercial agriculture. IFS increases the productivity of not just crops, but also of farmers. With better productivity and more marketable products in hand, small farmers are also able to generate handsome revenue. The practice of agroforestry on edges of farmlands and fallow lands

S. No.	State	Farmers covered	Gram Panchayat	Area covered	Implementing Agency
1.	Andhra Pradesh	5.92 lakh (12.3%)	3,730 (28%)	2.68 lakh Ha (4.6%)	RySS, State Govt. Corporation
2.	Himachal Pradesh	1.53 lakh (16%)	3,563 (98.2%)	9192 Ha (0.96%)	State Project Implementation Unit
3.	Gujarat	2 lakhs (3.76%)	8,500 (59.6%)	2.5 lakh Ha (2.5%)	Dedicated state Government unit

(Ministry of farming and farmers welfare, GOI)

provides farmers with revenue-generating products like timber, fruits, and herbs. Under 'Har Med pe Ped' initiative of Sub-mission on Agro-forestry, a sub-mission of Mission for Sustainable Agriculture, agroforestry is promoted among farmers. Bamboo survives in a variety of climates and matures very fast. For this reason, it is being promoted under National Bamboo Mission.

Social Impact

The enhanced production of various types of crops and other agro-products ensures food and nutritional security, impacting the overall health of the country. Animal husbandry provides dairy products; apiculture provides honey and agroforestry may provide fruits and medicine. Practices like agroforestry generate employment, which is helpful in solving the problem of unemployment and underemployment in rural areas. Since the availability of agro-products is enhanced by IFS, it promotes allied industries of agriculture in rural areas.

Ecological balance

IFS methods, if implemented properly, have a positive impact on the ecology of the region. In places where animal husbandry is practiced with

crop cultivation, the excreta from animals are utilized as manures. This decreases the dependency on chemical fertilizers, promotes organic farming at a low cost, and impacts soil fertility positively. With this integration, various organic farming models like IFS promote diversification of species in a local area, thereby increasing the complexity of the food web. This induces stability in the local ecosystem and supports more wildlife with time.

Resource and Knowledge Centers

While IFS has many benefits; proper management of farms is of crucial importance. Since all the elements are in the vicinity of each other, care should be taken that food or medicine for one should not harm the other. To enable farmers to make informed decisions, the Indian Council of Agriculture Research (ICAR) has developed 45 IFS models covering all the 15 agro-climatic zones of the country. The information on these models is being imparted through Krishi Vigyan Kendra (KVKs), which are the resource and knowledge centers in the field of agriculture in the district.

Challenges in IFS

The implementation of IFS is very important because it has many advantages. However, it can be

said that more positive impacts are obtained, namely the optimization of narrow agricultural land and is very suitable to be applied to rural areas because it has a small scale. In general, the challenges of implementing IFS are limited knowledge and skills of farmers, limitations in the use of technology, and access to capital. To deal with the above challenges, support from the government is needed in the form of training support and policy assistance, investment and easy access to capital so that IFS can be implemented properly and be able to encourage sustainable agriculture in Indonesia.



Insect Pest Management in Cotton Crop

Pooja Sharma, Bhawani Singh Meena and Abhinav

Introduction

Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fibre) to cotton textile industry. The prime cotton-producing countries are China, India, the USA, Pakistan, Uzbekistan, Turkey, Australia, Greece, Brazil, and Egypt, with total coverage of 34 million hectares (Khadi *et al.*, 2010). Cotton in India provides direct livelihood to 6 million farmers and about 40 -50 million people are employed in cotton trade and its processing. In India, there are ten major cotton growing states which are divided into three zones, viz. north zone, central zone and south zone. North zone consists of Punjab, Haryana and Rajasthan. Central zone includes Madhya Pradesh, Maharashtra and Gujarat. South zone comprises Andhra Pradesh, Telangana, Karnataka and Tamil Nadu. Besides these ten States, cotton cultivation has gained momentum in the Eastern State of Orissa. Cotton is also cultivated in small areas of non-traditional States such as Uttar Pradesh, West Bengal & Tripura. Cotton (*Gossypium hirsutum* L.), popularly known as “white gold”, is a natural fiber crop grown in more than 70 countries in the world (Nikam *et al.*, 2017).

It is a well-suited crop for both irrigated and dryland production systems. Cotton is one of the most important commercial crops of India. Cotton crop is infested with different kinds of insects in the production cycle. Jassids, thrips, aphids and whiteflies are among sucking pests and bollworm (American and spotted) and spodoptera caterpillars which attack on leaves and bolls. Among them, American bollworm *Helicoverpa armigera* Hüb. (Lepidoptera: Noctuidae) and spotted bollworm *Earias vittella* Fab. (Lepidoptera: Noctuidae) are the most important pests affecting the cotton plants from flowering to the fruiting period (Dhaliwal *et al.*, 2010).

American bollworms can cause upto 40 -50 % crop losses in severe incidences. The high resistance in American bollworms towards the insecticides is/was challenging and scientific research have developed transgenic cotton hybrids popularly known as Bt Cotton.

Cultivated Species

There are four cultivated species of cotton viz. *Gossypium arboreum*, *G. herbaceum*, *G. hirsutum* and *G. barbadense*. The first two species are diploid ($2n=26$) and are native to old world.

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They are also known as Asiatic cottons because they are grown in Asia. The last two species are tetraploid ($2n=52$) and are also referred to as New World Cottons. *G. hirsutum* is also known as American cotton or upland cotton and *G. barbadense* as Egyptian cotton or Sea Island cotton or Peruvian Cotton or Tanguish Cotton or quality cotton. *G. hirsutum* is the predominant species which alone contributes about 90% to the global production. Perhaps, India is the only country in the world where all the four cultivated species are grown on commercial scale.

Insect pest of cotton

1. American bollworm (*Helicoverpa armigera*)



The larvae of boll worms will feed on the inside contents of bolls making holes and larva's head will be inside and body be outside. The fecal pellets will be seen on the bolls. Each larva of American boll worm can damage up to 30 - 40 bolls. Minimum infestation of this *Helicoverpa armigera* or American is noticed on transgenic Bt Cotton varieties. Thresholds for conventional cotton depend on crop stage and are:

- ✓ Seedling to flowering: 2 larvae m^{-1} or 1 larvae (>8 mm) m^{-1} .
- ✓ Flowering to cut-out: 2 larvae m^{-1} or 1 larvae (>8 mm) m^{-1} or 5 brown eggs m^{-1} .

- ✓ Cut-out: 15% open bolls - 3 larvae m^{-1} or 1 larvae (>8 mm) m^{-1} or 5 brown eggs m^{-1} .
- ✓ 15%-40% open bolls: 5 larvae m^{-1} or 2 larvae (>8 mm) m^{-1} or 5 brown eggs m^{-1} .
- ✓ Thresholds for Bollgard II® cotton are the same for the entire season at 2 larvae (>3 mm) m^{-1} in 2 consecutive checks or 1 larvae (>8 mm) m^{-1} .

2. Pink bollworm (*Pectinophora gossypiella* Saunders)



Pink boll worm feeding behavior is similar to American bollworm infestation. When the pink boll worm attacks the flowers making them irregular shape more or less like rose flowers usually called the rosette. Worms feed inside the bolls, seed kernels and the entry holes will be covered with their fecal matter. Boll dropping is noticed due to the pink bollworm attack.

3. Tobacco caterpillar (*Spodoptera litura* Fab.)



Spodoptera litura moths will lay eggs on the young plants, larvae hatch out consume the epidermal layer of the leaves leaving the leaves mesh like. Severe infestations may also lead to total defoliation.

Recently another species of Spodoptera, the army worm *Spodoptera frugiperda* have become a very serious insect which may also infest on young cotton plants cutting the germinated cotton plants.

4. Spotted bollworm (*Earias insulana* and *Earias vitella* Fab.)



Spotted boll worm larvae directly feeds on the cotton squares, flowers, bolls and sometimes on the shoots. Spotted boll worms can damage the cotton plant branches in vegetative phase causing the terminal shoot drying and dying. When these boll worms attack on the bolls holes are formed and they get rotten.

The boll worm complex other than the American boll worm may be controlled by using chemicals with proper usage methodologies.

5. Jassids (*Amrasca biguttula*)

Cotton plants are also infested by jassids in the leaves making them pale coloured by sucking sap, leaves turn downward and plants grow very slow. The leaves turn downwards and colour of the plant turns pale. In case of severe infestations marginal chlorosis of the leaves is noticed.

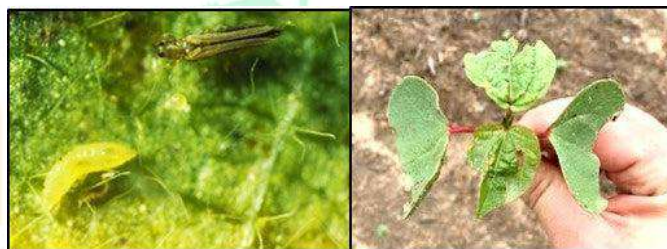


6. Cotton aphid (*Aphis gossypii*)



Aphids also infest on cotton crop. The young growing tips die, leaves will shrink and may bend backwards. The gum like honey dew is noticed on the infested branches and leaves later Black sooty mould is formed due to the excretion from the fungi after consuming the honey dew excreted by aphids.

7. Thrips (*Thrips tabaci*) of Cotton



Thrips are another sucking insect type which suck the sap of the young cotton leaves, the leaves turn yellowish to pale green. The younger leaves turn upward with reduced size and severe infestations may make the leaf edges turn brownish burnt like.

8. Red cotton bug (*Dysdercus cingulatus*)



Red cotton bug adults and older nymphs feed on the emerging bolls and later they may also attack on the cotton seeds. Bugs may also transmit cotton fibre staining fungi or bacteria which reduces the

quality of the cotton fibre. The lints turn red, bolls may rot turning black.

9. Mealy bugs (*Phenacoccus* sp, *Ferrisa* sp and *Maconellicoccus* sp)



Mealy bugs are also common sucking pests in cotton crop. Mealy bugs are found in clusters under surface of the leaves with waxy secretion. Sooty mould is also noticed in the plants with mealy bug infested plants. Plants become weak and yields will be reduced if not managed.

Weeds are always the alternate hosts and proper sanitation, weed free farms will have minimum infestations. Continuously monitor the incidence and early detection will help to manage effectively

Use of Encyrtid parasitoids, *Acerophagus papayae* @ 100 per village against *Paracoccus marginatus* and *Aenasius bambawaekli* against *Phenococcus solenopsis* are recommended.

10. Mite pest on cotton



Red Spider Mite: *Tetranychus Cinnabarinus* (*Tetranychide acarira*), Yellow Mite / Broad Mite: *Polyphagotarsonemus latus* (*Tarsonemidal*

acarina) and Wolly Mite : *Aceria gossypii* are three types of mites which usually infest cotton crop. The mites attack cotton plants at early stages of crop growth normally found under surface of the leaves sucking the sap.

Management

- ✓ Regular monitoring of the crop for the presence of larvae and/or damage is necessary in order to make timely decisions on control. This is especially important when targeting small and possibly insecticide-resistant larvae.
- ✓ In order to prevent insecticide resistance, the cotton industry has developed the Insecticide Resistance Management Strategy (IRMS). This strategy is reviewed annually to delay development of resistance of *H. armigera* to conventional insecticides. The core IRMS principles include:
 - ✚ Rotation between chemical groups with different modes of action
 - ✚ Limiting the time period during which an insecticide can be used
 - ✚ Limiting the number of applications of one particular insecticide.
- ✓ Post-harvest cultivation (pupae busting) to reduce the overwintering stage of *Helicoverpa* is one of the most important cultural control practices available. Cultivation to a depth of at least 10 cm will damage or disturb pupae, seal their emergence tunnels and trap emerging moths. Cultivation also leaves survivors open to attack by birds, mice, earwigs and wasp parasites

- ✓ Control weeds that serve as alternative hosts for aphids, including marshmallow, capeweed, thistles, nightshade, bladder ketmia and thornapples.
- ✓ Ratoon and volunteer cotton should be controlled as they are winter hosts and may also carryover CBT disease.
- ✓ Cotton aphid has developed widespread resistance to a number of insecticides, so adhere to the cotton IRMS.
- ✓ For chemical control options see the Cotton pest management guide.
- ✓ Control alternate weed hosts and consider planting cotton away from other hosts such as soybeans, sunflower and cucurbit crops.
- ✓ Develop an area-wide management strategy with neighbours including a tight planting window so that whitefly does not migrate to successive plantings.
- ✓ Avoid early season broad-spectrum insecticides that kill beneficial insects and subsequently flare whitefly populations. Natural enemies play a vital role in the management of SLW.
- ✓ Consider that thrips are natural enemies of spider mites. Use chemical control only if thrips damage exceeds the threshold.
- ✓ Cotton crops planted next to cereal crops are more at risk of thrips infestations.
- ✓ Thrips prefer cooler temperatures and populations decline if temperatures rise above 30°C.
- ✓ Western flower thrips are resistant to some insect

-icide groups.

- ✓ Predators of thrips include pirate bug, lacewing larvae, brown lacewing, and ladybird beetle.

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An Overview of Pesticide Use and Proper Pesticide Management to Reduce the Risk of Pesticide Poisoning

Soniya Ashok Ranveer, Pooja Nivrutti Bhagat and Bhavesh Chavhan

Introduction

“Any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies” (Food and Agricultural Organization (FAO), 1989).

There has been an increase in the use of pesticides over the last 50 years as a result of the need to produce more and better food. These substances have raised concerns about the risks and harm to the economy, environment, and public health as a result of improper handling and increased use. Approximately one million people are poisoned by pesticides each year, with a fatality rate of between 0.4 and 1.9 percent, according to the World Health Organization (WHO). Seventy percent of these deaths could be attributed to the harm done in the

course of one's job. In addition, low-level pesticide exposure has been linked to a wide range of illnesses, including cancers, reproductive problems, and problems with the nervous and reproductive systems. The use of agrochemicals is widespread and unrestricted throughout the world (Benitez *et al.*, 2009).

Therefore, people who use pesticides or regularly come into contact with them need to have an understanding of the relative toxicity of the products they use, as well as the potential health effects of those products, and the preventative measures that can be taken to reduce their exposure to those products. Always follow the directions and precautions on the label, including any requirements for the use of protective gear. User should only use pesticides on the crops or in the circumstances that are specified on the label. You should apply pesticides at the rates that are written on the label, or at lower rates if this publication suggests that you should.

a. Safety guidelines for pesticides usage

Most pesticides show a high degree of toxicity because they are designed to kill certain

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Table 1: Typical uses of pesticides

Activity	Use
Agriculture	Control of multiple crop pests in any stage
Public health	Control of disease vectors such as malaria, dengue, Chagas disease, onchocerciasis, plague, yellow fever, filariasis, trypanosomiasis, schistosomiasis, leishmaniasis and typhus. Control of pests (rodents) and eradication of plantations whose final product is a prohibited drug
Livestock and domestic care	In the disinfection of sheep and pets like dogs and cats
Treatment of structure	Treatment of public and private buildings, offices, hospitals, hotels, cinemas, theaters, restaurants, schools, supermarkets, department stores, sports facilities, food warehouses and the rail industry and sea and air
Maintenance of green areas	Treatment of parks, gardens, playgrounds, golf courses, highways, railways, platforms, towers, high voltage lines and poles
Maintenance of water reserves	Treatment of large reserves of water, natural or artificial, dams, reservoirs, dams, reservoirs, ponds, piscinas, canals, ponds and pools
Industries	In the manufacture of refrigerators, electrical equipment, paints, resins, adhesives, pastes, waxes, liquid limpiamentales, tents, sails for sailing, sports nets, mats, carpets and tapestries, the timber industry, packaging materials food, cardboard and paper multiple products. In the food industry for the preservation of fresh foods such as meat, pescados, etc.

organisms and thus create some risk of harm. Often, pesticide applications prove counterproductive because they kill beneficial species such as natural enemies of pests and increase the chances of development of pest resistance to pesticides. Furthermore, many end users have poor knowledge of the risks associated with the use of pesticides, including the essential role of the correct application and the necessary precautions. Improper usage of pesticides may create hazardous for human and other non-target species. Most of pesticides toxic in nature and pesticides ingestion and inhale may create adverse effect in long and short terms. Contamination of food, soil and drinking water with pesticides may increase risk after consumption. During the handling, transport and storage special

precaution required to prevent any contamination in environment, food etc. Cleaning and maintenance should be regular to avoid any leakage. Training for pesticides user is necessary.

b. precursory measure at farm level

Processed crops

A crop that has been treated with some of these chemicals may be rejected by certain processors. Before applying a pesticide to the crop, user should make sure to check with the processor first, especially if the crop is going to be processed.

Crop injury

Under certain conditions, the use of chemicals can be harmful to plant life (also known as phytotoxicity). Always check the label to see if there are any restrictions. Before applying any kind of

pesticide, users need to consider the current stage of plant development, the type and condition of the soil, the temperature, the amount of moisture, and the wind. The utilisation of components that are not compatible with one another can also lead to injury.

Protection of animals and plants

There are many types of pesticides, and many of them are toxic to animals that are beneficial or desirable, such as honey bees, natural enemies, fish, domestic animals, and birds. Incorrectly applying pesticides can be harmful to plants of all kinds, including crops. It is important to take the necessary precautions to protect nonpest species from direct contact with pesticides as well as contamination caused by drift, runoff, or residues. Animals that consume rodents that have been poisoned by certain rodenticides may be exposed to an increased risk.

Posting treated fields

In order to protect workers in the field from certain materials, restricted entry intervals have been established. Keep workers away from the field for the required amount of time after the application, and when regulations demand it, post signs in the treated areas indicating the safe re-entry date. Check with the agricultural commissioner in your county for the most up-to-date information on restricted entry intervals.

Preharvest intervals

Within a certain amount of time before harvest, certain crops are prohibited from having certain materials or rates applied to them. Be sure to follow the directions on the pesticide label, and give

the appropriate amount of time between application and harvest.

Permit requirements

Before one can possess or use a number of pesticides, one must first obtain permission from the county agricultural commissioner. In the treatment frames or chemical sections of this publication, those specific materials will be denoted with an asterisk (*) if a recommendation has been made to use them.

c. Corrective action regarding how to handle pesticides

Legal responsibility and personal safety

Any damage caused by improper use of pesticides falls under the user's legal responsibility. Effects caused by drift, runoff, or residues are also included in the scope of responsibility. Always read the label before doing anything. Don't let anything get on your clothes or cause a mess by splashing or spilling. Use of pesticides should never be accompanied by any of these activities. As required by law, arrange for immediate access to emergency medical services in advance.

Proper Storage and transportation

Before using pesticides, make sure they are stored in their original containers. Lock them away in a place where children, unauthorised people, animals, and livestock cannot get to them, such as a cabinet with a lock, a building, or a fenced-off area. Pesticides should NEVER be stored in the same area as foods, feed, fertilisers, or any other materials that have the potential to become contaminated by the

pesticides. It is essential that pesticides and food or feed not be transported or carried together in a manner that could result in contamination of the edible items. Under all conditions pesticides must be transported inside of a closed passenger vehicle or cab.

Labelling

Packaging and labelling of pesticides should according to specification of WHO. Contents, safety instructions and other important information should be in English and local language for better understanding of users.

Appropriate Disposal of left-over pesticides and Container

For safely disposal of left-over pesticides or insecticide suspension, it can be dump into ground or pit latrine. It should be disposed far away from water bodies. Take caution when disposing of empty containers. 'READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER'. Never use them again. Make sure that children and animals cannot get their hands on any containers that are empty. Never dispose of containers in areas where they could potentially contaminate natural waterways or water supplies. For information on the appropriate methods of managing and disposing of large quantities of empty containers, you should speak with the agricultural commissioner of your county.

Signs of poisoning by pesticides

- ✓ General: extreme weakness and fatigue.
- ✓ Skin: irritation, burning sensation, excessive

sweating, staining.

- ✓ Eyes: itching, burning sensation, watering, difficult or blurred vision, narrowed or widened pupils.
- ✓ Digestive system: burning sensation in mouth and throat, excessive salivation, nausea, vomiting, abdominal pain, diarrhoea.
- ✓ Nervous system: headaches, dizziness, confusion, restlessness, muscle twitching, staggering gait, slurred speech, fits, unconsciousness.
- ✓ Respiratory system: cough, chest pain and tightness, difficulty with breathing, wheezing

d. First-aid treatment

If a person's breathing has stopped, administer Cardiopulmonary resuscitation. No insecticide should be swallowed if resuscitation is attempted with mouth-to-mouth. Keep the patient's airway open by lifting the chin and tilting the head back with one hand. The thumb and index finger of the other hand should be pointed toward the patient's nose, and the hand should be placed on the patient's forehead. Keep the patient's airways closed with the thumb and index finger of the thumb and index of the thumb. Close your mouth around the mouth of the patient and take a deep breath. Take four full, rapid breaths before the lungs fully deflate.

Make sure to wash the eyes for at least five minutes if there is insecticide on the skin or in the eyes. Wear protective clothing and remove yourself from the contaminated area. Using soap, wash the body thoroughly for at least 10 minutes.

To remove pesticide from the skin if there is no water available, gently rub the skin with cloths or paper. Be careful not to over-rub or over-scrub.

e. Regulatory standards for monitoring pesticides in human and animal food

International and National Regulation

Usage of pesticides is control and monitor by different international and national bodies. These regulator bodies' approval pesticides or other chemical after evaluating safety and efficacy to customer and user. Its establishment the standard for different food which produced domestically or imported.

Indian regulation for pesticides

Agricultural and Processed Food Products Export Development Authority

The Agricultural and Processed Food Products Export Development Authority (APEDA) was formed under the Agricultural and Processed Food Products Export Development Authority Act, 1985. Organic farming and product APEDA given guidelines and standards and certify by National Accreditation Policy and Programme (www.apeda.gov.in).

Central pesticides Board & Registration Committee

Central pesticides Board & Registration Committee (CIBRC) beneath the board of directors of Plant Protection, Quarantine & Storage, Department of Agriculture & Cooperation formed by Ministry of Agriculture in year 1970 to control the import, manufacture, sale, transport, distribution and

use of pesticides. CIBRC is responsible for registering pesticides by validating claims associated with safety and effectivity of the pesticides (www.cibrc.nic.in).

Food Safety and Standard Authority of India

The FSSAI has been established under the Food Safety and Standards Act, 2006, Ministry of health and family welfare, are responsible for specifying maximum residual level (MRL) for pesticides residues that are registered under CIBRC food commodities.

International Regulation of pesticides

Codex Alimentarius Commission and European Union

It was established under the join regulatory bodies, FAO/ WHO in 1962, food standard conference, summon in Geneva for harmonising the food standard. Codex committee on pesticides residues (CCPR) is the special codex committee, which is fixed MRL for pesticide residues in different food matrices (www.codexalimentarius.org).

The main function of the European Union includes establishing EU laws, policies and observation whether or not a law is enforced. It issues MRLs for pesticide residues for different food commodities as well as milk and milk product.

e. Maximum residue limits for pesticides

Before applying pesticides to crops destined for export, check maximum residue levels (MRLs) of the importing country. Make sure to check the country's MRLs before applying pesticides to crops

that will be exported. MRLs shows the maximum concentration that legally permitted inside or outside of food matrices by ensuring good agricultural practice at all level. Some common pesticides may use in both foods as well as animal feed. In the case of agricultural crop, MRLs for pesticides are described, but for animal feed and green fodder, Codex Alimentarius Commission (CAC) set the limit. In India there is no recommended/fixed MRL for feed and fodder. FSSAI given MRLs for the pesticide residues in different food commodities under the Food Safety and Standards (Contaminants, Toxins and Residues) laws, 2011.



Benefits of Regenerative Agriculture for Soil: A Review

Pankaj Kumar, Payal Choudhary and Ravi Kalash

In order to replenish soil organic matter, diversify crop systems, and enhance water retention and nutrient uptake, regenerative agriculture is a holistic farming system. Agriculture must shift from degenerating to regenerating due to the loss of biodiversity, deterioration of soil health, warming, and drier weather in farming regions. Regenerative agriculture is defined as farming and grazing practises that stop climate change by restoring degraded soil biodiversity and building up soil organic matter, which reduces carbon emissions and improves the water cycle. Conventional farming methods like tilling remove valuable topsoil while also releasing carbon stored in the earth into the atmosphere. According to a Scientific calculations, it takes 1,000 years to produce three centimetres of topsoil, and if current rates of soil erosion continue, the entire planet's topsoil might disappear within 60 years. In addition, soil degradation sets off a vicious cycle whereby less carbon is stored, the planet becomes hotter, and the land becomes even more degraded. So, Using cover crops, eliminating tilling, rotating crops, spreading compost (as well as super-compost “inoculants”), and avoiding synthetic fertilisers, pesticides, herbicides, and factory farming are some of the first farming techniques that assist

rejuvenate the soil.

What is regenerative agriculture?

Regenerative agriculture is frequently used to refer to techniques that aim to improve soil health by replenishing the organic carbon in the soil. Rebuilding soil organic matter and recovering lost soil biodiversity are among the many advantages of "regenerative agriculture," which refers to farming and grazing methods. The soils of the planet serve as a natural carbon sink, storing several times as much carbon as the atmosphere does. However, due to factors including the conversion of natural landscapes to croplands and overgrazing, soil carbon stores have been diminishing globally. Regenerative methods aim to restore soil carbon by using part of the carbon that plants have taken up from the atmosphere.

No-till farming, in which farmers drill seeds into the ground rather than plough the soil, and the use of cover crops, which are plants planted to cover the soil following tillage, are examples of practises categorised under regenerative agriculture.

Why regenerative agriculture for soil?

Regenerative agriculture is a philosophy and a set of techniques that enhances ecological and financial resilience while restoring and maintaining

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soil fertility and health. It also supports biodiversity, safeguards watersheds, and supports watershed restoration. It takes its cues from nature, which has a very long history of effectively producing things, and concentrates on establishing the circumstances for life above and below earth. Regenerative agriculture can also absorb growing amounts of atmospheric carbon (CO₂) underground by re-carbonizing soils through photosynthesis and biology, especially on degraded land, making it a low-cost, "shovel-ready" response to climate change. It will be a crucial part of our response to growing climatic instability because of its many positive side effects, which include the production of wholesome, nutritious food.

The origins of regenerative agriculture

The terms "regenerative agriculture" and "regenerative farming" first gained popularity in the early 1980s after being adopted by the US-based Rodale Institute. The adjective "regenerative" has been associated with the nouns "agricultural" and "farming" since the late. The Rodale Institute has been at the vanguard of the organic agricultural movement for many years through its research and publications, which include the periodical Organic Gardening and Farming. According to Robert Rodale (1983), regenerative agriculture "increases our land and soil biological production base at increasing levels of productivity." It has a high degree of inherent biological and economic stability. Beyond the confines of the farm or field, it has little to no environmental impact. It creates foods without bio-

cides. During the transition to a low reliance on non-renewable resources, it allows for the constructive participation of growing numbers of people.

Potential of regenerative agriculture for soil health

In articles about regenerative agriculture, soil health is given great emphasis. In fact, the most, if not all, demands for regenerative agriculture are predicated on the concept that soil, and soil life in particular, are under threat. However, the phrase "soil health" is by its very nature problematic. Similar to soil quality, soil health is a container notion that needs to be broken down in order to be useful. Although it can be seen as something to aim at, underlying soil functions require significant indicators that can be assessed and watched over time. Agronomic principles and practices considered to be part of Regenerative Agriculture and their potential impacts on restoration of soil health.

Principles	Practices
Minimize tillage	Zero-till, reduced tillage, conservation agriculture, controlled traffic
Maintain soil cover	Mulch, cover crops, permaculture
Build soil C	Biochar, compost, green manures, animal manures
Sequester carbon	Agroforestry, silvopasture, tree crops
Avoid pesticides	Diverse crop rotations, multi-species cover crops, agroforestry
Encouraging water percolation	Biochar, compost, green manures, animal manures, holistic [Savory] grazing

- ✓ The most of regenerative agriculture methods depend on soil management, with a focus on raising soil carbon (C), on the theory that doing

so will boost crop yields and slow down climate change. SOM plays a variety of roles in the soil, including nutrient supply, soil structure, water holding capacity, and maintaining soil life. As a result, it is a key indication of soil fertility.

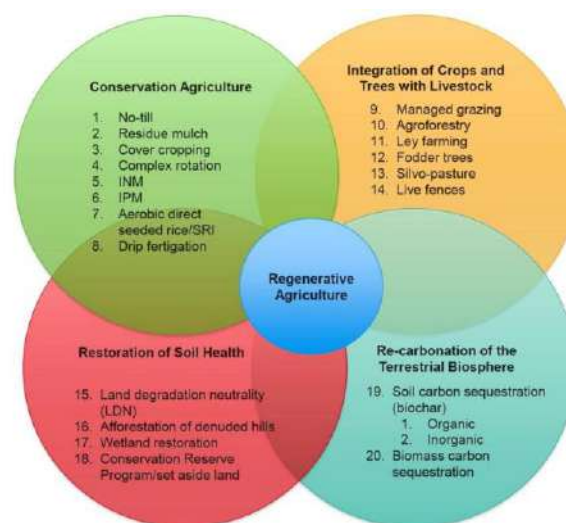
- ✓ The amount of organic matter added to the soil and the texture of the soil play a big role in how much carbon is stored there. Clay soils have a far higher capacity for carbon storage than sandy soils. Depending on the initial conditions, it is possible to enhance the quantity of carbon that is stored in the soil.
- ✓ Degraded clay soil that has been repeatedly worked and is severely depleted of soil C can store far more additional carbon than degraded sandy soil. It's possible that a productive soil has already reached its C saturation capacity. As a result, by modifying management techniques such as the application of animal manure, the development of green manures, or the return of crop wastes, soil C can only be slightly raised under continuous cultivation.
- ✓ Other technical solutions can imitate, add to, or replace part of the contributions that SOM makes to soil fertility, much like with the external nutrient supply. For instance, irrigation and tillage can both improve soil water availability and soil structure.

Agronomic approaches for soil health

- ✓ Soil erosion can play a significant role in soil conservation, most of the time this concern can be summed up as "closing the barn door after the

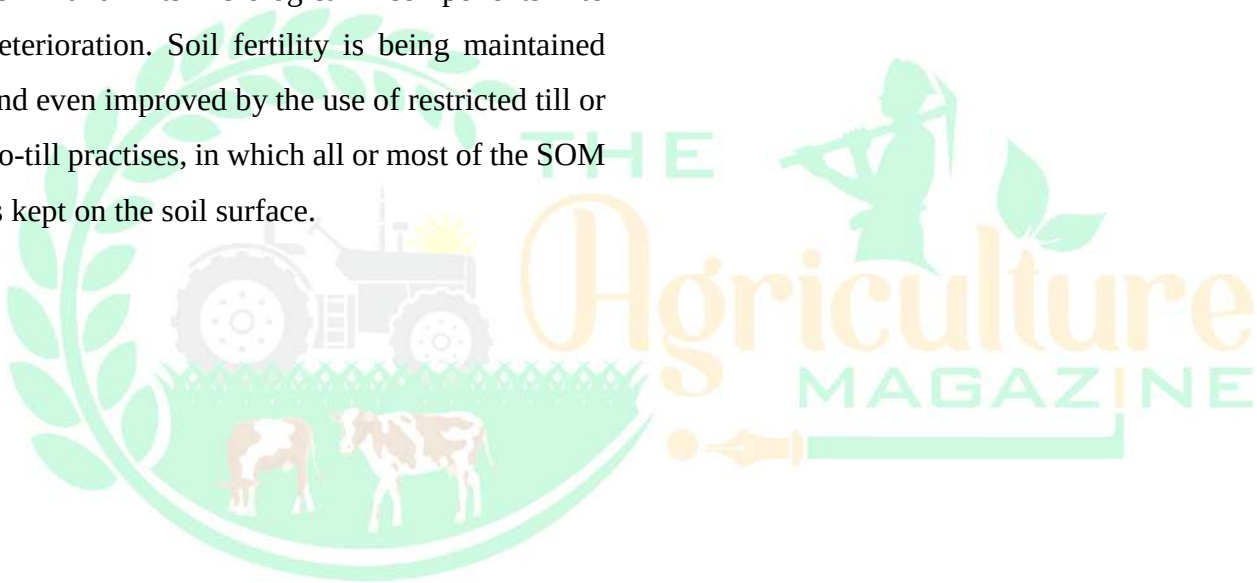
horse has been stolen."

- ✓ To control soil temperature, to safeguard the soil surface, and to support healthy surface biological processes, soil cover is necessary.
- ✓ Structure of the soils is similar to that of buildings, with the main activity taking place inside the buildings and in the spaces between them, or in the spaces. Water flow, gas exchange, animal and plant movement, and other processes necessary for agricultural productivity take place here.



- ✓ Diverse biology is necessary for ecosystem vigour and resilience as well as to take use of biological and other buffers capacities.
- ✓ Amendments containing nutrients - as required to replenish nutrients lost from the soil system due to plant harvest, leaching, and unavoidable runoff. The soil can be improved by adding organic or inorganic materials, although the former has benefits that go beyond nutrient replenishment.

- ✓ High soil organic matter (SOM) content is attracting new interest, especially in light of mounting evidence that the use and availability of organic materials improve the benefits of nutrient cycling and the addition of chemical fertilisers.
- ✓ Limited tillage: Although some soil disturbance helps with aeration, which is crucial for plant growth, and can change the balance of flora and fauna in desired ways, it frequently exposes the soil and its biological components to deterioration. Soil fertility is being maintained and even improved by the use of restricted till or no-till practises, in which all or most of the SOM is kept on the soil surface.



Crop Growth Simulation Model: An Introduction

Subhash, Rana Pratap Singh and Khemraj Dubey

Model: A model is a simplified representation of a system or a process. Modelling is based on the assumption that any given process can be expressed in a formal mathematical statement or set of statements. Simulation is the process of building models and analyzing the system. A crop model or crop simulation model describes process of crop growth, development and related attributes (Yield, LAI, Biomass, Nutrient uptake etc.) as a function of weather conditions, soil condition of crop management process. Crop models are tools of systems research which help in solving problems related to crop production.

Why We Need Simulation Models?

- ✓ To assimilate knowledge gained from field experimentation.
- ✓ To provide a structure that promotes interdisciplinary collaboration.
- ✓ To promote the use of systems analysis for solving problems
- ✓ To offer dynamic, quantitative tools for analyzing the complexity of cropping systems, Crop models require certain input data which is used by the model to further generate the required output.

Introduction of Simulation models

Crop growth simulation models and biogeochemical and biophysical models have been very helpful in projecting the future crop and soil productivity. These models in connection with different General circulation model (GCM) models predict the future agricultural practices that can adapt to different climate change scenarios. Here are a few of the models that can be used for different scenarios analysis to combat impact of climate change on agricultural production of the globe.

Simulation models that are able to assess climate change impact on crop growth, yield and farm economy, still lack complete feedback structures. Only single aspects can be investigated. However, modelling these single aspect increases knowledge on to the aspects of expectations from climate change, if interpreted carefully and in the context of the model's abilities. Simulation models are widely used to address "what if" type questions, such as, what if the climate changes, different irrigation or fertilization regimes are used, different sowing dates are used, different cultivars are used, etc. In addressing actual yield predictions required by governments, private corporations, or NGOs, different types of simulation models are used for

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solving these "what if" type questions.

Simulation management

The Manager component contains all the management options for the simulation.

- ✓ Sowing
- ✓ Tillage
- ✓ Fertilizing
- ✓ Resetting of water and nitrogen
- ✓ Irrigation
- ✓ Rotations

Approaches for simulation study i.e., Assessment of crop yield or rules of simulations

Most of the crop simulation models include crop modules like cereals, legumes, oil seeds, sugar crops etc. The crop models are composed of parameterization of important physiological processes responsible for plant growth and development, evapo-transpirations, partitioning of photosynthesis to produce economic yield. The simplified functions enable prediction of growth of crops as influenced by major factors that affect yield i.e. genetics, climate (daily solar radiation, maximum and minimum temperature, rainfall etc), soils and management practices. The models include soil water sub-models so that they can be used to predict crop yield both under irrigated and rainfed conditions. The models also simulate effects of nitrogen on crop growth. The following steps to be used before one could use crop simulation models for climate studies.

- ✓ Defining the representative crop management (i.e., variety, fertilizer input, rainfed or irrigated production systems, number crop rotations, soils etc).

- ✓ Definition of base line climate data. More the years better the predictions. Usually, current climate to past thirty years weather data is considered for this scenario.
- ✓ Validation of crop models under current climate from the experimental data from field trials to the extent possible.
- ✓ Simulation of crop response to modified climate scenarios i.e., change in temperature, rainfall and CO₂ concentration.
- ✓ Testing for farm level adaptations i.e., shifting of planting dates, additional application of irrigation water and N to the crops under stress and changing of crop varieties to adapt different climate change scenarios.
- ✓ Crop simulation results for main crops are aggregated to agro-climatic regions by weighting their representative contribution to current regional production.
- ✓ Statistical analyses are used to derive regional yield response functions.
- ✓ The yield functions are used to the spatial climate change data (scenario changes in temperature, CO₂ concentration and rainfall) to derive scenario yield change estimates for individual crops.

Input Data Requirement

Crop modeling requires data related to weather, crop, soil, management practices and insect-pests.

1. **Weather data:** Maximum and minimum temperature, rainfall, relative humidity, solar

radiation and wind speed. Weather data is required at daily time step to assess daily crop growth processes.

2. **Crop data:** Name of crop, variety name, crop phenology (days to anthesis, days to maturity etc.), leaf area index, grain yield above ground biomass, 1000 grain weight, etc.
3. **Soil data:** Thickness of soil layer, pH, EC, N, P, K, soil organic carbon, soil texture, sand and clay percent, plant available water content, soil moisture, saturation, field capacity, wilting point, bulk density of soil at different depth.
4. **Crop management:** Date of sowing of crop is required to initiate the simulation process. Generally sowing date is taken as the start time for the simulation. Seed rate depth of seeding row spacing, numbers of plant /m², are also required. Use of inputs in the crop field, namely, irrigation, fertilizer, manure, crop residue etc. needs to be mentioned. Amount of these inputs are specified along with their type, date of application and depth of placement. If crop residues or organic nutrient sources are applied in the field then C: N ratio of these sources needs to be quantified.
5. **Pest data:** Name and type of the pest, their mode of attack, pest population at different crop growth stages. Data on insects or pests are included only in those models which contains the pest module.

Steps in Modeling

Define goals: Agricultural system is complex comp-

-rising of various disciplines. In order to develop or understand a crop model one requires strong knowledge base of different subjects. Depending upon the objective of study, knowledge base of different disciplines is integrated to develop a crop model.

Define system and its boundaries: In crop modeling, crop field is chosen as a system.

Define key variables in system: Variables include state, rate, driving and auxillary variables. State variables are those which can be measured or quantified, e.g., soil moisture content, crop yield etc. Rate variables are the rates of different processes operating in a system, e.g., photosynthesis rate, transpiration rate. Driving variables are the variables which are not part of the system but the affect the system, e.g., sunshine, rainfall. Auxiliary variables are the intermediated products, e.g., dry matter partitioning, water stress etc. These variables are identified in the crop field.

Quantify relationships: Once the relationship is established it is then quantifies using different mathematical equations and functions.

Calibration/Validation: When the model is developed, it requires calibration and validation. First the model is run with any experimental data set and calibrated accordingly. Calibrated model is then validated with another experimental dataset to check its simulation ability under different situations or environment.

Sensitivity analysis: Validated model is than tested for its sensitivity to different factors (e.g. temperatu-

re, rainfall, N dose). This is done to check whether the model is responding to changes in those factors or not.

Use of models in decision support: Once developed, calibrated and validated any model can be used in any decision support system for forecasting or making suitable decisions regarding crop management.

Possible Applications of Crop Model

- ✓ Estimation of potential yields and forecasting
- ✓ Estimation of yield gaps: principal causes and their contribution
- ✓ Impact assessment of climatic variability and climatic change
- ✓ Optimizing management: Dates of planting, variety, irrigation and nitrogen fertilizer
- ✓ Environmental impact: percolation, N losses, GHG emissions, SOC dynamics

Conclusions

- ✓ Models are holistic, knowledge-based global tools for global and local applications
- ✓ Help us in assimilating knowledge gained from experimentation
- ✓ Help understand/predict behavior of biological systems on the basis of underlying level of integration
- ✓ Offer dynamic, quantitative tools for analyzing the complexity of agricultural systems
- ✓ Promote inter-disciplinary research
- ✓ Increase the efficiency of agricultural research and management
- ✓ Improve agronomic efficiency and environme-

tal quality.

Panchagavya: Boon for Sustainable Agriculture

Gajendra Nagar, Sonu Nagar, Bharat Lal Meena and Radhey Shyam Nagar

India's growth story is service sector led. Manufacturing sectors growth remaining stagnant, relevance of agriculture is fast declining. Even though contribution from agriculture to national income and economic growth is fast receding still agriculture is capable of leading our growth path. In the name of special economic zones and mega projects, huge fertile agricultural lands are in industrial use today. Land available for cultivation is declining. In spite of all these India is able to achieve self-sufficiency in food production. The economic and trade liberalization and adoption of food security bill are exerting heavy pressure on India's land resource partitioning in sectors such as forestry, agriculture, pasture lands, human settlements and industries. Thus, the coupled effect of meeting food demand under limited area and toxin-free agricultural produce have become an important factor forcing countries like ours to explore possibilities for opting conventional agriculture to the dominant farming approach called organic farming, holistic production management system

and sustainability. Development should not be at cost of destruction of ecology. Sustainable development is the need of the hour. With the increase in population our compulsion would be not only to stabilize agricultural production but to increase it further in sustainable manner. Through organic farming a healthy interface between human resource and natural resources in general and commons in particular can be ensured. A humane approach to agronomy will mean a quality assurance for people and the environment (Basil, 2014). Thus, a natural balance needs to be maintained at all cost for existence of life and property for the present and future generation also. The obvious choice is organic farming.

Organic farming emerged as a potential alternative for meeting food demand, maintaining soil fertility and increasing soil carbon pool. With more and more education, information and awareness people are going in for green products. The protection of environment through sustainable consumption is possible only through green products

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With rising concern of health issues and food safety, many consumers have turned their site to organic products. The increased consumers' interest in organic food has been attributed among others to the growing demand for food free from pesticides and chemical residues. Organic foods promote balance among humans, other living organisms and the nature. It also promotes no artificial preservatives and best maintains the originality of food. This prevents excess use of harmful ingredients and thereby ensures health (Raahinipriya, 2018). Organic farming system emphasizes on the use of organic matter for enhancing soil properties, minimizing food chain associated health hazards and attaining closed nutrient cycles, the key factors for sustainable agriculture. Organic agriculture is a production system which includes agriculture with biodiversity, ecosystem and biological cycle and excludes all chemical and synthetic inputs. It avoids chemical fertilizers, hormones, feed additives and pesticides and promotes natural techniques like crop rotation, animal manure, off-farm waste, crop residues, plant protection and nutrient mobilization (Negi and Negi, 2018).

The panchagavya solution containing cow dung, urine, curd and ghee. The cow has been a cornerstone of Indian agriculture for centuries and has soared as a source of nutrition for farmer's families through milk products as well as providing draught animal power for both agricultural operations such as ploughing and tilling the land. Nearly all basic necessities of life were woven

around the contributions in all aspects of life including family and manure. Panchagavya is also mentioned in Vrikshayurveda texts and it has been experimented by farmers. It has a significant role in providing resistance to pests" disease and increasing the overall yield.

Panchagavya is an organic formulation, which in Sanskrit means the blend of five products obtained from cow i.e. milk, ghee, curd, dung and urine (all these products are individually called as "Gavya" and collectively named as panchagavya). Panchagavya has got reference in the scripts of Vedas (devine scripts of Indian wisdom) and Vrikshayurveda (Natarajan, 2002). In India, the use of panchagavya of organic farming is gaining popularity in recent years, especially in India in states like Rajasthan.

In Veda, cow's urine was compared to the nectar. In substrata several medicinal properties of cow's urine have been mentioned and are known to cause weight loss, reversal of certain cardiac and kidney problems, indigestion, stomach ache, edema, etc. Cow urine has a unique place in Ayurveda and has been described in Sushrita Sumhita and Ashtanga Sangraha to be most effective substances secretion of animal origin with innumerable therapeutic values. It has been recognized as water of life or Amrita (beverages of immortality) the nectar of the God. In India drinking of cow urine has been practiced for thousands of years. Panchagavya is a term used in Ayurveda to describe five important substances obtained from cow, namely urine, dung, milk, ghee

and curd. A number of formulations mentioned in Ayurveda described the use of panchagavya components either alone or in combination with drugs of herbal, animal or mineral origin.

Panchagavya is a foliar nutrition prepared by organic growers of Rajasthan and used widely for various agricultural and horticultural crops. In Sanskrit, Panchagavya means a combination of five products obtained from the cow. When suitably mixed and used, these have miraculous effects. Panchagavya is used in different means such as foliar spray, soil application along with irrigation water, seed or seedling treatment, etc. For foliar spray 3%, 5% and 10% concentration is being adopted by organic farmers using hand-operated sprayers with high pore sized nozzle Cow's urine provides nitrogen which is essential for crop growth. Milk provides protein, fat, carbohydrates, amino acid and calcium. Curd provides lactobacillus which act as a catalyst in the digestion of organic waste. Ghee provides vitamins A and B, calcium and fat. These contents stimulate the growth and yield of all agronomic and horticulture crops. (Nagar *et al.*, 2016).

Preparation of panchagavya

Panchgavya was prepared with a mixture of five components in the ratio of 5:4:3:2:1, viz., cow dung, cow urine, milk, curd, ghee 1 liters, tender coconut water and six ripe bananas respectively, which was fermented for 21 days. *Panchgavya* 5% solution was prepared by adding 500 ml prepared *panchgavya* and filtered solution in 10 liters of water, and applied as foliar spray at 30, 45 DAS in Legume

crops and 40 and 60 DAS in cereals crops.

Table 1: Ingredients of Panchagavya

S. No.	Ingredients	Quantity
1.	Cow dung	5 kg
2.	Cow urine	4.0 Lit.
3.	Cow milk	3.0 Lit.
4.	Cow curd	2 kg
5.	Cow ghee	1.0 Lit.
6.	Tender coconut	100 ml
7.	Ripe bananas	6.0

Characteristics of panchagavya

The Nitrogen, Phosphorus, potassium, pH and electrical conductivity test are required of panchagavya solution. These five parameters are important for the plant growth.

Panchgavya	
N (%): 1.68	P ₂ O ₅ (%): 0.25
K ₂ O: 0.63	pH: 6.37
EC: 1.02	

The components like cow dung and cow urine enhances the insecticidal activity of pachagavya which can reduce the number of application hazardous chemicals on crops. It is a mixed culture of naturally occurring, beneficial microbes' mostly lactic acid bacteria (*Lactobacillus*), yeast (*Saccharomyces*), actinomyces (*Streptomyces*), photosynthetic bacteria (*Rhodopsuedomonas*) and certain fungi (*Aspergillus*) which promotes the growth and yield in different crops and provides high B:C ratio. So, panchagavya can be effective organic growth-promoter for small and marginal farmers. Panchagavya is an organic product having the potential for promoting growth and providing immunity in plant system.

Uses

- ✓ Seed and seedling treatment
- ✓ As a soil fertility enhancer by applying through irrigation water
- ✓ The rooting is profuse and dense. Further they remain fresh for a long time. The roots spread and grow into deeper layers were also observed. All such roots help maximum intake of nutrients and water
- ✓ Helps in decreasing the use of Chemical Fertilizers. By reducing or replacing costly chemical inputs, Panchagavya ensures higher profit and liberates the organic farmer from loan.

Time of application

- ✓ Pre flowering phase: Once in 15 days, two sprays depending upon duration of crops.
- ✓ Flowering and pod setting stage: Once in 10 days, two sprays.
- ✓ Fruit/Pod maturation stage: Once during pod maturation.

Fig. 3. Graphical representation of Panchagavya



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Terminator Technology: An Insight into Seed Suicidal Technology

Manuj Saini, Rajvinder Singh, Aarti Kamboj, Pooja and Sonu Langaya

Abstract

Plant breeding has been major concern of public sector institutes rather than profit oriented private seed companies for more than century especially in India. This was done to safeguard the farming community and provide small and marginal farmers who lack resources unrestricted access to planting supplies. Terminator technology provides legal right to the developers or originators of transgenic plants or animals to protect their material or breed from using by somebody in an unauthorised way. The farmer is not allowed to use farm-produced seed in the following generation by the terminator technology. Farmers must therefore buy new seeds from the market each season. This technology ensures exclusivity in the seed industry and prevents the usage of seeds from prior seasons.

Introduction

Genetic engineering is used in "terminator technology" to end the fertility or viability of saved seed and to prevent its further use. The gene that is involved in viability termination is referred to as a terminator gene in this market-driven technology. The method came into the public domain when the United States Patent and Trademark Office granted the United States Department of Agriculture and the Delta and Pine Land Co., USA, a patent (No. 57,23,765) on "Control of Plant Gene Expression" on March 3, 1988. For already well-known genes, a patent was awarded.

Either in the first generation of plants or in succeeding generations, these genes oversee the manifestation of desirable features.

Genetic Use Restriction Technology (GURT) limits any genetic characteristic in a plant that can be activated or inactivated by the application of an external chemical inducer. The attribute may include colour, ripening, softening, sterility, resistance to cold and drought, etc. The restriction of a certain trait expression in a plant is referred to as T-GURT (Traitor technology, trait-specific). Terminator technology, variety specific, or V-GURT, refers to genetically modified plants whose seeds will not

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sprout when planted. The second-generation seeds are rendered infertile or non-viable by the terminator technology, which uses a suitable fatal gene.

The first generation (F_1) seeds are fully developed, normal, and fertile when sold by the seed company to produce healthy plants bearing seeds or fruits that can be used as food, but they do not germinate when planted. This forces farmers to purchase new seeds from the seed company each year because they are unable to use the harvested seeds from the previous season for the current season.

Genetic Basis of Terminator Technology

Three genes are used in this approach to transfer the essential genetic data into the plants.

1. Lethal Gene (Terminator)

A unique protein called a lethal gene makes plants poisonous and prevents seed germination. The ribosome inhibitory protein (RIP), which is encoded by a fatal gene and prevents the production of all proteins in plant cells without being hazardous to other organisms, is lethal. Thus, the expression of the RIP gene in the developing plant cells would prevent seeds from germinating. The RIP gene is joined to a particular promoter called LEA (late embryogenesis abundance), which is only activated in the later stages of seed development. In the second generation of seeds and beyond, the characteristic was expressed using the LEA promoter (Figure 1A). The promoter won't start working until the plant's first generation of vegetative development is over. In order to stop the lethal RIP gene from being expressed in the first-

generation seeds, a blocking sequence is inserted between the LEA promoter and the lethal gene. The blocking sequences are flanked by specific excision sequences (LOX sites). Blocking sequences at adjacent LOX sites were removed using site-specific excision. As a result, the fatal gene directly interacts with the promoter and expresses itself in all succeeding generations throughout the late stages of embryogenesis.

2. Recombinase Gene

Recombinase is an enzyme that is encoded by the second gene. By using the recombination process, this enzyme excises off the excision sequence (LOX site) and the blocking sequence from the initial gene construct. The CRE protein (Recombinase) performs site-specific recombination of DNA at LOX sites in the Bacteriophage CRE/LOX system, which is a favoured recombinase-excision system. Repressible promoter is located behind the recombinase gene. This promoter is very particular for a repressor protein that the third gene encodes. Recombinase enzyme can be repressed, meaning that if a specific repressible protein is present, it won't create. The excision and blocking sequences from the initial gene construct are eliminated by the site-specific recombination, which occurs during the germination of the first generation of seeds after sowing.

3. Repressible Gene

The third gene, which produces a repressor protein, inhibits the second gene construct's second recombinase gene's promoter.

activate their germination-specific promoter during germination. The first gene construct's excision sequence and blocking sequence will be removed by the active recombinase gene, which will also create a certain protein. The hybrid plant will be heterotic in and of itself, and the seeds it produces will have a typical phenotypic appearance. The fatal gene will manifest itself by inhibiting germination when seeds from one crop season are sown into the following crop season. Because of this, farmers are required to buy fresh seeds from the seed supplier each year.

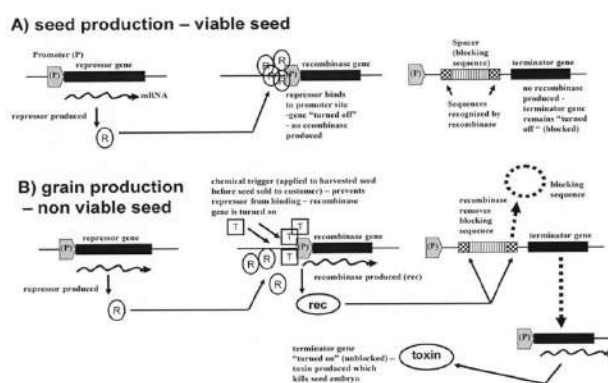


Figure reproduced from (Acker *et al.*, 2007).

1. Hybrid Seed Production

2. Pure Line Seed Production

According to reports, plant cells will be genetically altered (transgenic) and the plants will be grown again using tissue culture techniques. The plants having these sections of DNA will be healthy during the first generation, or the time when businesses are making the seeds. The promoter and the deadly gene are both firmly separated by the blocking sequence. Thus, seeds develop without difficulty. When the seeds from the first generation reach maturity, they are treated to a specific chemical (tetracycline) before being sold to farmers on the open market. The third gene creates a repressor protein; however, this protein is rendered inactive by tetracycline and is unable to attach to the repressible promoter binding site. The recombinase gene will activate, erasing the blocking and excision regions from the original gene construct. At this point, the deadly gene and the LEA promoter are in close proximity. However, because the promoter won't become active until a specific stage of seed develop-

2. Pure Line Seed Production

According to reports, plant cells will be genetically altered (transgenic) and the plants will be grown again using tissue culture techniques. The plants having these sections of DNA will be healthy during the first generation, or the time when businesses are making the seeds. The promoter and the deadly gene are both firmly separated by the blocking sequence. Thus, seeds develop without difficulty. When the seeds from the first generation reach maturity, they are treated to a specific chemical (tetracycline) before being sold to farmers on the open market. The third gene creates a repressor protein; however, this protein is rendered inactive by tetracycline and is unable to attach to the repressible promoter binding site. The recombinase gene will activate, erasing the blocking and excision regions from the original gene construct. At this point, the deadly gene and the LEA promoter are in close proximity. However, because the promoter won't become active until a specific stage of seed develop-

ment, i.e., the late embryonic stage, the lethal gene won't express. This causes the seed to correctly germinate and grow into a strong second-generation plant in the farmer's field.

In the late embryogenesis stage, when the second-generation plant begins to develop seeds, the LEA promoter becomes active and releases a significant number of ribosome-inducing proteins, which in turn inactivate the cell's ribosome-based protein synthesis machinery. Third-generation seeds are produced as a result; however, they are infertile. These seeds can be utilised as food, but they won't sprout into new plants if planted for a later generation.

Conclusion

The employment of terminator technology may have a variety of effects on users, including farmers and breeders who are innovators. Because transgenic material cannot be reused, the GURT processes offer the creators of the material special protection. This technology has a significant impact on agrobiodiversity, the environment, and the socioeconomic position of farmers.

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Microbial Bio-priming Replacing Chemical Fertilizers

Manuj Saini, Sonu Langaya, Gagandeep Singh and Aarti Kamboj

Abstract

With excessive chemical usage, Indian farms are slowly losing their productive edge. Decades of pesticide and fertilizer overdose has left the soils with a low organic carbon content and poor nutrient retention capacity. The soil micro ecosystem has now been reduced to a skeleton of what it expected from a healthy soil. Less organic carbon means the microbes responsible for providing stability to soil are considerably reduced. To balance out the harmful effects of low soil microbiota, usage of bio fertilizers is proving to be a good strategy.

Bio-Priming using Bio-fertilizers?

Bio-fertilizers are essentially a biological compound of a single or a complex of microbes, which when present near the roots of a plant, improves its growth and development in a symbiotic relationship. Different types of microbes can help the plant in a variety of ways.

Benefits

They are usually helpful in mineral solubilization, protection from biotic stresses like pathogen attack and abiotic stresses like drought or freezing stress. The added benefit of using bio fertilizers is that they're completely natural. They already are a part of natural ecosystem, and we are just trying to promote their growth to help undo the

imbalance in soils. They can help make agriculture in the current times more sustainable and efficient. While fertilizer directly provides a specific nutrient to plant, bio fertilizer promotes the overall growth of plant. Moreover, different microbial populations affect the growth in different ways. For example, *Rhizobium spp.*, which is a widely used strain of bio fertilizers, associated with legumes to fix atmospheric nitrogen. The legumes and their symbiotic association with the rhizobium bacterium result in the formation of root nodules that fix atmospheric N. Successful nodulation of leguminous crop by rhizobium largely depends on the availability of a compatible stain for a particular legume. Rhizobium population in the soil is dependent on the

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presence of legumes crops in field. In the absence of legumes, the population of rhizobium in the soil diminishes. Some microbes also improve the availability of other plant nutrients in the root vicinity.

Phosphorus is one of the most important plant nutrients that directly or indirectly affects all biological processes. For example, P is key in all major plant metabolic processes such as photosynthesis, energy transfer, signal transduction, biosynthesis of molecules, and respiration. A considerable amount of P is present in soils, in both inorganic and organic forms, but its availability is one of the main factors limiting plant growth in many ecosystems worldwide. Soil microbes are capable of converting insoluble soil P into plant available form through mechanisms like solubilisation and mineralization. Phosphate-solubilizing microbes (PSM) solubilize inorganic P (e.g., tricalcium phosphate, hydroxyapatite, and rock phosphate) by metabolic activity. By increasing P bioavailability, PSM reduce the need for mineral P fertilizer inputs, which in excess can lead to negative environmental impacts such as eutrophication of fresh-water bodies. Most microbes used for this belong to *Pseudomonas*, *Bacillus*, *Rhizobium* genus etc.

Microorganisms can increase Potassium (K) availability via solubilization, a process that plays a key role in the K cycle by making K available to plants. Similar to P, the most well-known mechanism of microbial K solubilization involves the synthesis and discharge of organic acids like tartaric, citric,

oxalic, gluconic, lactic, and malic acid. These organic acids lead to the acidification of the surrounding environment and lead to release of K^+ from minerals. Other important K release mechanisms include chelation, and exchange reactions involving organic acids. Several groups of soil bacteria e.g., *Rhizobium* and fungi e.g., *Trichoderma*, *Glomus*, and *Penicillium* can solubilize K minerals.

Conclusion

Due to its long-term beneficial effects, bio priming is one of the primary sources of nutrients in organic farming. It is also being used in commercial farming practices as it reduces the amount of chemical fertilizers used and hence saves the input costs of farmer. Due to its slow acting nature, it is often dismissed as being non-functional. Considerable efforts are still being done by the extension agencies to promote their usage and provide a cheap, natural and sustainable alternative to chemical inputs.

Post-harvest Technoiques of Turmric

Dr. Pankaj Kumar Ray and Pallavi Bharti

Turmeric (*Curcuma domestica*) is a tall perennial plant used for its rhizome as an annual crop (underground root like stem bearing roots and shoots). It is related to family of ginger (Zingiberaceae) and grows in a similar hot and humid tropical habitat. Turmeric is a plant that originated in the Indian subcontinent and is now the world's largest producer and consumer. Turmeric is an important part of Indian culture, as it is a vital element in curry, as well as a cosmetic, a fabric dye, and a variety of traditional health cures. 'Indian saffron' is another name for the spice.

Harvesting: Turmeric is collected between the ages of 7 and 10, when the stems and leaves have begun to dry out and die back. The entire plant is dug up, with care taken not to harm or bruise the rhizomes. Before entering the market, the collected turmeric rhizomes are transformed into a stable commodity through a series of post-harvest processing activities such as boiling, drying, and polishing. Turmeric is boiled three to four days after it is harvested. Because the bulbs (or mother rhizomes) take a little longer to cook, the fingers and bulbs are separated and cured separately. The dry recovery of various turmeric cultivars varies greatly, ranging from 19 to 23%.

Boiling: The first post-harvest process undertaken at the farm level is boiling, which entails boiling new rhizomes in water until tender before drying. Boiling kills the vitality of new rhizomes, eliminates the raw odour, shortens drying time, and produces a consistently colored product. When huge amounts of turmeric need to be cured, an improved turmeric boiler with steam boiling technology is used. A trough, inner perforated drums, and lid makes up the enhanced turmeric steam boiler. The outer drum is made of mild steel that is 18 SWG thick and is 122 x 122 x 55 cm.

A lid with hooks for simple lifting is included, as well as an inspection door. An exit is located at the bottom of the drum for simple draining and cleaning. The outer drum has four interior drums with dimensions of 48 x 48 x 45 cm each. Four inner drums have a capacity of 100 kg each. The inner drums have a 10 cm-high leg so that the rhizomes do not come into touch with the water in the outer drum, which is filled to a depth of around 6-8 cm.

By digging a pit that serves as a furnace, the outer drum is covered with more than half of its depth below ground level. This furnace has two openings: one for feeding the fuel and one for removing the ash

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and unburned material. 75 litres of water are added to the turmeric boiler after it is placed in the furnace (6-8 cm depth). In each inner drum, about 55-70 kg of well-washed rhizome is placed in the boiler, and the cover is placed in place.

Fire is built in the furnace using agricultural waste materials, usually turmeric leaves. It takes roughly 25 minutes to build steam and boil the first batch of rhizomes, and 10 - 15 minutes for the succeeding batches during the boiling process. The stage of boiling of the rhizome is determined by pressing the rhizomes with a hard pin / needle through the inspection door. The lid is removed with a long pole, and the inside drums are lifted one by one.

Depending on the amount of water lost due to evaporation, around 20 litres of water is added to the outer drum for the following batch. The next batch of rhizomes is poured into all of the drums, and the process of heating continues. To avoid damage and extend the life of the equipment, all of the drums must be cleaned free of dirt and soil at the end of the boiling operation. The boiler has a batch capacity of roughly 100 kilograms, and the fuel need is 70-75 kg of agricultural waste materials.

Drying: The cooked fingers are laid out on the drying floor in 5-7 cm thick layers to dry in the sun. A thin layer is not recommended since the color of the dry product may be damaged. The material should be stacked or covered during the night. The rhizome may take up to 10-15 days to thoroughly dry. The bulbs and fingers are dried separately, with

the latter taking longer. To ensure that the product is not polluted by foreign materials, turmeric should be dried on a clean surface.

Mold growth on the rhizomes should be avoided at all costs. To promote equal drying, the rhizomes are flipped on a regular basis. Turmeric can also be dried in solar tunnel driers using UV stabilised semi-transparent polyfilm sheets of 200 microns thickness. Solar radiation is passed via a plastic sheet with a 90 percent transmittance. Short wave radiations pass through the UV sheet, but long wave radiations pass through it opaquely.

Short wave radiation is entrapped by the UV sheet during daylight hours, heated by the black absorb at the bottom, and transformed to long wave radiation. The temperature within the dryer rises due to the conversion of short-wave radiation to long wave radiation. The heat from the absorber is transferred to the air above it. The moisture is absorbed by the warm air from the bottom as it passes over the product. The products in the drier are additionally heated by solar radiation that passes through the clear cover of the drier.

This raises the temperature and speed of drying of the product inside the drier compared to the ambient temperature. The dry product yield ranges between 20 and 25% depending on the variety and the place where the crop is cultivated. During the boiling process, the starch gelatinizes, and during the drying process, intercellular gaps expand, allowing for better water diffusion and a shorter drying time.

Polishing and Colouring: The look of dried turme-

ric is poor, with a rough, dull exterior surface covered in scales and root fragments. Smoothing and polishing the exterior surface with a manual or mechanical rubbing improves the appearance. Polishing continues until the desired polish level of 7-8 percent is reached. During complete polishing, polishing waste accounts for 5 to 8% of the weight of the turmeric, and 2 to 3% during half polishing.

Wrinkles can also be removed by polishing dried turmeric. The dried turmeric fingers are rubbed on a hard floor to polish them manually. The dried rhizome has a rough look and a dull colour after manual polishing. In an upgraded process, polishing is done with a hand or power operated drum positioned on a central axis with enlarged metal screen on the sides.

The abrasion of the surface against each other as they roll inside the turmeric-filled drum results in polishing as it is turned. The colour of the turmeric after it has been processed has an impact on the pricing of the product. As a result, turmeric powder is sprinkled during the final polishing phase to produce an attractive product.

Storage: The bulk rhizomes are stored away from direct sunlight in a cold, dry location. When ground turmeric is exposed to light for an extended amount of time, its colour fades. As a result, the packets should be kept in a cardboard box out of direct sunlight. The storage area must be clean, dry, cool, and pest-free. To keep pests and insects out of the room, mosquito netting should be installed on the windows. Foods with a strong odour, detergents, and

paints should not be kept in the same room. To keep storage pests at away, insecticides should not be used on dried/polished turmeric.

Processing of Turmeric Powder

1. Grinding: Grinding is one of the most popular methods for preparing turmeric powder for use and resale. The major goal of spice grinding is to achieve smaller particle sizes while maintaining high product quality in terms of flavor and colour. For this procedure, many ambient grinding mills and methods are available, including hammer mills, attrition mills, and pin mills. Turmeric is traditionally ground in India using plate mills and hammer mills.

2. Sieving: The size of ground spices is filtered using screens, and the larger particles can be processed further. Screens with a mesh size of 60 to 80 meshes are commonly employed.

3. Packing: The turmeric powder is packaged in materials that protect it from hygroscopicity, loss of aroma/flavor, discoloration, insect infestation, and microbiological contamination, which are all frequent deteriorating factors of turmeric powder. Flexible Intermediate Bulk Containers (FIBCs), also known as Jumbo bags, are extensively used for bulk packing and have a capacity of up to 1 tonne. LDPE is utilised in institutional packaging such as laminated flexible pouches and plastic weaving bags.

Conservation of Genetic Resources

Shikha Jain, Shubham Jagga, Subhashree Subhasmita and Ankit Kumar Sinha

The need

Genetic resources for food and agriculture are the biological basis of world food and nutrition security and they directly support the livelihood of people.

- ✓ Horticultural genetic resources are a few of biological assets available to resource poor farmers to ensure sustainable production to improve livelihood options.
- ✓ Genetic diversity gives resource poor farmers a low cost option to manage the shocks and vulnerability of production systems by its ability to adapt to changing environments.
- ✓ It is the foundation upon which plant breeding depends for the creation of new varieties.

The rapid loss of genetic diversity (genetic erosion) is a worldwide concern and is particularly severe among crop landraces. Farmer's varieties or landraces are the most valued genetic resources as they provide option for a range of climatic and edaphic stress. Therefore, agricultural biodiversity has a critical public value for global food security.

There are some main factors that are responsible for loss of genetic diversity.

Habitat loss

- ✓ Rapid Industrialization
- ✓ Urbanization
- ✓ Food demand
- ✓ Deforestation and thereby land degradation.

Pollution

- ✓ Air pollution: Emissions of Toxic gases, Acid Rain
- ✓ Water Pollution: Eutrophication, Bioaccumulation followed by biomagnifications, Toxicity imparted by domestic and industrial effluents

Over exploitation of selected species

Introduction of Hybrid Varieties and genetically modified crops

The intensive genetic improvement and technological development of agricultural inputs has led to the replacement of many local varieties by a few modern cultivars. The genetic uniformity of cultivars of a widely grown crop makes them uniformly susceptible to biotic or abiotic hazards, and this genetic vulnerability may lead to complete crop loss. Cultivar replacement is main cause of genetic erosion around the world.

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Lot of genetic erosion occurred through the introduction of hybrid varieties and genetically modified (GM) crops.

Changing agricultural system and climate change Conservation of Biodiversity

There are two basic strategies for biodiversity conservation; these are most effective and efficient mechanism for conservation.

- ✓ In situ (onsite) conservation
- ✓ Ex situ (off site) conservation

In situ Conservation

The term in situ conservation denotes conservation of species in its natural habitat that is where the species is normally found. The in situ conservation strategies stress on protection of total ecosystems through a network of protected areas.

Protected Areas

- ✓ To facilitate the growth and reproduction of plants and animals in their habitat, the area is protected by restricting human activities like hunting, firewood collection, timber harvesting etc.
- ✓ Today, there are about 37,000 protected areas, parks, sanctuaries and biosphere reserves all around the world.
- ✓ India has over 600 protected areas, which includes over 90 national parks, over 500 animal sanctuaries and 15 biosphere reserves.
- ✓ Protected areas contain maximum biological diversity.

National Parks

- ✓ It is a protected area which is strictly reserved

for the conservation/betterment of the wild life and where activities like forestry, grazing and cultivation are not permitted.

- ✓ Their boundaries are well marked and circumscribed. They are usually small reserves spreading in an area of 100 sq. km. to 500 sq. km.
- ✓ In national parks, the emphasis is on the preservation of a single plant or animal species.

- ✚ Kaziranga national park in Assam.
- ✚ Gir national park in Gujarat.
- ✚ Kanha national park in M.P.

Wildlife Sanctuaries

- ✓ It is a protected area which is reserved for the conservation of only animals and human activities like harvesting of timber, collection of minor forest products are allowed to a certain extent.
- ✓ Boundaries of sanctuaries are not well defined and controlled biotic interference is permitted, *e.g*-tourist activity.
- ✚ Anamalai wildlife sanctuary, Tamil nadu
- ✚ Bir moti bagh wildlife sanctuary, Punjab
- ✚ Chilka lake bird sanctuary, Orissa
- ✚ Jaldapara sanctuary in West Bengal *etc.*

Biosphere Reserves

- ✓ It is a special category of protected areas where human population also forms a part of the system.
- ✓ They are large protected area of usually more than 5000 sq. km.

- ✓ A biosphere reserves has 3 parts- core, buffer and transition zone.
- ✓ The core zone is innermost zone, this is undisturbed and legally protected area.
- ✓ Buffer zone lies b/w the core and transition zone. Some research and educational activities are permitted here.
- ✓ Transition zone is the outermost part of biosphere reserves. Here cropping, forestry, recreation, fishery and other activities are allowed.

Main Functions of Biosphere Reserves

- 1) Conservation: To ensure the conservation of ecosystem, species and genetic resources.
- 2) Development: To promote economic development while maintaining cultural, social and ecological identity.
- 3) Scientific Research: To provide support for research related to monitoring and education, local, national & global issues.

Some biosphere reserves of India:-

Nilgiri (Kerala, Karnataka and Tamilnadu), Nanda devi in Uttarakhand, Sunderbans in Rajasthan, Manas in M.P, Gulf of Mannar in Assam *etc.*

Ex situ Conservation

This is a conservation of species outside their habitat. This includes gene, pollen, seed, tissue cultures and DNA banks and also includes various zoos and botanical gardens etc.

To conserve all these we have various methods of ex situ conservation:-

1. Seed bank, gene bank, germplasm bank

2. Translocation area
3. Botanical parks
4. Zoological parks

1) Use of Seed Bank, Gene Banks or Germplasm

Some seeds show variable periods of dormancy. Most of seed plants therefore can be preserved in the form of their seeds in small packets for long durations. Places where seeds are stored are called seed banks or gene banks or sometimes germplasm banks.

Term germplasm refers to any of plant organ or its part (living) from which new plants can be generated. They utilize the technique of cryopreservation in liquid nitrogen at a temperature of (minus)-196 degree Celsius.

2) Animal Translocations

Release of animals in a new locality:

Translocation is carried in following cases:

- ✓ When a species on which an animal is dependent becomes rare.
- ✓ When a species is endemic or restricted to a particular area.
- ✓ Due to habit destruction and unfavorable environment conditions.
- ✓ Increase in population in an area.

3) Botanical Gardens

A botanical garden is a place where flowers, fruits and vegetables are grown. The botanical gardens provide beauty & calm environment. Most of them have started keeping exotic plants for educational & research purposes.

Many rare and endangered plants live in botanical gardens which have taken task of conservation of plants in a real sense.

In India, the 1st botanical garden was established in Bombay in 1830 by agricultural society and in 1838 one more garden was established in madras.

Some Botanical gardens of India:

Lloyd botanical garden at Darjeeling, Indian botanical garden at Calcutta, National Botanical garden at Lucknow *etc.*

4) Zoological Gardens or Zoos

- ✓ In zoos wild animals are maintained in captivity.
- ✓ Conservation of wild animals species which are rare and endangered.
- ✓ The oldest zoo, the Schonbrunn zoo which exists today also, was established in Vienna in 1759.
- ✓ The first Indian zoo was setup by Raja Rajendra Mullick Bahadur at marble palace in Calcutta (1854).

Some of the important International Institutes conserving germplasms of horticultural crops are:

- 1) Centre International de-agricultural Tropical Palmira, Columbia (CIAT) - Cassava and Beans
- 2) International Institute of Tropical Agriculture, Ibadan, Nigeria (IITA) - Roots and Tubers
- 3) International Crops Research Institute for Semi-Arid Tropics, Hyderabad, India (ICRISAT) - Groundnut, Bengal gram, Red gram
- 4) Natinal Clonal Germplasm Repositor, Corvallis

(NCGR) - Soft fruits.

Conclusion

Biological resources once lost may not be replaced. Therefore, their conservation is of prime importance and of great significance for present and future use. Conservation of genetic resources can be achieved either in situ or ex situ. Both the approaches are complementary which can be judiciously integrated so that the conservation efforts are effectively realized for sustainable use of variability.

Biodiversity and Germplasm Conservation of Indian Gooseberry (Aonla)

Shikha Jain, Shubham Jagga, Subhashree Subhasmita and Ankit Kumar Sinha

Introduction

Indian gooseberry, or aonla, or *Emblica officinalis* Gaertn., is a fruit that has been prized for its therapeutic and medicinal qualities by health-conscious people since ancient times. In India, it has been grown and recognized for more over 3500 years. It is a member of the Euphorbiaceae family. It is amongst the significant native fruits of the Indian subcontinent. It goes by several different local names throughout India, including Amla or Aonla in Hindi, Dhatri, Dhatriphala, or Amalaki in Sanskrit, Amla or Amalaki in Bengali and Oriya, Nelli in Malayalam and Tamil, Amlakamu in Telugu, Amolphal in Punjabi (Gurmukhi), and Aonla, Myrobalan, or Indian Gooseberry in English.

Aonla is not only a source of vitamins and medicines, but it is also a highly remunerative crop for farmers with poor land. Aonla has typically been a crop grown in forests or by households, but during the past ten years, the country has seen an exceptional increase in the area under aonla cultivation thanks to the use of wasteland. As a result, there has been more effective resource management, which has improved farmer income,

increased employment, and wasteland rehabilitation.

Origin

Tropical Southeast Asia, specifically central or southern India, Pakistan, Bangladesh, Sri Lanka, Malaya, Southern China, and the Mascarene Islands are home to the aonla tree's native range. Ascending from sea level (western and eastern ghats, Aravali and Vindhyan hills) to 1300 above mean sea level, from the northwest Himalayas (Jammu and Kashmir, Himachal Pradesh, Uttarakhand) to the eastern Himalayas in Assam, Meghalaya, Mizoram, Manipur, and Tripura, seedling trees are a common occurrence in the mixed deciduous dry forests of India.



Germplasm characterization

In systematic germplasm characterization studies, Ojha and Pathak (1992, 1993) gave a detailed account of physico-chemical properties of cultivars.

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Aonla cultivars were characterized and evaluated at NDUAT, Faizabad, using aonla descriptors developed at the University.

Germplasm diversity areas of Aonla in India

States/ region	Diversity areas
Andhra Pradesh	Virag, Anantpur
Gujarat	Anand, Nadiad, Surendranagar
Rajasthan	Ajmer, Jaipur, Kota, Churu, Hanumangarh, Alwar, Jaisalmer
Maharashtra	Akola, Bhandara, Buldhana, Chandrapur, Jalgaon Kholapur, Satana, Joetmal
Tamil Nadu	Salem, Dindugal, Tuticorin
Uttar Pradesh	Vindhyhan hills, Mirzapur and Sonbhadra, Mathura, Agra, Etawah, Mainpuri, etc.
Madhya Pradesh	Bhopal, Gwalier, Shivpuri, Indore, Sheopur, Betul, Hoshangabad, Balaghat, Salana, Sidhi, Panna
Northwestern Himalaya	J&K, Himachal Pradesh and uttarakhand upto 1500 above msl
Northeastern Himalaya	Assam, Meghalaya, Manipur, Tripura, Khasi hills, Mizoram

Molecular characterization

No attempts have so far been made for molecular characterization and the information in this area is lacking and needs to be initiated at few centres.

DNA finger printing

In order to have claim rights on the promising varieties, identified in the country, DNA finger printing, micro-satellite studies and molecular markers can be efficiently utilized. Such studies have now been initiated at the Central Institute for Subtropical Horticulture (CISH), Lucknow.

Registration of germplasm

There had been pressing demand of aonla varieties from China and Israel. Since promising cultivars of aonla have not been developed from other countries, this is high time that Indian cultivars are registered at an early date with the appropriate authority. This is extremely important in view of the intellectual property rights (IPR) issues.

Status of documentation of germplasm

The descriptors lists of aonla were published from N.D.U.A.T, Faizabad during 1993-1994. There is urgent need to collect available germplasm, study their morphological, reproductive and molecular behavior and document these.

Sources/donors for various traits

Specific information is lacking for various traits and it requires systematic study on identification of tolerant lines for biotic and abiotic stress and start systematic breeding programme to study the inheritance pattern and identification of donors.

Germplasm conservation

There are presently large numbers of seedling trees of cultivated aonla, which are genetically heterogenous giving scope of seedling selections. The status of wild aonla is not very well documented and utilized. Only mention of one species is made i.e., *P. acidus*.

Ex situ field genebanks

At present the aonla germplasm is being maintained at several places in the country in field genebanks. These germplasm were mainly collected

from NDUAT, Faizabad.

Aonla field genebank holdings

Institutes/centres	Number of accessions
Dryland Agricultural Research Station, Anantpur, Andhra Pradesh	12
Regional Research Station, Aruppukottai, Tamil Nadu	5
Dryland Agriculture Research Station, Sardarkrushinagar, Gujarat	12
Nadrendra Dev University of Agriculture and Technology, Faizabad, U.P	21
G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand	10
National Research Centre for Arid Horticulture, Bikaner, Rajasthan	16
National Bureau of Plant Genetic Resources, Pusa, New Delhi	5
Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow, Uttar Pradesh	12
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra	6

Under the Indo-US project, National Bureau of Plant Genetic Resources (NBPGR) is maintaining National Active Germplasm Sites (NAGS) of Aonla at Central Horticulture Experimental Station, Ranchi, and Jharkhand in Bihar state. Apart from that, a total of 51 aonla accessions along with two accessions of *P. indofischeriari* are maintained at the NBPGR Regional Station, Trissur, Kerala.

In vitro conservation and pollen storage

A sincere effort for cryopreservation and pollen storage of aonla has not been attempted. Considering the importance of the crop, there is urgent need to initiate such studies.

In situ conservation

Vindhyan hills particularly in Madhya Pradesh, Chattisgarh, Jharkhand, Meghalaya, Mizoram, Tripura, etc. have rich diversity of wild genotypes of aonla. These areas need to be declared as natural gene pools for in situ conservation of diversity of aonla.

Germplasm utilization

Species / Varieties	Important uses
NA-9	Suitable for preserve and candy making
NA-6	Ideal for preserve and candy
NA-7	Ideal for commercial cultivation, Free from Necrosis, Ideal variety for preserve products
Chakaiya	Ideal for making pickle
Goma Aishwarya	Drought tolerance
<i>Phyllanthus niruri</i>	Potential to help in the treatment of diabetes

Future prospects

- ✓ Emphasis on the collection and evaluation of newly released varieties of aonla.
- ✓ Special attention is to be given on crop improvement for better qualitative and quantitative traits.
- ✓ Development of aonla tree based cropping system.
- ✓ Standardization of techniques for faster multiplication of planting material and for rejuvenation of old/unproductive plantations.
- ✓ More work on utilization of aonla fruits for value addition.

Genome Editing in Apple

Shikha Jain, Shubham Jagga, Subhashree Subhasmita and Ankit Kumar Sinha

Introduction

The conventional breeding of fruits and fruit trees has led to the improvement of consumer-driven traits such as fruit size, yield, nutritional properties, aroma and taste, as well as the introduction of agronomic properties such as disease resistance. However, even with the assistance of modern molecular approaches such as marker-assisted selection, the improvement of fruit varieties by conventional breeding takes considerable time and effort. The advent of genetic engineering led to the rapid development of new varieties by allowing the direct introduction of genes into elite lines. Genome editing is a powerful technique for genome modification in molecular research and crop breeding, and has the great advantage of imparting novel desired traits to genetic resources. Genome editing allows the introduction of mutations at predefined sites by targeting a particular unique sequence with a guided nuclease. Various genome editing platforms have been described, but the three that have been used in fruit crops are zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and the CRISPR/Cas9

system. Among these genome editing approaches, due to its simplicity, design flexibility, and high efficiency, the CRISPR/Cas9 system is now utilized widely for editing the genome of various organisms of all types, including plants, animals, yeast and bacteria.

Types of Genome Editing Technologies

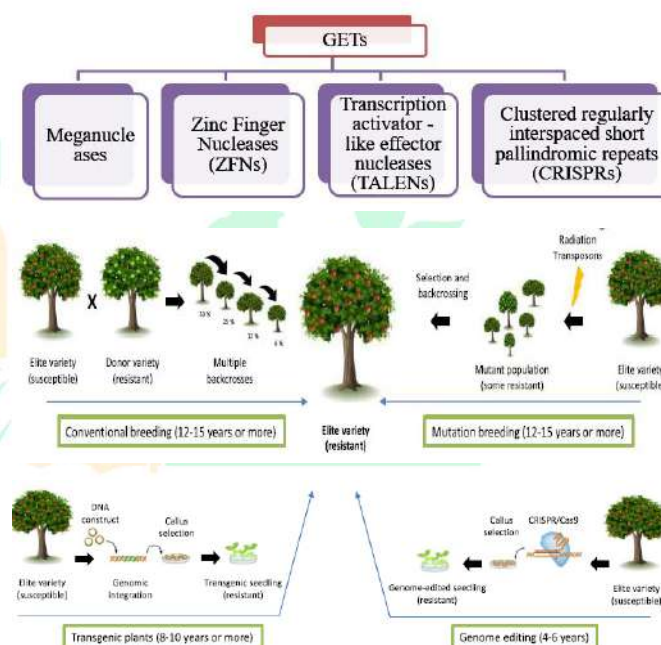


Fig.1. Comparison of different methods and timelines to develop fruit crops with a desirable new trait

Genome Editing Tools and Mechanisms

In GETs, engineered endonucleases are

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Table 1: List of studies utilizing Genome editing technologies (GETs) for genetic improvement of Apple

Target gene/ Sequence	GET and Strategy	Gene function	Effect
<i>uidA gene</i>	ZFNs under a heat shock promoter	Reporter gene	ZFN-mediated gene mutation and repair were stable and passed onto regenerants
<i>MdPDS gene</i>	CRISPR-Cas9 Four guide RNAs (sgRNAs)	Conversion of phytoene to all-trans lycopene in carotenoid pathway in apple	Clear and partial albino phenotypes in 32% of regenerated plants
<i>MdPDS</i>	CRISPR-Cas9	<i>PDS</i> - Carotenoid biosynthesis	Albino phenotype in 85% of <i>MdPDS</i> lines
<i>MdDIPM4</i>	CRISPR/Cas9 sgRNAs targeting the gene Heat-shock inducible FLP/ FRT system to excise the T-DNA with expression cassettes	DspA/E effector interacts with the apple susceptibility protein MdDIPM4 to produce disease	Seven edited lines showed substantial reduction in susceptibility. No potential off target sites were mutated. Editing efficiency was about 75%.
<i>ALS and PDS</i>	CRISPR/Cas9 base editing with cytidine deaminase	<i>ALS</i> -Herbicide tolerance <i>PDS</i> - Carotenoid biosynthesis	Co-editing <i>ALS and PDS</i> produced chlorsulfuron resistant and albino lines

utilized to create specific modifications at targeted loci in the genome. At first, the DNA-binding domains of zinc finger (ZF) proteins were developed as genome editing tools known as ZF nucleases (ZFNs); followed by Transcription Activator-Like Effectors (TALENs) and recently, the Clustered, Regularly Interspaced, Short Palindromic Repeats (CRISPR)-CRISPR-associated protein 9 (CRISPR-Cas9) system were developed as the genome editing tools. The basic principle in the ZFNs, TALENs, and CRISPR-Cas9 based genome modifications is that the respective endonucleases make double stranded breaks (DSBs) in the DNA sequences at the targeted loci and these DSBs are repaired by one of two DNA repair pathways viz. Homologous recombination (HR) and non homologous end-joining (NHEJ) in the cell. In the NHEJ mechanism, the repair of DSBs occurs without any repair template resulting in deletions or insertions in the repaired DNA. The mutations created by NHEJ pathways are at random and cannot be regulated. In contrast, in the HDR-based pathway, the DSBs are repaired using a repair

template with sequences that are homologous to the sequence in the proximity of DSBs. The HDR pathway allows for precise control of mutations creations in the genome. However, the efficiency of repair of DSBs by the HDR pathway is low compared to the NHEJ pathway.

Conclusion

The genome-editing technology is becoming a useful technology for pursuing genetic engineering efforts for various fruit crops including apple. Recent studies have provided promising results in using various genome editing technologies for apple such as for purposes of trait modifications, identification of functionality of distinct family genes, as well as of foreign gene-free technologies using transient expression of RNP transfection. It is also worth noting that genome editing has been applied to rootstocks breeding, as rootstocks are highly critical in promoting fruit quality and cultivation of fruit crops.

Growth Regulators in Plant Disease

Shaik Munnysha and R. Abhi

Introduction

Plant growth is regulated by a small number of groups of naturally occurring compounds that act as hormones and are generally called growth regulators. The most important growth regulators are auxins, gibberellins and cytokinins, but other compounds, such as ethylene and growth inhibitors, play important regulatory roles in the life of the plant. Growth regulators act in very small concentrations and even slight deviations from the normal concentration may bring about strikingly different plant growth patterns. The concentration of a specific growth regulator in the plant is not constant, but it usually rises quickly to a peak and then declines quickly as a result of the action of hormone-inhibitory systems present in the plant. Growth regulators appear to act, at least in some cases, by promoting the synthesis of messenger RNA molecules. This leads to the formation of specific enzymes, which in turn control the biochemistry and the physiology of the plant. The pathogens can cause disease through the secretion of growth regulators in the infected plant or through their effects on the growth regulatory systems of the infected plant is made evident by the variety of abnormal plant growth responses they cause, such as stunting, overgrowths, rosetting, excessive root branching,

stem malformation, leaf epinasty, defoliation, and suppression of bud growth.

Auxins

The auxin occurring naturally in plants is indole-3-acetic acid (IAA). Produced continually in growing plant tissues, IAA moves rapidly from the young green tissues to older tissues, but is destroyed constantly by the enzyme indole-3-acetic acid oxidase, which explains the low concentration of the auxin. The effects of IAA on the plant are numerous. It is required for cell elongation and differentiation, and absorption of IAA to the cell membrane also affects the permeability of the membrane. The compound causes a general increase in the respiration of plant tissues and promotes the synthesis of messenger RNA and, subsequently, of proteins/enzymes as well as structural proteins.

Increased auxin (IAA) levels occur in many plants infected by fungi, bacteria, viruses, mollicutes, and nematodes, although some pathogens seem to lower the auxin level of the host. Thus, the basidiomycete *Exobasidium azalea* causing azalea leaf and flower gall, the protozoon causing clubroot of cabbage (*Plasmodiophora brassicae*), the bacterium *A. tumefaciens* causing crown gall and the one causing leafy gall of sweet pea and other plants, the fungi causing corn smut (*Ustilago maydis*), cedar

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apple rust (*Gymnosporangium juniperi-virginianae*), banana wilt (*Fusarium oxysporum* f. *cubense*), pine western gall rust the rootknot nematode (*Meloidogyne* sp.) and others not only induce increased levels of IAA in their respective hosts, but are themselves capable of producing IAA. In some diseases, however, increased levels of IAA are wholly or partly due to the decreased degradation of IAA through the inhibition of IAA oxidase, as has been shown to be the case in several diseases, including corn smut and stem rust of wheat. The production and role of auxin in plant disease have been studied more extensively in some bacterial diseases of plants. *Ralstonia solanacearum*, the cause of bacterial wilt of solanaceous plants, induces a 100- fold increase in the IAA level of diseased plants compared with that of healthy plants.

Gibberellins

Gibberellins are normal constituents of green plants and are also produced by several microorganisms. Gibberellins were first isolated from the fungus *Gibberella fujikuroi*, the cause of the foolish seedling disease of rice. The best-known gibberellin is gibberellic acid. Compounds such as vitamin E and helminthosporol also have gibberellin-like activity. Gibberellins have striking growth-promoting effects. They speed the elongation of dwarf varieties to normal sizes and promote flowering, stem and root elongation, and growth of fruit. Such elongation resembles in some respects that caused by IAA, and gibberellin also induces IAA formation. Auxin and gibberellin may also act

synergistically. Gibberellins seem to activate genes that have been previously “turned off.” The foolish seedling disease of rice, in which rice seedlings infected with the fungus *Gibberella fujikuroi* grow rapidly and become much taller than healthy plants, is apparently the result, to a considerable extent at least, of the gibberellins secreted by the pathogen. Although no difference has been reported so far in the gibberellin content of healthy and virus or mollicute-infected plants, spraying of diseased plants with gibberellin overcomes some of the symptoms caused by these pathogens. Thus, stunting of corn plants infected with corn stunt spiroplasma and of tobacco plants infected with severe etch virus was reversed after treatment with gibberellin. Axillary bud suppression, caused by prunus dwarf virus (PDV) on cherry and by leaf curl virus on tobacco, was also overcome by gibberellin sprays.

Cytokinins

Cytokinins are potent growth factors necessary for cell growth and differentiation. In addition, they inhibit the breakdown of proteins and nucleic acids, thereby causing the inhibition of senescence, and they have the capacity to direct the flow of amino acids and other nutrients through the plant toward the point of high cytokinin concentration. Cytokinins occur in very small concentrations in green plants, in seeds, and in the sap stream. The first compound with cytokinin activity to be identified was kinetin, which, however, was isolated from herring sperm DNA and does not occur naturally in plants. Several cytokinins e.g.

zeatin and isopentenyl adenosine (IPA), have since been isolated from plants. Cytokinins act by preventing genes from being turned off and by activating genes that have been previously turned off. The role of cytokinins in plant disease has just begun to be studied. Cytokinin activity increases in clubroot galls, in crown galls, in smut and rust galls, and in rust-infected bean leaves. In the latter, cytokinin activity seems to be related to both the juvenile feature of the green islands around the infection centers and the senescence outside the green island. However, cytokinin activity is lower in the sap and in tissue extracts of cotton plants infected with verticillium wilt and in plants suffering from drought. A cytokinin is partly responsible for several bacterial galls of plants, such as “leafy” gall disease of sweet pea caused by the *bacterium Rhodococcus* (Corynebacterium) fascians, and for the witches’ broom diseases caused by fungi and mollicutes. Treating plants with kinetin before or shortly after inoculation with a virus seems to reduce the number of infections in local lesion hosts and to reduce virus multiplication in systematically infected hosts.

Ethylene: CH_2KCH_2

Produced naturally by plants, ethylene exerts a variety of effects on plants, including chlorosis, leaf abscission, epinasty, stimulation of adventitious roots, and fruit ripening. Ethylene also causes increased permeability of cell membranes, which is a common effect of infections. However, ethylene production in infected tissues often parallels the formation of phytoalexins and the increased

synthesis or activity of several enzymes or signal compounds that may play a role in increasing plant resistance to infection. Never-the-less it has not been shown that ethylene actually provides resistance. Ethylene is produced by several plant pathogenic fungi and bacteria. In the fruit of banana infected with *Ralstonia solanacearum*, the ethylene content increases proportionately with the (premature) yellowing of the fruit, whereas no ethylene can be detected in healthy fruits. Ethylene has also been implicated in the leaf epinasty symptom of the vascular wilt syndromes and in the premature defoliation observed in several types of plant diseases. In Verticillium wilt of tomato, the presence of ethylene at the time of infection inhibits disease development, whereas the presence of ethylene after infection has been established enhances Verticillium wilt development.

Polysaccharides

Fungi, bacteria, nematodes, and possibly other pathogens constantly release varying amounts of mucilaginous substances that coat their bodies and provide the interface between the outer surface of the microorganism and its environment. Exopolysaccharides appear to be necessary for several pathogens to cause normal disease symptoms either by being directly responsible for inducing symptoms or by indirectly facilitating pathogenesis by promoting colonization or by enhancing survival of the pathogen. The role of slimy polysaccharides in plant disease appears to be particularly important in wilt diseases caused by pathogens that invade the

vascular system of the plant. In vascular wilts, large polysaccharide molecules released by the pathogen in the xylem may be sufficient to cause a mechanical blockage of vascular bundles and thus initiate wilting. Although such an effect by the polysaccharides alone may occur rarely in nature, when it is considered together with the effect caused by the macromolecular substances released in the vessels through the breakdown of host substances by pathogen enzymes, the possibility of polysaccharide involvement in the blockage of vessels during vascular wilts becomes obvious.



Role of Toxins in Plant Disease

Shaik Munnysha and R. Abhi

Introduction

Living plant cells are complex systems in which many interdependent biochemical reactions are taking place concurrently or in a well-defined succession. These reactions result in the intricate and well-organized processes essential for life. Disturbance of any of these metabolic reactions causes disruption of the physiological processes that sustain the plant and leads to the development of disease. Among the factors inducing such disturbances are substances that are produced by plant pathogenic microorganisms and are called toxins. Toxins act directly on living host protoplasts, seriously damaging or killing the cells of the plant. Some toxins act as general protoplasmic poisons and affect many species of plants representing different families. Others are toxic to only a few plant species or varieties and are completely harmless to others. Many toxins exist in multiple forms that have different potency. Fungi and bacteria may produce toxins in infected plants as well as in culture medium. Toxins, however, are extremely poisonous substances and are effective in very low concentrations. Some are unstable or react quickly and are bound tightly to specific sites within the plant cell. Toxins injure host cells either by affecting the permeability of the cell membrane or by inactivating

or inhibiting enzymes and subsequently interrupting the corresponding enzymatic reactions. Certain toxins act as anti-metabolites and induce a deficiency for an essential growth factor.

Toxins That Affect a Wide Range of Host Plants

Several toxic substances produced by phytopathogenic microorganisms have been shown to produce all or part of the disease syndrome not only on the host plant, but also on other species of plants that are not normally attacked by the pathogen in nature. Such toxins, called nonhost-specific or nonhost-selective toxins. These toxins increase the severity of disease caused by a pathogen, i.e., they affect the virulence of the pathogen, but are not essential for the pathogen to cause disease, i.e., they do not determine the pathogenicity of the pathogen. Several of these toxins, e.g., tabtoxin and phaseolotoxin, inhibit normal host enzymes, thereby leading to increases in toxic substrates or to depletion of needed compounds. Several toxins affect the cellular transport system, especially H^+/K^+ exchange at the cell membrane. Some, e.g., tagetitoxin, act as inhibitors of transcription in cell organelles, such as the chloroplasts. Others, e.g., cercosporin, act as photosensitizing agents, causing the peroxidation of membrane lipids.

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Tabtoxin

Tabtoxin is produced by the bacterium *Pseudomonas syringae*; pv. tabaci, which causes the wildfire disease of tobacco; by strains of pv. tabaci occurring on other hosts such as bean and soybean; and by other pathovars (subspecies) of *P. syringae*, such as those occurring on oats, maize and coffee. Toxin-producing strains cause necrotic spots on leaves, with each spot surrounded by a yellow halo. Tox-strains are indistinguishable from *P. angulata*, the cause of angular leaf spot of tobacco, which is now thought to be a non toxigenic form of *P. syringae* pv. tabaci. Tabtoxin is a dipeptide composed of the common amino acid threonine and the previously unknown amino acid tabtoxinine. Tabtoxin as such is not toxic, but in the cell it becomes hydrolyzed and releases tabtoxinine, which is the active toxin. Tabtoxin, through tabtoxinine, is toxic to cells because it inactivates the enzyme glutamine synthetase, which leads to depleted glutamine levels and, as a consequence, accumulation of toxic concentrations of ammonia.

Phaseolotoxin

Phaseolotoxin is produced by the bacterium *Pseudomonas syringae* pv. phaseolicola, the cause of halo blight of bean and some other legumes. The localized and systemic chlorotic symptoms produced in infected plants are identical to those produced on plants treated with the toxin alone so they are apparently the results of the toxin produced by the bacteria. Infected plants and plants treated with purified toxin also show reduced growth of newly

expanding leaves, disruption of apical dominance, and accumulation of the amino acid ornithine. Phaseolotoxin is a modified ornithine-alanine-arginine tripeptide carrying a phosphosulfinyl group. The toxin affects cells by binding to the active site of and inactivating the enzyme ornithine carbamoyltransferase, which normally converts ornithine to citrulline, a precursor of arginine. By its action on the enzyme, the toxin thus causes the accumulation of ornithine and depleted levels of citrulline and arginine. Phaseolotoxin.

Tentoxin

Tentoxin is produced by the fungus *Alternaria alternata* (previously called *A. tenuis*), which causes spots and chlorosis in plants of many species. Seedlings with more than one-third of their leaf area chlorotic die, and those with less chlorosis are much less vigorous than healthy plants. Tentoxin is a cyclic tetrapeptide that binds to and inactivates a protein (chloroplast-coupling factor) involved in energy transfer into chloroplasts. The toxin also inhibits the light-dependent phosphorylation of ADP to ATP.

Cercosporin

Cercosporin is produced by the fungus *Cercospora* and by several other fungi. It causes damaging leaf spot and blight diseases of many crop plants, such as *Cercospora* leaf spot of zinnia and gray leaf spot of corn. Cercosporin is unique among fungal toxins in that it is activated by light and becomes toxic to plants by generating activated species of oxygen, particularly single oxygen.

The generated active single oxygen destroys the membranes of host plants and provides nutrients for this intercellular pathogen. Cercosporin is a photosensitizing perylene quinone that absorbs light energy, it is converted to an energetically activated state and then reacts with molecular oxygen and forms activated oxygen. The latter reacts with lipids, proteins, and nucleic acids of plant cells and severely damages or kills the plant cells, thereby enhancing the virulence of the pathogen. The ability of fungal spores and mycelium to survive the general toxicity of cercosporin is due to the production by the fungus of pyridoxine (vitamin B₆). Pyridoxine reacts with single oxygen atoms and is currently neutralized during that reaction.

Other Non host-Specific Toxins

Numerous other non-host-specific toxic substances have been isolated from cultures of pathogenic fungi and bacteria and have been implicated as contributing factors in the development of the disease caused by the pathogen. Among such toxins produced by fungi are fumaric acid, produced by *Rhizopus* spp. in almond hull rot disease; oxalic acid, produced by *Sclerotium* and *Sclerotinia* spp. in various plants they infect and by *Cryphonectria parasitica*, the cause of chestnut blight; alternaric acid, alternariol, and zinniol produced by *Alternaria* spp. in leaf spot diseases of various plants; ceratoulmin, produced by *Ophiostoma ulmi* in Dutch elm disease; fusicoccin, produced by *Fusicoccum amygdali* in the twig blight disease of almond and peach trees; ophiobolins, produced by several

Cochliobolus spp. In diseases of grain crops; pyricularin, produced by *Pyricularia grisea* in rice blast disease; fusaric acid and lyco marasmin, produced by *Fusarium oxysporum* in tomato wilt; and many others. Other nonhost-specific toxins produced by bacteria are coronatine, produced by *P. syringae* pv. *atropurpurea* and other forms infecting grasses and soybean; syringomycin, produced by *P. syringae* pv. *syringae* in leaf spots of many plants; syringotoxin, produced by *P. syringae* pv. *syringae* in citrus plants; and tagetitoxin, produced by *P. syringae* pv. *tagetis* in marigold leaf spot disease. One family of toxins essential for pathogenicity, is the thaxtomins, produced by species of the bacterium *Streptomyces* that cause root and tuber roots.

Host-Specific or Host-Selective Toxins

A host-specific or host-selective toxin is a substance produced by a pathogenic microorganism that, at physiological concentrations, is toxic only to the hosts of that pathogen and shows little or no toxicity against non susceptible plants. Most host-specific toxins must be present for the producing microorganism to be able to cause disease. So far, host-specific toxins have been shown to be produced only by certain fungi (*Cochliobolus*, *Alternaria*, *Periconia*, *Phyllosticta*, *Corynespora* and *Hypoxylon*), although certain bacterial polysaccharides from *Pseudomonas* and *Xanthomonas* have been reported to be host specific.

Victorin or HV Toxin

Victorin, or Hv-toxin, is produced by the fungus *Cochliobolus* (*Helminthosporium*) *victoriae*.

This fungus appeared in 1945 after the introduction and widespread use of the oat variety Victoria and its derivatives, all of which contained the gene Vb for resistance to crown rust disease. *C. victoriae* infects the basal portions of susceptible oat plants and produces a toxin that is carried to the leaves, causes a leaf blight, and destroys the entire plant. All other oats and other plant species tested were either immune to the fungus and to the toxin or their sensitivity to the toxin was proportional to their susceptibility to the fungus. Toxin production in the fungus is controlled by a single gene. Victorin has been purified and its chemical structure has been determined to be a complex chlorinated, partially cyclic pentapeptide. The primary target of the toxin seems to be the cell plasma membrane where victorin seems to bind to several proteins. The possible site of action of victorin seems to be the glycine decarboxylate complex, which is a key component of the photo respiratory cycle. Considerable evidence, however, indicates that victorin functions as an elicitor that induces components of a resistance response that include many of the features of hypersensitive response and lead to programmed cell death.

T Toxin [Cochliobolus (Helminthosporium) heterostrophus Race T Toxin]

T toxin is produced by race T of *C. heterostrophus* (*Bipolaris maydis*), the cause of southern corn leaf blight. Race T, indistinguishable from all other *C. heterostrophus* races except for its ability to produce the T toxin, appeared in the United

States in 1968. By 1970, it had spread throughout the Corn Belt, attacking only corn that had the Texas male-sterile (Tms) cytoplasm. Corn with normal cytoplasm was resistant to the fungus and the toxin. Resistance and susceptibility to *C. heterostrophus* T and its toxin are inherited maternally (in cytoplasmic genes). The ability of *C. heterostrophus* T to produce T toxin and its virulence to corn with Tms cytoplasm are controlled by one and the same gene.

The T toxin reacts with a specific receptor protein molecule (URF13) that is located on the inner mitochondrial membrane of sensitive mitochondria. It is now thought that plants exhibiting cytoplasmic male sterility of the Texas type have a slight rearrangement in their mitochondrial DNA comprising gene T-urf13 that codes for the production of protein URF13. This gene and its protein are absent from maize lines with normal cytoplasm. When the T toxin is present, protein URF13 forms pores in the inner mitochondrial membrane of maize lines with cytoplasmic male sterility. The pores cause loss of mitochondrial integrity, i.e., loss of selective permeability of the mitochondrial membrane, and disease.

HC Toxin

Race 1 of *Cochliobolus* (*Helminthosporium*) carbonum (*Bipolaris zeicola*) causes northern leaf spot and ear rot disease in maize. It also produces the host specific HC toxin, which is toxic only on specific maize lines. Two other races of the fungus do not produce toxin but infect corn around the world, although they cause smaller lesions.

The mechanism of action of HC toxin is not known, but this is the only toxin, so far, for which the biochemical and molecular genetic basis of resistance against the toxin is understood. Resistant corn lines have a gene (Hm1) coding for an enzyme called HC toxin reductase that reduces and thereby detoxifies the toxin. Susceptible corn lines lack this gene and, therefore, cannot defend themselves against the toxin.

Alternaria alternata Toxins

Several pathotypes of *Alternaria alternata* attack different host plants and on each they produce one of several multiple forms of related compounds that are toxic only on the particular host plant of each pathotype. Some of the toxins and the hosts on which they are produced and affect are the AK toxin causing black spot on Japanese pear fruit, the AAL toxin causing stem canker on tomato, the AF toxin on strawberry, the AM toxin on apple, the ACT toxin on tangerine, the ACL toxin on rough lemon, and the HS toxin on sugar cane. As an example of *A. alternata* toxins, the AM toxin is produced by the apple pathotype of *A. alternata*, known previously as *A. mali*, the cause of alternaria leaf blotch of apple. The toxin molecule is a cyclic depsipeptide and usually exists as a mixture of three forms. AM toxin causes rapid loss of chlorophyll, suggesting that this toxin has more than one site of action.

Other Host-Specific Toxins

At least two other fungi produce well-known host specific toxins: *Periconia circinata* produces peritoxin (PC toxin), which causes sorghum rot in

sorghum root rot disease; *Mycosphaerella* (*Phyllosticta*) *zeae-maydis* produces the PM toxin (T toxin) in corn that has Texas male-sterile cytoplasm; and *Pyrenophora tritici-repentis* produces the Ptr toxin, which causes the tan spot of wheat. Another fungus, *Corynespora cassicola*, produces the CC toxin in tomato. Toxins produced by some other fungi, e.g., *Hypoxyton mammatum* on poplar and *Perenophora teres* on barley, seem to be species selective rather than host specific. In addition, there are the SV toxins produced by *Stemphylium vesicarium* on European pear and destruxin B from *A. brassicae* on brassicas.

Biodiversity and Germplasm Conservation of *Malus* spp.

Shubham Jagga, Shikha Jain, Subhashree Subhasmita and Ankit Kumar Sinha

Introduction

The *Malus* belongs to the subfamily Pomoideae and the family Rosaceae with a basic chromosome number of 17. The genus *Malus* has 25 species and several subspecies of so-called Crab apples, many of which are cultivated as ornamental trees for their attractive flowers and fruits. The cultivated apple has been designated as *Malus pumila* (formerly *M. communis* or *Pyrus malus*). Some workers prefer to split this species in *M. domestica* (the cultivated apple). *M. pumila* (including var. *paradisiaca*, the paradise apple) and *M. sylvestris* (the wild Crab apple). However, *M. pumila* is considered to be the parent of most of our cultivated apples. The primary centre of origin of apple (*M. domestica*) is thought to be the region which includes Asia Minor, the Caucasus, Soviet Central Asia and Himalayan India and Pakistan. The basic chromosome number of the genus is $x=17$ and somatic no can be $2n=34, 51, 68, 85$. Most of our domestic cultivars are derived from *Malus domestica* Borkh. the common apple of Europe, these large fruited derivatives have been under selection and improvement by man for thousands of years, so it is not possible to know their

origin with certainty. Domestic crab-apples are considered to be hybrids between *M. pumila* and one of the primitive species, *M. baccata* (L.) Borkh.



Fig. 1: Origin of different species of *Malus*

Origin and distribution

The main ancestor of apple is now considered to be *Malus sieversii*, which is wild from the Heavenly Mountains (Tien Shan) at the boundary between Western China and the former Soviet Union, to the edge of the Caspian Sea. This species is diverse and wild trees bearing the full range of forms, colours and tastes are found in Kazakhstan and other independent countries of Central Asia formed from the breakup of the Soviet Union and especially around Alma Ata. Apple account 55% area and 75% production of temperate fruits in India. China is the largest apple producing country in the world.

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Over 700 accessions of apple, introduced from USA, Russia, U.K., Canada, Germany, Israel, Netherlands, Australia, Switzerland, Italy and Denmark have been tried. In India, 83% of the area under apple in H.P., 45% in J&K and 30% in Uttarakhand. It has also been extended to Arunachal Pradesh, Sikkim, Nagaland, and Meghalaya in north-eastern region and Nilgiri hills in Tamil Nadu. The cultivated apple *Malus domestica* Borkh. (*M. pumila* Miller), is native of European and west Asiatic region. East Asia is particularly rich in species diversity. Most of the wild species are diploid ($2n = 2x = 34$), sexually reproducing and self-incompatible.

Species Diversity

The description of some principal *Malus* species is as follows:

1) *M. floribunda* (Flowering Crab): It is a native of Japan. Trees are small and thorny. Flowers are highly ornamental, rose red in colour.

2) *M. baccata* (Siberian Crab): The Siberian Crab grows wild from Siberia to Manchuria and the Himalayan region. Spreading trees, flowers white and showy. Fruits yellow, red firm and translucent.

3) *M. angustifolia* (Narrow-leaved Crab-apple): It is distributed from Pennsylvania to Tennessee and Florida. Leaves are small, narrow and lanceolate. Flowers are pink colour, fruits small.

4) *M. coronaria* (American Crab-apple): Trees are small, bushy and thorny. Flowers are large with persistent calyx. Fruits are greenish yellow, fragrant and waxy.

5) *M. ioensis*: Trees are small. Flowers large, fruits are green with light coloured spots.

6) *M. sylvestris* (wild crab apple): Trees are large. There are several cultivars differing in form, size, colour, and taste. It is considered to be native of western Asia and south Eastern Europe.

Species Diversity specific to India: The diversity of temperate fruits in India is mainly confined to Himalayan Region. The genus *Malus*, of the 30 species, only two, *Malus baccata* and *M. sikkimensis* occur in India. Two varieties of *Malus baccata* have also been identified as *M. baccata* var. *himalaica* in North- Western region and Meghalaya and *M. baccata* var. *dirangensis* in Arunachal Pradesh.

Varietal Diversity

Some of the major apple varieties are described as under:

1) Ambri Apple: Pride of the Kashmir valley, these apples have a flat base. The cream flesh texture is crispy and firm with a sharp floral note. The fruit peel has a green-hue, with red stripes. The apple has good keeping quality.

2) McIntosh apple: Having a mix of red-green skin and off-white flesh, this variety has a sweet-tart taste. It is great for raw consuming, cooking, desserts, and pie preparation. In India, it grows in Uttaranchal, UP and Himachal Pradesh.

3) Granny Smith: Unlike other apples, granny smith apples have a grass-green peel, with white dots. The crunchy and juicy flesh is tart-acidic and makes a great choice for processing pies, cakes, and pastries.

It mainly grows in Himachal Pradesh and has high levels of antioxidants and phenols.

4) Golden Delicious: As the name signifies, these apples have pale green-yellow skin. The flavour is sweet, making it a staple ingredient of salads, apple butter, and sauce. The texture is semi-firm. It mainly grows in Jammu, Kashmir and Himachal Pradesh.

5) Honeycrisp: Honeycrisp retains its crispiness and shelf life for long and has a sweet-tangy flavour. These apples make a good choice for raw consumption and beverages.

6) Sunehari: This hybrid variety is developed in India and is the resultant cross of *Ambri* and *golden delicious apple*. They have a yellow peel with crimson streaks. The flesh is crunchy and juicy with sweet- acetous taste.

7) Lal Ambri: Indigenous to India, this hybrid variety is developed by crossing Red delicious and *Ambri* apple breeds. The cream-white pulpy flesh has a crisp, tender texture and has a sweet-juicy flavour. The variety comes from Jammu and Kashmir.

8) Chaubattia Anupam: A cross of Early Shanburry and Red Delicious, this hybrid variety grows extensively in Uttar Pradesh and Uttaranchal. It has glossy skin with vertical red stripes. The crunchy white flesh is sweet-tangy and also exudes a distinctive aroma.

9) Red Delicious: A popular variety of Himachal Pradesh, this cultivar produces large and oblong-conical shaped apples. This dark red apple has a mild-sweet and tender flavour. It grows throughout the year

and famous for table or raw consumption purposes.

10) Fuji Apple: Fuji apples are large in size with round shape and pale red-green skin. The crispy texture and sweet flesh make them the first choice for raw consumption. They also have a comparatively longer shelf life.

Note: Out of nearly one thousand cultivars in India, Red Delicious, Golden Delicious, Starking Delicious (syn. Royal) and Richard cover 60-70 percent area. Other prominent cultivars include *Ambri*, *Hazaratbali*, *Kesri* and *Maharaji* in Kashmir, *Beauty of bath*, *Early Shanburry*, *Green Sweet*, *Cortland Rymer* and *Spitzenberg* in UP, *Perlin's Beauty* in Nilgiri hills, *Red June*, *Red Gold*, *King of Pippins*, *Granny Smith*, *Winter Delicious*, *Commercial*, *Winter Banana*, *Black ben devis*, *Rus Pippin* and *Jonathan* in H.P.

Germplasm Collection and Conservation

Malus collection in India has 6734 total accessions, of which 5226 are trees in the field and 1508 are seed lots. In India nearly 743 germplasm accessions are being maintained at National Active Germplasm Sites (NAGS) and other crop based institutes. Good collection of Germplasm has been collected in 19 research centres out of which 11 are located in North West Himalayan region such as:

- ✓ NBPGR, Phagli (New Delhi)
- ✓ CITH, Srinagar (Jammu and Kashmir)
- ✓ IARI, New Delhi
- ✓ Fruit Research centre, Shalimar
- ✓ Hill Fruit Research centre, in Chaubattia and Chakrata, Uttarakhand

- ✓ Himachal Agricultural University, H.P

The conservation of genetic diversity is carried out by the following methods:

In situ conservation: It means in the wild natural habitats where specific species evolved and continue to do so. It is also known as on-farm conservation in farmers' fields where continuous cultivation, adaptation and improvement of cultivars is often carried out by small-scale farmers cultivating traditional local cultivars.

Ex situ conservation: In this type, conservation of biological diversity is done outside their natural habitats. The National Genebank at NBPGRI has a large ex-situ conservation facility including field genebanks, seed genebank, in vitro multi-crop repository, and cryobank.

Note

- ✓ Important temperate fruit accessions are being conserved in the field gene banks
- ✓ *Malus* seeds and pollen are both amenable to long term preservation. Current methods use dormant woody buds that are collected mid-winter, desiccated and slow-cooled prior to long-term storage in liquid nitrogen vapour.

Germplasm Evaluation and Utilization

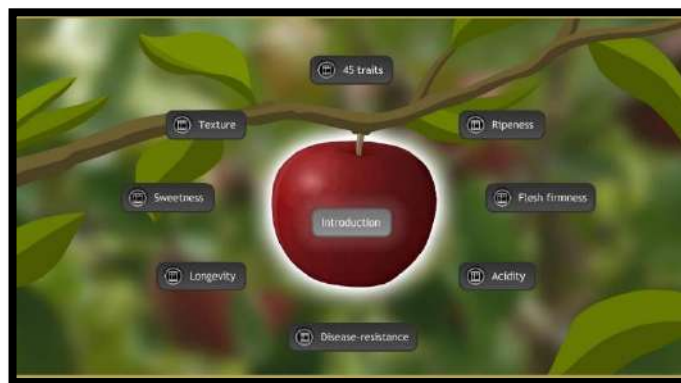
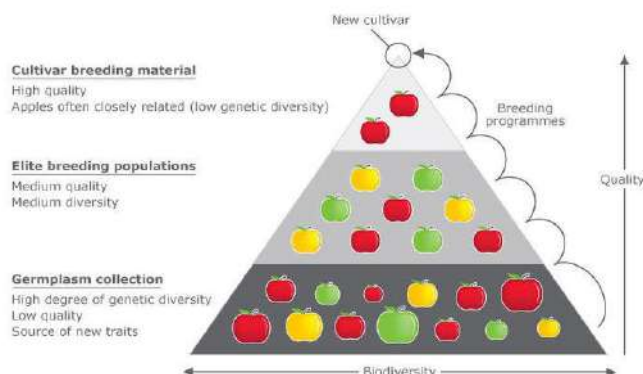


Fig. 2: Germplasm evaluation and utilization of *Malus* spp.

A germplasm is a library of genetic resources for an organism. Germplasm collections can be stored in several ways – as seeds in cool storage, as whole plants in a nursery or orchard or as cryopreserved dormant buds. Many of the apple trees in the germplasm collection contain specific traits that might enhance existing apple varieties. These can be used as parents in breeding programmes, with the aim of producing new, better apples with that trait. Apples from the germplasm collection in breeding programmes can help avoid the risks associated with inbreeding (including disease susceptibility) and improve apple quality. Some of them are listed as under:

- 1. Fruit colour:** Europe - Golden delicious, Jonagold, Elstar North American - Golden delicious, Red delicious, Mc Intosh (low acid/ low sugar and good culinary apples) India - Red delicious, Royal delicious
- 2. Yield:** it should have high yield cv like Greensleeves, Jupiter, Romus-2, Himekami
- 3. Pest and disease resistance:** *Malus floribunda*, *Malus zumi*, *Malus hupehensis*.

4. **Cold hardiness:** Honeycrisp, Lobo, Katjo, Mantet, Fireside, Wealthy, Yellow Transparent

5. **Winter chilling requirements:** Anna, Ein Shemer, Schlor, Mollie delicious, Adina

Conclusion

Worldwide, apples are amongst the most popular fruits, particularly in temperate climates. They are consumed fresh, baked, and processed as juice, alcoholic cider, cider vinegar, sauce, and fillings. The development of new apple cultivars with a wider genetic base is dependent upon breeders having access to a diverse array of cultivars and germplasm. Breeding programs may maintain their own collections, but often they acquire new materials from public apple genebanks. Traditional apple breeding is a complex process that involves many years of crossing, multi-site field evaluation trials, and consumer testing. Collections of apple genetic resources provide access to living materials (in either tree or seed form) for use in taxonomy, physiology, molecular and evolutionary biology, horticulture, and breeding programs. However, germplasm remains under the threat of loss due to pest-pathogen attack, natural calamities and climate change. Future strategies must include monitoring of in situ genetic diversity loss due to climate change, identification of trait-specific germplasm such as low-chilling, biotic and abiotic stress resistance, systematic conservation and efficient utilization.

Survival Biology of Entomopathogenic Nematode

Ramavath Abhi, Shaik Munnysha, Manisha and Paupuleti Sneha Latha

Introduction

- ✓ Nematodes are a highly diverse organisms that show a variety of adaptations to extremes in environments.
- ✓ Many nematodes including EPNs can undergo temporary quiescence in response to environmental stress specially water stress and enter into.
- ✓ Among PPN, *Anguina*, *Ditylenchus* and *Aphelenchoides* show anhydrobiotic survival strategy as they feed on aerial plant parts and are subjected to sun drying.
- ✓ It is important for seasonal survival and long-term longevity.

Survival stages of EPN

Quiescence

- ✓ Is a dormant state where the nematode metabolism and activity are slowed down in response to environmental stress
- ✓ Dormant state ends when the environmental stress is over and nematodes return to normal activity
- ✓ Variety of environmental stresses can trigger quiescent states; for example: water stress in the

soil lead to anhydrobiotic survival ('life without water')

Anabiosis or Cryptobiosis

- ✓ It is extreme form of quiescence
- ✓ during quiescence when the metabolic rate fall below detectable levels and cease, the nematode enters anabiosis/cryptobiosis

Anhydrobiosis

- ✓ When water evaporates from the soil, the IJs are under stress and therefore enter into anhydrobiosis.
- ✓ IJs enter anhydrobiosis when the water loss is slow and gradual



- ✓ IJs mass together forming large aggregations and some species coil to reduce the surface area exposed to the environment this slows down the rate of water loss
- ✓ Sudden loss of water will kill the IJs

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- ✓ In nature, water loss is always gradual which gives a chance for the nematodes to acclimatize and enter anhydrobiosis
- ✓ All EPN IJs can enter partial anhydrobiosis and can survive for a few months
- ✓ Anhydrobiosis in EPNs is a reversible as the IJs revive and become active when soil becomes moist (irrigation, rainfall)
- ✓ PPN (*Anguina*, *Ditylenchus*, *Aphelenchoides*) are true anhydrobiotes as they can survive for several years.



Anhydrobiosis induced in *H. indicus* IJs



Anhydrobiotic *Ditylenchus* in onion

Anhydrobiotic *Anguina* in wheat gall

EPN survival at low temperature

- ✓ At low temperature EPN accumulate freeze-tolerant cryoprotectants to survive intracellular freezing, example *S. feltiae*
- ✓ Cryoprotectants protect nematodes from chilling and freezing injury
- ✓ These include sugars (trehalose, glucose, fructose) and sugar alcohols/polyhydric alcohols (glycerol, sorbitol, myo-inositol, ethylene glycol, ribitol, erythritol, inositol)
- ✓ At 5°C or less, the principal cryoprotectants accumulate are trehalose and glycerol which are synthesized from nematode's glycogen or lipid reserves
- ✓ Cryoprotectants replace the body water and suppress the melting point of water
- ✓ Thus, decrease the amount of ice formed in the body
- ✓ Trehalose assists the nematodes with short-term freezing stress
- ✓ Recrystallization inhibition protein (RIP) assist the nematode with long-term freezing stress
- ✓ RIP helps to stabilize the structure and size of the ice crystals formation
- ✓ Glycerol increases the freezing tolerance of nematodes by permeating the membrane (i.e. make the membranes wet) once the water is lost
- ✓ Cryoprotectant synthesis has been observed in freeze-tolerant earthworms

Anhydrobiotic EPN formulation

- ✓ Current international biopesticide market is supplying EPN products in which partial anhydrobiosis is induced
- ✓ Dried IJs are stored in absorbent clays (WP) and water-dispersible granules (WDG)
- ✓ Physiologically arrested state of dormancy induced by anhydrobiosis help to improve the storage stability in the formulations
- ✓ Water Dispersible Granules (WDG) of *S. carpocapsae* = 80% survival and >60% infectivity after 5 months storage at 25°C.

Formulation Technology of Entomopathogenic Nematode

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Entomopathogenic nematode?

Entomogenous nematodes are parasitic worms that have either a facultative or a mandatory parasitic relationship with insects. Entomogenous nematodes cause sterility, reduced fecundity, longevity, and flight activity in their hosts, as well as delayed development, behavioural, physiological, and morphological abnormalities, and, in some cases, fast mortality.

- ✓ Formulation is a process of the transformation of living entities into a product that can be applied by practical methods.
- ✓ Formulation is important for successful commercialization of EPNs
- ✓ EPNs are formulated to facilitate their storage, transport and application
- ✓ Formulations are based on the fundamental principle of energy conservation:
 - ✚ Restricting their movements (physical restraint)
 - ✚ Reducing oxygen consumption to induce partial anhydrobiosis

Attribute of a good formulation

- ✓ Show high and consistent quality

- ✓ Easy handling and transport
- ✓ High effectiveness
- ✓ Easy application in the field

Components of stable formulations are:

- ✓ An active ingredient - EPN IJs
- ✓ A carrier material- water, sponge, alginate, gels, cadavers
- ✓ Additives - various substances with different functions, such as adsorbents, emulsifiers, surfactants, thickeners, humectants, disperants, antimicrobials, UV-ray protectors.

Main purpose of additives to increase survival and maintain virulence of the EPNs.

- ✓ International Biocontrol Agents Market Value for EPN was 17 million USD in 2016 which is estimated to grow to 28 million USD in 2022
- ✓ Unfortunately, India does not figure in the International Market.
- ✓ No Indian products match the International Standards

EPN formulations

- ✓ Formulation with live IJs: aqueous/sponge/gels
- ✓ Formulation with partially dried/anhydrobiotic

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IJs: WP/WDG

- ✓ EPN infected cadavers

1. Aqueous suspension

- ✓ Most common EPN formulation is water-based aqueous suspension
- ✓ Water is used for storage, transportation and application
- ✓ Optimum storage temperatures is 4 to 15°C
- ✓ survival Steinernema: 6-12 months; Heterorhabditis: 3-6 months
- ✓ Factors that affect survival time:
 - ✚ Sedimentation
 - ✚ High oxygen demand
 - ✚ Susceptibility to microbial contamination
 - ✚ Special storage conditions (refrigeration)
 - ✚ Appropriate concentration for each species

Drawback

- ✓ Large volumes of water make it bulky for transportation
- ✓ Refrigeration requirements increase costs of product

2. Synthetic sponges



- ✓ Polyurethane sponge cubes are used as carrier
- ✓ Water suspension of 500-1000 IJs cm^{-2} is added to the sponge
- ✓ IJs enter the galleries of the sponge and are trapped inside
- ✓ Placed in a plastic bags for storage

- ✓ Survival time of 1-3 months at 5-10°C
- ✓ For release of IJs the sponge is dipped in a bucket containing water
- ✓ IJs trapped in the sponge channels released in water
- ✓ Water is transferred to sprayer tanks and sprayed in the field or foliage

Drawbacks

- ✓ Sponge formulation is not good for long distance distribution because it needs refrigeration storage
- ✓ This method is time and labour demanding
- ✓ Large amounts of sponge waste are generated

3. Gels

Activated carbon powder: IJs homogeneously mixed to form a cream

Drawbacks: high cost, unpleasant, low stability at room temperature

Polyacrylamide gel: IJs added in partially desiccated form

Drawbacks: poor survival at room temperature, difficulty to dissolve

Macrogels: partially hydrogenated vegetable oil paste containing mono-glycerides and di-glycerides

Drawbacks: poor survival at room temperature

Hydrogenated oil and acrylamide paste: 80% survival after 35 days at 24-35°C.

Drawbacks: this survival time is considered commercially unacceptable.

Alginate beads: (sodium alginate + calcium chloride)

- ✓ Live IJs are entrapped in bead form
- ✓ Better than other gel-based formulation
- ✓ 99.8% survival after 6 months at 23°C and 100% relative humidity



Drawbacks:

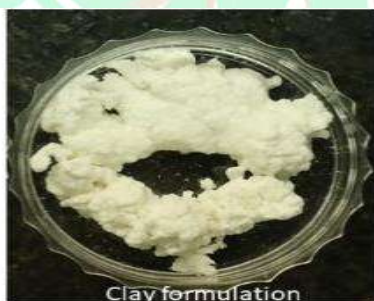
- ✓ Extraction steps time-consuming/ expensive/ unsuitable for large-scale applications
- ✓ Cannot be sprayed

4. Wettable powder (WP)

Attapulgate clay formulation survival time of 8 weeks at 23°C.

Drawbacks

- ✓ Poor storage stability
- ✓ Clogging of the spray nozzles



Vermiculite: survival time 4-5 weeks at 20°C

Drawbacks: poor storage stability

5. Water dispersible granules (WDG)



- ✓ Most promising and advanced formulation
- ✓ IJs are immobilised through partial anhydrobiosis
- ✓ Reduces the basal metabolic rate (BMR) of the IJs
- ✓ Prevents depletion of lipids and glycogen reserves
- ✓ On rehydration, IJs revive from desiccation and are healthy and viable
- ✓ Survival and pathogenicity extended to 6 months at 4 to 25°C, and to 8 weeks at 30 °C

Presently, there are about 115 companies mostly in USA and other parts of the world (UK, Germany, Canada, Italy, Japan, Switzerland, Sweden, Denmark, Australia) which are producing, formulating and marketing the EPN (Table 1).

6. Cadaver

- ✓ EPN infected galleria cadavers are applied directly in the fields
- ✓ Highly effective for soil borne pests- white grubs, termites, root borer
- ✓ Efficient for field crops, orchard trees, tea-plantations
- ✓ Galleria is infected with epn
- ✓ Cadavers are coated with inert agents to avoid sticking and easy shipment
- ✓ One day before application, the field is lightly irrigated
- ✓ Cadavers are applied in small holes (2-3 inches deep) made in the field
- ✓ They are covered with soil
- ✓ Dose: 3000 cadavers acre⁻¹

Crop	Insect pest	Nematode species	Formulation
Artichoke	Artichoke plume moth (<i>Sphenophorus parvulus</i>)	<i>S. carpocapsae</i>	WDG, WP,
Berries	Root weevil (<i>Diaprepes abbreviatus</i>)	<i>H. bacteriophora</i>	Sponge
Citrus	Root weevil (<i>Diaprepes abbreviatus</i>)	<i>S. riobrave</i>	WDG and LC
Cranberry	Root weevil	<i>H. bacteriophora</i>	Sponge
	Cranberry girdler (<i>Chrysoteuchia topiaria</i>)	<i>S. carpocapsae</i>	WDG, WP
Mushrooms	Sciarid flies (<i>Lycoriella</i> spp.)	<i>S. feltiae</i>	Vermiculite
Ornamentals	Root weevils	<i>H. bacteriophora</i>	Sponge
		<i>H. megidis</i>	WP
		<i>S. carpocapsae</i>	WDG,WP
	Wood borers (<i>Holcocercus insularis</i>)	<i>H. bacteriophora</i>	Sponge
	Fungus gnats (<i>Bradysia</i> spp.)	<i>S. feltiae</i>	Vermiculite
Turf grass	Scarabs (<i>Cyclocephala hirta</i>)	<i>H. bacteriophora</i>	Sponge
	Mole crickets (<i>Scapteriscus vicinus</i>)	<i>S. riobrave</i>	WDG
		<i>S. scapterisci</i>	WP
		<i>H. bacteriophora</i>	Sponge
	Billbugs (<i>Sphenophorus venatus</i>)	<i>S. carpocapsae</i>	WDG,WP
	Army worm (<i>Spodoptera frugiperda</i>)	<i>S. carpocapsae</i>	WDG,WP
	Cut worm (<i>Agrotis ipsilon</i>)	<i>S. carpocapsae</i>	WDG,WP
	Web worm (<i>Cephalcia abietis</i>)	<i>S. carpocapsae</i>	WDG,WP

- ✓ Each Galleria releases up to 1,50,000 IJs and they spread in the soil
- ✓ Each IJ is healthy and pathogenic
- ✓ Good for small scale cottage industry
- ✓ Can be developed on 'demand and supply' basis.



Empowering women, girls and marginalized farmers on *Galleria* rearing...

Drawback

- ✓ Shelf-life limited: cadavers have to be applied within 4-5 days
- ✓ Cannot be used as spray application



Soil Test Crop Response: Modern Approach of Soil Fertility Evaluation and Fertilizer Recommendation

Pallavi Bharti and Pankaj Kumar Ray

Soil Test Crop Response (STCR)

After high yielding varieties and hybrid crops were introduced, it became clear that systematic soil test crop response research was required in various soil agro-climatic locations. The STCR concept was created by Ramamoorthy in 1987, and the ICAR formed the AICRP on STCR in 1967. STCR shows how soil test result and crop yields are related.

The results of the soil test must be correlated with the actual crop response measured in the field. There should be different calibration charts for every crop and soil. The concepts of targeted yield, regression, and fertility gradient were developed. This method, also known as “rationalized fertilizer prescription technique,” recommends fertilizer doses by taking into account the crop's yield level and inherent soil fertility.

Objective of STCR

- ✓ To use mathematical equations for various crops and various soil agro-climatic zones independently to prescribe fertilizer dosages for a certain crop based on soil test values to reach the “Targeted yields” in a particular soil agro-climatic region under irrigation or protected irrigation conditions

- ✓ This takes into account the crops' nutrient needs for a “desired production level” as well as how well the soil and additional fertilizer nutrients are utilized by the crops.

Concept of STCR

The STCR approach aims to obtain a basis for exact quantitative adjustment of fertilizer dosages for desired levels of crop output under varied soil test results and farmer response conditions. These are put to the test in field tests as follow-up verification to support soil testing laboratories' advising purpose under particular soil, crop, and agro climatic circumstances. The following factors are used to propose the fertilizers.

- ✓ Regression analysis-based fertilizer recommendations
- ✓ Suggestions for a specific percentage of the maximum yield

STCR methodology takes in to account the three factors

- 1) Nutrient requirement (NR) in kg/ quintal of the produce
- 2) Percentage contribution from soil available nutrients (SE)

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- 3) Percentage contribution from added fertilizers towards making effective fertilizer prescriptions for specific yields.

Advantages

- 1) Site-specific fertilizer recommendations that are effective and profitable for increasing crop yield and maintaining soil fertility.
- 2) Strives to provide fertilizer application rates that are balanced, effective, and profitable while taking into account the soil's fundamental fertility status in order to meet pre-established yield targets.

Targeted yield concepts

These suggestions are based on soil test results, but they are made for many yield targets rather than just one ideal yield level. By entering the results of the soil test into specific mathematical formulae and calculating the quantities of nutrients required to achieve a specified yield target, a wide range of fertilizer prescriptions have become available.

Sustainable Agricultural Practice by Zero Budget Natural Farming

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Zero Budget Natural Farming (ZBNF): What is it?

The United Nations' food and agricultural organization gave zero budget natural farming (ZBNF) the moniker. Since the terms “budget” and “expenses” are related, the phrase “Zero Budget” refers to neither the use of credit nor the expenditure of cash on input purchases. “Natural farming” refers to chemical-free, in-tune with nature farming. It is essentially a form of organic gardening where there are no expenses associated with cultivating or gathering the plants. This indicates that farmers do not need to buy pesticides and fertilizers to ensure the healthy growth of crops.

Instead of fertilizers based on chemicals, it employs biological insecticides. In order to increase microbial activity, seed health, and soil protection, respectively, ZBNF primarily relies on the use of items like *Jivamrita*, *Bijamrita* and *Acchadana* (natural mulch). It effectively addresses the ambiguities of climate change. It is distinctive in that it is founded on the most recent agricultural science discoveries while also having roots in Indian tradition. The method has shown significant success in southern India, particularly in the state of Karnata-

ka where it originated. By using this farming technique, you can lower your farming expenses and risks, improve soil fertility and lessen the unpredictability caused by climate change. This method has evolved into a movement in the State of Karnataka with the assistance of farmer Subhash Palaker and the Karnataka Farmers' Association, and it has been extremely effective in Karnataka. Andhra Pradesh launched successful pilot programmes in 2015, and as a result, the state became the first to enact a ZBNF Policy. By 2024, it is hoped that Andhra Pradesh would be completely chemical-free. Following this, farmers in many other regions of the nation, particularly in the states of South India, started using the approach. To date, this agricultural technique has been used by more than 40 lakh farmers nationwide.

Farmers are being encouraged to adopt it by the governments of numerous states. The government would encourage farmers to practice zero-budget farming, according to Nirmala Sitharaman, the finance minister, who delivered the 2019–2020 budget speech. Sitharaman thought that this technology would enable farmers to double their incomes while also lowering the costs associated

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with farming. It was reaffirmed in the 2020 budget address as well. Additionally, it will advance efforts to double farmers' incomes by 2022.

Objectives of Zero Budget Natural Farming

- ✓ To get farmers out of debt; to stop using chemical pesticides;
- ✓ To encourage regenerative agriculture methods.
- ✓ To make small-scale farming profitable.
- ✓ To build the social and human capital required for a thriving and inclusive agriculture sector.
- ✓ To return to a “pre-green revolution” method of farming and reduce production costs to almost nothing.

Locally available materials which may be used for Zero Budget Natural Farming

- ✓ Biological pesticides, such as frogs, earthworms, earthworm residue from plants, cow or human excrement, etc., guarantee the healthful growth of crops.
- ✓ For seed treatment purposes, formulations based on cow dung and urine can be employed.
- ✓ By combining cow dung and pee, it is possible to ensure the fertility of the soil.
- ✓ Mulching and soil aeration to improve soil quality.
- ✓ For improved soil moisture, water vapor condensation.
- ✓ The dried biomass in the soil is broken down by microorganisms into nutrients that are available for use by plants.

Benefits of Zero Budget Natural Farming (ZBNF)

- ✓ It promises to stop relying on loans and substant-

ially reduce production costs, which would further help dejected farmers break the cycle of debt.

- ✓ It is a natural farming method that protects crops using biological pesticides such as earthworms, cow dung, urine, plants, and human excreta while also lowering farmers' expenditure.
- ✓ It conserves water and lowers the cost of power needed in farming equipment.
- ✓ In ZBNF, oxen are used to help with crop framing and field ploughing. This method saves a lot of money because it doesn't use any diesel or resources related to fuel.
- ✓ Restoring soil fertility and nutrient value has proven to be a very effective use of cow dung.
- ✓ It satisfies the desire for a resilient food system with little ecosystem exploitation.
- ✓ Through varied and multi-layered cropping systems, it restores the health of the ecosystem.
- ✓ ZBNF might increase crops' capacity to adjust to and produce under changing climatic conditions.
- ✓ It lowers expenses for farmers by doing away with outside inputs and restoring soils with locally available resources.
- ✓ This farming method increases agricultural biodiversity and ecosystem services, making the farm more profitable.
- ✓ ZBNF does not cause the generation of greenhouse gases, in contrast to conventional agriculture and organic farming.
- ✓ It improves the rural impoverished community's

means of subsistence.

Limitations of Zero Budget Natural Farming (ZBNF)

- ✓ The “virtuous cycle model”, which views investments as a major engine of growth, doesn't seem to be compatible with the zero budget approach to natural farming.
- ✓ Better investments and technologies are required due to the shifting patterns of high value commodity consumption and demand.
- ✓ Only zero budget natural farming is being promoted, but in order to implement ZBNF, it is also important to promote cattle rearing.
- ✓ The ingredients needed to make jivamrut-jaggery and powdered lentils are bought from marketplaces, which contradicts the ZBNF tenets.
- ✓ Finding customers to sell to for a premium price is another challenging task.
- ✓ Only regional varieties are utilized. No GM or hybrid crops.

Conclusion

ZBNF represents a major advance in sustainable agriculture. After so many modern and scientific revolutions, this step ultimately helped us recognize that returning to nature is the greatest course for our way of life. Though it sounds quite exciting when we talk about environmental sustainability, its viability in the marketplace has not yet been shown. The government is currently pushing natural farming on a zero budget. To quadruple farmers' income by 2022, Rajeev Kumar,

vice chairperson of Niti Aayog, asks for a paradigm shift in the agricultural industry. In the various states across the nation, it has been agreed to adopt ZBNF through the Rashtriya krishi vikas yojana and Paramparagat krishi vikas yojana. Although ZBNF provides many benefits, there are also some drawbacks. Since zero budget natural farming has so much potential, we must take a deliberate strategy to implementing it.

Dragon Fruit: A Resource for Boosting the livelihood of Farmers in India

Rashmi Kumari and Ranjeet Kumar Ranjan

Introduction

Dragon fruit is an exotic fruit introduced in India few decades back. It is well known for its attractive fruit color and pulp with minute black seeds in it. It is a semi-epiphytic plant, can climb up to some height but most often it requires vertical supports, either of bamboo, iron post or wood. Due to scales on its pericarp, its fruit is also called Pitaya. It belongs to the family Cactaceae. There are four different types of Dragon fruits, each varying with other in fruit colour are:

1. ***Hylocereus undatus***: It has white flesh with pink color pericarp.
2. ***Hylocereus polyrhizus***: It has red flesh with pink color pericarp.
3. ***Hylocereus costaricensis***: It has violet red flesh with pink pericarp.
4. ***Hylocereus megalanthus***: It has white flesh with yellow pericarp.

Among the above four types, *Hylocereus undatus* and *Hylocereus polyrhizus* are most preferred for commercial cultivation in India. It can be grown in field as well as on terrace or in kitchen garden.



Dragon fruit cultivation on terrace and in field plot

Features

It is rich in carbohydrates, flavanoids, crude fibre, protein, sorbitol, Vitamin C, Vitamin A, fats etc. It is used in juices, fruit salad, smoothies etc.

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Regular consumption helps in fighting cough, asthma, diabetes and heart diseases. It is rich in vitamin C which boost immunity and heal wounds. It is also used in cosmetics as face pack

Areas of Dragon Fruit cultivation in India

The major dragon fruit producing states are Gujarat, Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat, Odisha, Andhra Pradesh, and West Bengal. The first successful cultivation of Dragon fruit took place at Gujarat.

Cultivation practices

It can be grown in wide range of soil, with slightly acidic pH from 5.6 to 6, rich in organic matter and temperature ranging from 20-30° C is ideal for its cultivation. Even though it belongs to Cactaceae family, but it is unable to thrive on low water. So, optimum irrigation is a must. It requires 600 to 1800 mm of rainfall with regular sunshine and alternate wet and dry season for its growth.

Propagation

It can be propagated through both seeds and stem cutting, but stem cutting provide comparatively early fruiting and higher yield. Stem cuttings of size 20-30 cm are used for planting. One-two days old cutting is used for planting. The cutting is taken from elite mother plants after the fruiting season is over. These cuttings are planted in polythene bags of 12 x 20 cm dimension, filled with soil, farmyard manure and sand in the ratio of 1:1:1. These cutting roots profusely and become ready for planting in 4-5 months in the field plot.

Planting

The cutting is planted in the field plot mainly during the summer season. Generally, 100-120 plants can be planted per acre. The initial investment is high in dragon fruit as it requires vertical support. The plant is fast growing vines and thus, requires vertical support such as bamboo, iron post, reinforced cement concrete cast poles of about 1.5 to 2 m height with either rectangular plate or circular plate for balancing the main stem and lateral stems. Generally 2-3 plants are planted near a single pole. The plant climbs the pole and till it reaches the plates height, only single stem is maintained and lateral branches are pruned off. Once the main stem reaches the post, the lateral branches are allowed to grow, which later form umbrella like structure. In a year, around 30-40 lateral branches grow which bear flowers and later develops into fruits.

The plants grown through stem cuttings start to bear fruits after 1 to 1.5 years. The greenish-yellow flower grows on the margin of the stem during May-August. After 25-27 days of fruit set, the fruit starts changing color from green to red. Within one week, fruit reaches maximum coloration. Fruits are ready for harvesting 30-35 days after flowering. The fruits to be sold in local markets can be harvested when it reaches maximum coloration stage, while those to be sold at distant places are harvested when the change in color begins from green to red.

Nutrient Management

Before applying the nutrients, it is advised to get the soil sample tested to know the nutrient status

of the soil. After getting the soil tested, the required dose of nutrients is supplied in the soil. Potash: Superphosphate: Urea in the ratio 40:90:70 (gram) per plant gives best result for yield and quality. Along with nutrients, the regular supply of irrigation is important for fruit setting and yield. Flooding irrigation is avoided as it may cause fungal infection. Drip irrigation may be practiced for optimum supply of water to the plant.

Harvesting

Fruits are harvested with the help of secateurs or merely by twisting the fruits. The harvested fruit varies in weight, from 400 g to 800 g each. Depending upon the management practices, the flowering and fruiting continues from June to November, thus providing the fruit round the year. The average yield is 5 tons per acres.

Diseases/ Pest Management

Sun burn is the main problem affecting the plant. The scorching sun for longer period of time affects the plant. In order to avoid, it is advised to grow shade providing plants such as Sesbania, Moringa etc in the same field plot.

Conclusion

The cultivation of dragon fruit is advantageous to the farmers as once planted, it can provide fruit continuously for 20 years. It starts flowering after 1.5 years only and achieves full production after 5 years. The initial investment is generally high and may range from 5-10 lakhs. The use of iron pillar or concrete pillars and installing drip irrigation may add up in high initial cost. But the

return one gets from its cultivation is worth doing it. An individual farmer can earn Rs 10 lakh per annum on an average from it. Thus, it is a peak time for the farmers to grab this opportunity.

The government has also taken initiative to boost the cultivation of dragon fruit for which it has launched Mission on Integrated Development of Horticulture. This scheme is centrally sponsored with aim of holistic growth of the horticulture sector. In order to meet the domestic and global demand due to its nutritional value, the Central government has also decided to expand the area under cultivation for dragon fruit from 3,000 hectares to 50,000 hectares in the next 5 years. Earlier, states like Haryana and Gujarat have also announced incentives and subsidy to the dragon fruits farmers as a tool for reducing the higher initial cost. Therefore, it can be considered as useful resource for the economic growth of farmers.

Soil Carbon Sequestration: A Way to Improve Soil Health under Climate Change Conditions

Hansa Kumawat, Neha Khardia and Sonal Sharma

Since the industrial revolution, greenhouse gas emissions have increased tremendously, notably from the mid- to late-twentieth century onwards. There are many greenhouse gases which causes greenhouse effect *i.e.* carbon dioxide (CO₂), Methane (CH₄), Nitrous oxide (N₂O), Chlorofluorocarbons (CFCs). All these gases have different life time (years) and global warming potential (100 years) which decides their contribution to changing climatic conditions. The major anthro-pogenic cause for the emission of these gases is burning of fossil fuels to generate electricity.

There are many other sectors which causes emissions of these greenhouse gases as represented in Table 1.

Greenhouse Gas (GHG)	Atmospheric Lifetime (yrs)	Global Warming Potential (GWP)	Primary Current Sources
Carbon dioxide (CO ₂)	50-200	1	Fossil fuel use, land use, cement
Methane (CH ₄)	12±3	21	Fossil fuel use, agriculture
Nitrous oxide (N ₂ O)	120	310	Mostly agriculture, ~1/3 are anthropogenic
Hydrofluorocarbons (HFCs)	1.5 to 209	150 to 11,700	Alternative to ozone depleting substances
Perfluorocarbons (PFCs)	2,600 to 50,000	6,500 to 9,200	Primary aluminum production; semiconductor manufacturing
Sulfur Hexafluoride (SF ₆)	3,200	23,900	Used in electric power transmission, magnesium and semiconductor industries

High GWP gases

Deforestation, biomass burning, conversion of natural to agricultural ecosystems, wetlands draining, and soil cultivation all contribute to land use change-related greenhouse gas (GHG) emissions. Additionally, higher carbon emissions are

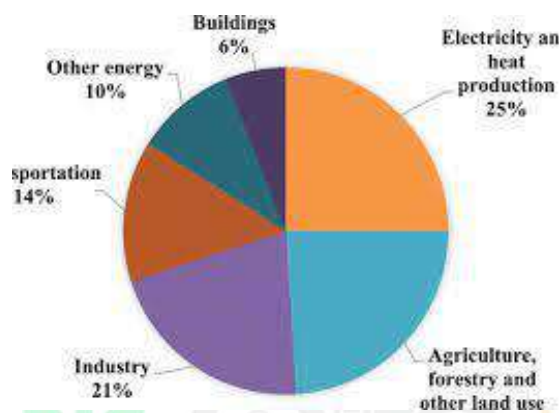
caused by soil carbon depletion due to land exploitation, increased dependency on agro-chemicals and soil degradation. Increases in atmospheric CO₂ and global temperatures may have a range of consequences on soil carbon inputs, including an effect on photosynthetic rates and carbon losses through respiration and organic matter breakdown. Increased CO₂ concentrations cause plants to fix more carbon via photosynthesis, resulting in increased biomass. Carbon loss, on the other hand, may rise as a consequence of higher plant respiration as a result of increased root biomass or as a result of increased microbial activity. Similarly, rising temperatures may have an effect on the carbon balance by restricting the availability of water and so lowering photosynthetic rates. On the other side, when water is plentiful, rising temperatures may boost plant productivity, affecting the carbon balance as well. Increased temperatures may also result in increased rates of SOM decomposition, leading in increased CO₂ generation and positive feedback effects on climate change.

The transfer of natural ecosystems to agricultural use has led in the decrease of SOC levels since the industrial revolution. This is a result of decreased plant roots and residues returning to the

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soil, increased decomposition caused by soil tillage, and increased soil erosion. The depletion of SOC stores has created a soil carbon deficit, presenting an opportunity to store carbon in soil through a variety of land management strategies. As a result, the carbon content of soil must be increased. Climate change, particularly growing levels of carbon dioxide (CO_2), gives a good opportunity for soil carbon sequestration.



What is soil carbon sequestration?

Soil carbon sequestration, often known as “carbon farming” or “regenerative agriculture,” is a technique that involves extracting CO_2 from the atmosphere and storing it in the soil carbon pool. This is mostly accomplished by plants through photosynthesis, with carbon stored as SOC.

Factors affecting carbon Sequestration capacity

The carbon sequestration capacity of the soil may be influenced by local controls on ecosystem processes.

Regions

The forest region stored the most carbon ($15990 \text{ kg C ha}^{-1} \text{ yr}^{-1}$), probably due to the ecosystem's greater aptitude for physical and chemi-

cal interaction as compared to other locations.

Rainfall infiltration: Carbon sequestration occurred at a faster pace in wet areas due to increased precipitation than in dry ones. Differences in precipitation patterns can have a significant influence on community composition, as well as on the structure and function of the ecosystem. Annual grasslands' carbon cycle will be less susceptible to variations in rainfall amount and more impacted by changes in seasonal rainfall timing, with a longer or later wet season resulting in considerable carbon losses from annual grasslands.

Soil type: Oxisols trapped the most carbon ($2205 \text{ kg C ha}^{-1} \text{ yr}^{-1}$). The soil carbon pool is composed of two components: the soil organic carbon (SOC) pool and the soil inorganic carbon (SIC) pool. The SIC pool is particularly essential in desert soils. SOC concentrations range from very low in desert soils to quite high in temperate soils and extremely high in peat soils.

Soil temperature: Carbon sequestration occurs at a rate that varies with mean yearly temperature. Carbon sequestered rose from less than 150°C to 250°C , at which point it decreased. Additionally, the SOC pool varies significantly between ecoregions, being greater in cold and wet regions than in warm and dry parts. The key rate determinant of microbial activities is soil temperature. As a result, increasing soil temperature accelerates mineralization, resulting in a drop in the SOC pool.

Slope: Slope location has an effect on soil moisture and nutrient levels, which has an effect on plant root

development and may have an effect on soil carbon.

The combined impacts of variations in carbon inputs and losses from land use, as well as the effects of land management on carbon input and loss rates, result in heterogeneity in the capacity of landscapes to sequester carbon.

Ways to soil carbon sequestration Carbon

Sequestration in soil is performed in a variety of methods, including the following:

- ✓ Reducing soil disturbance through the use of no-till or low-till practises or the cultivation of perennial crops.
- ✓ Changing planting dates or rotations, for example, by planting cover crops in place of fallow lands.
- ✓ Avoid cattle overgrazing.
- ✓ Frequent application of compost or agricultural leftovers to fields.

Co-Benefits

- ✓ Improved soil health
- ✓ Increased climate resilience
- ✓ Decreased fertiliser usage

Concerns

- ✓ **Measurement difficulty:** measuring and validating carbon removal by soil carbon sequestration is complex and expensive.
- ✓ **Saturation:** soils have a restricted capacity to store carbon.
- ✓ Reversibility.

Conclusion

SOC storage occurs as a result of dynamic biological processes such as photosynthesis, break

down, and soil respiration interacting. Human activities have disrupted these processes over the last 150 years, leading in the depletion of SOC and amplification of global climate change. However, these human activities now provide a mechanism for soil carbon sequestration. Future warming and increasing CO₂, as well as previous land use patterns and management practises, together with the physical variety of landscapes, are anticipated to result in complex patterns of SOC capacity in soil. Thus, the significance of land management techniques in carbon sequestration is being evaluated as a component of acceptable mitigation strategies in order to promote sound land management as a means of accomplishing agricultural and environmental goals.

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Conservation Agriculture: A Modern Approach to Soil Problems

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The main challenges facing the majority of Asian countries are ensuring food security for a growing population and reducing poverty while maintaining agricultural systems in the face of dwindling natural resources, adverse effects of climatic variability, spiralling input costs, and unstable food prices. Along with these difficulties, salinization, soil erosion, and soil organic matter reduction are the main signs that agricultural systems are not sustainable. These are caused mainly by: (i) intensive tillage induced soil organic matter decline, soil structural degradation, water and wind erosion, reduced water infiltration rates, surface sealing and crusting, soil compaction, (ii) insufficient return of organic material, and (iii) monocropping. conservation agriculture (CA), defined as minimal soil disturbance (no-till, NT) and permanent soil cover (mulch) combined with rotations, as a more sustainable cultivation system for the future. The benefits of tillage in agriculture are explored before introducing conservation tillage (CT), a practice that was borne out of the American dust bowl of the 1930s. Conservation agriculture (CA) changes soil properties and processes compared to conventional agriculture. These changes can, in turn, affect the

delivery of ecosystem services, including climate regulation through carbon sequestration and greenhouse gas emissions, and regulation and provision of water through soil physical, chemical and biological properties. Conservation agriculture can also affect the underlying biodiversity that supports many ecosystem services. In this overview, we summarize the current status of the science, the gaps in understanding, and highlight some research priorities for ecosystem services in conservational agriculture.

1. Conservation agriculture definition and goals

With no till/zero and reduced tillage, conservation agriculture is a type of land management that keeps the soil cover intact. According to its description, CA is a strategy for agricultural crop production that conserves resources and is focused on boosting natural and biological processes above and below the ground.

Conservation agriculture (CA) is not “business as usual” based on maximizing yields while exploiting the soil and agro-ecosystem resources. Rather, CA is based on optimizing yields and profits, to achieve a balance of agricultural, economic and environmental benefits.

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It argues that the social and economic gains from both production and environmental protection, including lower material and labour costs, outweigh those from production alone. Through reduced use of fossil fuels, pesticides, and other pollutants, as well as through the preservation of environmental integrity and services, agricultural communities become suppliers of better hygienic living conditions for the larger community. Conservation agriculture systems require a total paradigm shift from conventional agriculture with regard to management of crops, soil, water, nutrients, weeds, and farm machinery.

2. Conservation Agriculture: Principles

2.1 Minimal mechanical soil disturbance

The CA system represents a significant divergence from previous practises. This suggests that a wide variety of procedures, including as planting and harvesting, managing water and nutrients, controlling disease and pests, etc., must be modified, assessed, and matched in the context of new systems. The soil biological activity produces very stable soil aggregates as well as various sizes of pores, allowing air and water infiltration. This process can be called “biological tillage” and it is not compatible with mechanical tillage.

2.2 Permanent organic soil cover

A permanent soil cover is important to protect the soil against the deleterious effects of exposure to rain and sun; to provide the micro and macro organisms in the soil with a constant supply of “food”; and alter the microclimate in the soil for

optimal growth and development of soil organisms, including plant roots. In turn it improves soil aggregation, soil biological activity and soil biodiversity and carbon sequestration.

2.3 Diversified crop rotations

The rotation of crops is not only necessary to offer a diverse “diet” to the soil micro-organisms, but also for exploring different soil layers for nutrients that have been leached to deeper layers that can be “recycled” by the crops in rotation. Furthermore, a diversity of crops in rotation leads to a diverse soil flora and fauna. Cropping sequence and rotations involving legumes helps in minimal rates of build-up of population of pest species, through life cycle disruption, biological nitrogen fixation, control of off-site pollution and enhancing biodiversity.

Conservation Agriculture’s Impact

Global use of conservation agriculture is widespread. However, there are no accurate estimates on the full scope of any conservation agricultural measures. On the scale of zero-tillage, a component of conservation agriculture, there are some trustworthy estimations, though. The data made it clear that many regions of the world had implemented zero-tillage agriculture. The estimates show that zero-tillage agriculture is adopted in an area of little more than 105 million ha (Brown, 2008). The adoption of zero-tillage practices was rapid; from 45 million hectare in 1999 to 95 million in 2005 and now estimated to be more than 105 million. About 125 million hectares worldwide are used for CA USA (26.5 M ha), Brazil (25.5 M ha),

Argentina (25.5 M ha), Canada (13.5 M ha), and Australia are the top CA practicing nations (17.0 M ha). The adoption of CA is still in its early stages in India. About 1.5 million hectares have adopted zero tillage and CA during the past few years.

Country	Area (M ha)	% of Global Area
USA	26.5	21.2
Brazil	25.5	20.4
Argentina	25.5	20.4
Australia	17.0	13.6
Canada	13.5	10.8
Russian Federation	4.5	3.6
China	3.1	2.5
Paraguay	2.4	1.9
Kazakhstan	1.6	1.3
Others	5.3	4.2
Total	124.8	100.0

Benefits of Conservation Agriculture

The advantages of conservation at the farm, regional, and national levels, agriculture is evident. Three main categories may be used to group the advantages: There are three types of benefits: agronomic ones that increase soil productivity, economic ones that increase production efficiency and profitability, and societal and environmental ones. The following is a list of some advantages of conservation agriculture:

- ✓ Reduction in cost of production by Rs 2,000 to 3,000 ha⁻¹
- ✓ Enhancement, in the long term C sequestration and build-up in soil organic matter.
- ✓ Reduction of the incidence of weeds, such as *Phalaris minor* in wheat
- ✓ Enhancement of water and nutrient use efficiency
- ✓ Enhancement of production and productivity

(4% - 10%)

- ✓ Avoiding crop residue burning reduces loss of nutrients, and environmental pollution, which reduces a serious health hazard
- ✓ Providing opportunities for crop diversification and intensification-for example in sugarcane-based systems, mustard, chickpea, pigeon pea etc.
- ✓ Improvement of resource use efficiency through residue decomposition, soil structural improvement, increased recycling and availability of plant nutrients and
- ✓ Use surface residues as mulch to control weeds, moderate soil temperature, reduce evaporation, and improve biological activity.

Barriers to conservation agriculture adoption

Adoption of conservation agriculture is hampered by a variety of issues. The attitude of the agricultural community, which has received significant education and has been persuaded to practise intensive agriculture and employ outside inputs, is of utmost importance. Farmers have previously reaped significant financial rewards from using intensive farming techniques.

A comprehensive teaching campaign showcasing the advantages of conservation agriculture is required to make the transition from intense tillage to zero or minimum tillage. The widespread use of agricultural waste as fuel and animal feed Farmers confronts a shortage of agricultural wastes due to lower biomass output of many crops, especially in rainfed conditions.

This poses a significant obstacle to the development of CA under rainfed conditions. Inadequate seeders, particularly for small- and medium-sized farmers: Although major efforts have been made to develop and promote equipment for planting wheat in no-till systems, widespread adoption will necessitate increased efforts to create, standardise, and promote high-quality equipment for a variety of crops and cropping patterns.

The fourth problem is related with the skills development. Most of the farmers lack skills in using zero-till machines and cultivation practices that prevents adoption of conservation agriculture practices.

Conclusion

There has been an increase in the need for more advanced/sustainable agricultural management practises that farmers can use to increase productivity and maintain environmental sustainability without endangering the ecosystem in order to feed the growing global population, which is expected to grow by between 8.9 and 10.6 billion by 2050. 95 percent of the food we eat originates from soil, either directly or indirectly. Although South Asia (SA) has experienced rapid economic growth, the region continues to experience extremely high rates of poverty, hunger, and degradation of its natural resources, including soil. This region urgently needs cost-effective resource conservation solutions, such conservation agriculture, due to the existence of a sizable rainfed area and the issues that go along with it (CA). The advantages span several

scales, including nano-level (improving soil qualities), micro-level (saving inputs, lowering cost of production, boosting farm revenue), and macro-level (reducing poverty, enhancing food security, and decreasing global warming). A mission mode programme is required to promote conservation agriculture in order to enhance and sustain agricultural productivity, increase farmer income in developing nations, and make them more competitive in the face of the fast-moving integration of the world's markets. By educating policy advisers, experts, and financial organisations in India, the idea of conservation agriculture may be incorporated with various government initiatives.

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Wheat Diseases: Symptoms and their Effective Management

Hansa Kumawat, Hemraj Nagar and Surendra Dhayal

Wheat is the most important cereal crop cultivated worldwide which contributes substantially to human diet and food security. Wheat is an important food grain crop of Rabi season in India. For good crop harvest, quality seed, application of balance fertilizers, irrigations and other plant protection measure are pre-requisite. Wheat suffers from a number of diseases like rusts, smuts, bunts and powdery mildew, etc. hence good management of range of wheat diseases can be achieved when growers adopt a strategy that includes:

Resistant / tolerant varieties Seed and/or fertilizer treatments Active monitoring of crops with a view to fungicide applications if required

1. Powdery Mildew: Scattered masses of powder like symptoms appear on the leaf. The disease progresses from lower leaves to upper leaves. Leaf dries in severe attack and even the development of earheads is adversely affected and grains formed are shriveled and lighter in weight. The disease is more common in irrigated areas, because of the high humidity. Powdery mildew can be effectively managed by following ways:

- ✓ Grow resistant/tolerant varieties viz, WH 912, WH 542 WH 896 and WH 283.
- ✓ Spray of soluble sulphur @ 2-2.5 kg ha⁻¹ in

400-500 litres on appearance of diseased symptoms.

- ✓ Avoid late sowing of timely sown varieties.



2. Loose Smut: It occurs throughout the state in almost all commercially grown wheat varieties and causes yield losses. The disease is noticed at or after spike emergence when black powdery spike heads appear from infected plants. In smutted spikes, all the spikelets are filled with black powdery mass of spore. The spore from diseased spikes are blown away by the wind and cause infection at the anthesis stage of the crop to the developing grains in the healthy spike heads and pathogen gets established in the embryo of seed. Such internally infected seed apparently looks healthy serves as a source of inoculum for the disease during next crop season. It has been observed that at boot stage the flag yellowing or tips drying of infected tillers can easily be recognised in the field from a distance and such

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tillers plants⁻¹ can be rouged out to control the secondary spread of the disease. Loose smut can be managed by following ways:

- ✓ Treat the seed with systematic fungicides i.e. Tebuconazole 2 DS @ 1 g kg⁻¹ or carboboxin or carbendazium @ 2 g kg⁻¹ seed.
- ✓ Rogue out the diseased plants as soon as observed and destroy them by burning or burying in the soil.
- ✓ Durum wheat varieties viz., WH 896 and WH 912 are resistant to loose smut.



3. Flag Smut: The disease is more important pronounced in light sandy soils. The disease can cause heavy losses if susceptible varieties are taken in the infested fields after year continuously. Symptoms of the disease are produced on leaf, leaf sheath, culms and ear heads but leaf and leaf sheath are more commonly affected, long narrow lead gray or black streaks or stripes running parallel to the veins are formed on leaf and other affected parts. These stripes are initially covered with epidermis which later ruptures and expose & black sooty mass of the fungus spores. The affected leaves become twisted and drooping (flagged). Later the shredding of diseased leaves also takes place. The spikes emerged on the affected tillers remain sterile

bearing no grains and if grains formed they are shrivelled with poor viability. The pathogen can survive in soil and disease plants debris for many years. The disease can be managed by following ways:

- ✓ Seed treatment with Tebuconazole 2 DS @ 1 g kg⁻¹ or carboboxin or carbendazium @ 2 g kg⁻¹ seed.
- ✓ Rogue out the diseased plants and destroy by burning. Grow resistant varieties viz., WH 896 and WH 283 in infested yields year after year.

4. Brown Rust: Brown coloured lesions or pustule are formed on leaf and leaf sheath. The pustules are scattered throughout the leaf areas. The disease is generally observed in second fortnight of February or 1st week of March. Disease intensity varies with growth stage of the crop. Grains are usually light and shriveled depending on disease severity. The brown rust can be managed by following ways:

- ✓ Grow resistant varieties like WH 542, WH 1105, WH 896, WH 1124, WH 912, WH 1105 and WH 3765
- ✓ Spray mancozeb or zineb @ 2 kg ha⁻¹ on the first appearance of the disease symptoms and repeat 2-3 sprays at 10-15 days interval



5. Yellow or Stripe Rust: Yellow rust has a distinguishable characteristic of producing light yellow, straight-sided pustules that occur in stripes between the veins of the leaves and occasionally on the heads. When the pustules reach maturity, orange-yellow spores are produced. Disease is recognised by the presence of linear chains of yellow rust pustules formed on leaf. The yellow rust causes losses if it appears in early seedling stage of the crop. In severe attack yellow pustules are formed on glumes of earhead and even on the awns. Disease usually appears during the month of January when average temperature is between 11-15°C. The yellow rust can be managed by following ways:

- ✓ Grow resistant varieties like WH 542, WH 1105, WH 1142, WH1124, WH 912 and WH 3765
- ✓ Spray mancozeb or zineb @ 2 kg ha⁻¹ at the appearance of the disease symptoms and repeat 2-3 sprays at an interval of 10-15 days or spray of propiconazole @ 1 ml litre⁻¹ of water or 200 litres of water acre⁻¹ on just appearance of diseased symptoms



6. Karnal Bunt: The disease has international importance and strict quarantine has been imposed by countries where it is not known. Its permissible limits at international level are zero per cent. Karnal bunt

disease in the wheat seeds/ grains is observed only after threshing of the wheat crop and there are no symptoms of the disease in the standing crop. The disease grains are generally, partially or sometimes wholly converted into black powdery mass enclosed by pericarps of the seed. Freshly harvested diseased grains emit fishy rotten smell. During threshing the pericarp of the diseased grain ruptured and the exposed fungus spores stick to the surface of the healthy seeds which helps in built up of disease inoculum in the field. The flour prepared from seed lot having more than five per cent bunted grains imparts fishy odour, blackish colour of flour and makes it unfit for human consumption. The pathogen is seed as well as soil borne and infection takes place at anthesis stage of the crop by secondary sporadic through wind currents. The disease can be managed by following ways:

- ✓ Seed treatment with Tebuconazole 2 DS @ 1 g kg⁻¹ seed or Thiram @ 2 g kg⁻¹ seed for borne inoculum.
- ✓ Avoid cultivation of highly susceptible varieties like WH 147 and HD 2329 in disease prone areas or infested fields
- ✓ Grow resistant / tolerant varieties i.e. WH 283, Raj 3765, PBW 502, WH 896 and WH912.
- ✓ Follow 2-3 years crop rotation with non-host crop.



Utilizations of Magnetic Water Technology in Agriculture

Kanik Kumar Bansal, Vijay Kumar, Hritik Srivastava and Harpreet Singh

The use of electromagnetic fields (EMFs) in industrial, environmental, and medicinal settings has shown significant promise. Due to the fact that all cells and living things have an electrical origin, EMFs have the ability to interact with all living things and influence their functioning. When carried out under the right circumstances, these modulations can provide beneficial effects like therapy or the induction of compounds' desire-inducing properties. A lot of water is utilised in agriculture each year. Therefore, it is crucial to develop innovative methods for reducing water use. The use of magnetic water technology is one of the innovative tactics. Water production can be increased by magnetic treatment of irrigation water, according to several studies. The MWT has demonstrated encouraging potential for conserving water resources, which will be very important in the near future. MWT has demonstrated a range of potentials in agricultural and environmental applications.

Magnetic Water Treatment in Agriculture

Water molecule clusters made up of many water molecules are weakly attracted in normal or non-MW conditions. This sloppy and disorganised sort of attraction makes it easier for contaminants and poisons to move around inside the cluster of water molecules. Massive sections of these water molecule

clusters are blocked from passing through the cell membrane due to their large structure or the presence of toxins. These disorderly clusters can penetrate the cell due to their reduced size and the fact that some of them carry toxins 11-13. Therefore, a lot of ordinary water is needed to hydrate a plant. Water molecules that have undergone magnetic treatment are reorganised into very tiny clusters, each made up of six symmetrically arranged molecules. Because of the hexagonal configuration of this small, homogeneous cluster, it may readily pass through the openings in the cell membranes of both plants and animals. Furthermore, no harmful substances may penetrate the MW structure. These characteristics make MW a biocompatible substance for both plant and animal cells. MW can be used to boost cattle health, promote seed germination, and enhance agricultural productivity. Studies have shown that using MW for irrigation can increase water productivity, preserving water resources in preparation for the anticipated future global water crisis. Additionally, MW apparently works well at preventing and eliminating scale buildup in water-containment structures and pipelines.

Magnetic Treatment of Irrigation Water

Previous research has demonstrated a number of advantageous impacts of MF treatment on plant

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development. It has been shown that a good external EMF can speed up plant development, especially in terms of seed germination rates. According to reports, broad bean seeds exposed to varying magnetic fields before to planting have a considerable impact on seed germination and seed production. Furthermore, they demonstrated how MF applied to broad bean plants during the growth season might improve the number of pods produced per plant and decrease plant losses relative to area. The usefulness of MFs on the root development of different plants has been shown in several research. Water that has been magnetically treated goes through many physical changes. The soil-water-plant system is also affected in a number of ways by it. At all soil depths, leaching the soil with MW results in a large increase in the amount of phosphorus that is readily accessible. The magnetic susceptibility of nutrients determines how they will behave in a magnetic field.

According to earlier research, there were statistically significant increases in plant yield and water productivity after magnetic treatment that varied according to the kind of plant and irrigation water utilised (kg of fresh or dry produce per kL of water used). In particular, celery production improved by 12 and 23 percent and water productivity by 12 and 24 percent, respectively, following the magnetic treatment of recycled water and 3000 ppm salty water. With recycled water, 1000 ppm saline water, and magnetically treated potable water, respectively, snow pea pod production increa-

sed by 7.8%, 5.9%, and 6.0%.

Advantages for plants

Numerous research have shown that MF treatment increases plant growth and fruit output. Plant growth rate, transplant dry weight, transplant leaf area, and seed germination are a few of the key consequences of magnetic treatment of seeds or irrigation with MW in plants. Applying magnetically treated water boosts water productivity in both agricultural and livestock output, similar to this, several studies have demonstrated that MF treatments increase the blooms and overall fruit output of tomatoes and strawberries. Magnetic treatment also enhances tomato's ability to absorb nutrients.

The weight of the squash rises when it is irrigated with MW. As a result of bio-magnetic water's higher solvent content and lower surface tension, nutrients are absorbed more fully in the liquid. Water treated with a magnetic field or that has passed through a magnetic device is referred to as MW. Some properties of water change when it is magnetised, and these changes can affect how plants grow and produce. It was proposed that MW irrigation may promote seed germination. Similar to this, numerous field experiments have shown that MW irrigation of seeds significantly improves seedling development. Additionally, MW increases maize germination, fresh weight, and shoot length as well as the amount and quality of bean crops. Additionally, a magnetic treatment applied prior to seeding results in more pods per plant and lower

plant losses per unit area. Using the MWT technique, the root development of several plant species can be improved.

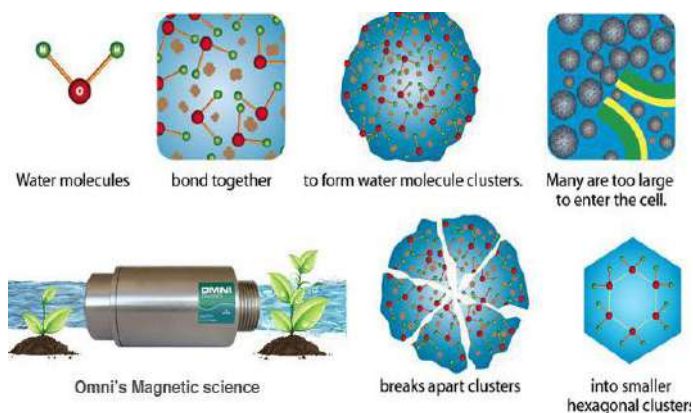
Effects on crop yield

Researchers have concentrated on employing a physical growth stimulation technique to increase crop output since it has no known negative effects on the environment. A possible strategy for stimulating physical expansion is MW technology. Plant qualities, growth, and production can change due to changes in the properties of water treated by the magnetic field. Water may be conserved for irrigation by using MW. The seed germination rate can be improved via MWT. Growth characteristics, potassium, GA3, kinetin, nucleic acids (RNA and DNA), photo-synthetic pigments (chlorophyll a & b and carotenoids), photosynthetic activity, and translocation efficiency of photo-assimilates are some of the parameters that are modulated by MW irrigation and are related to crop yield. Numerous studies have demonstrated the increase in water productivity in agricultural and animal output, number of blooms, and total fruit yield for various crops, including strawberries and tomatoes. Weak MF can cause metabolic system changes, including Ca^{2+} homeostasis in root cells, as well as an increase in the size and volume of mitochondria. One significant benefit of MF treatment is that it lessens the effects of heat stress on several seedlings, including cress.

Conclusion

MWT has made new agricultural research

opportunities possible. The key benefits of this technology are safety, compatibility, simplicity, environmental friendliness, minimal running costs, and no known negative consequences. Some of the stated advantages of MWT in agriculture include increases in irrigation water quality and quantity, crop yields and quality, soil enhancement, scale prevention/elimination in water-using systems, and water savings. Additionally, MF treatments have demonstrated positive benefits on seed germination, plant growth and development, fruit ripening, and agricultural production. The key issue in MW uses in agriculture is effective irrigation component integration, including developing pumps that are acceptable for the technical and practical needs of magnetic MWT systems. Additional controlled laboratory and field investigations are required to clarify the precise mechanism of activities of MWT in producing physical and electrochemical effects. There haven't been many research done on the impact of irrigation water treated with magnets on plant growth, agricultural yield, and water use. In order to overcome the field obstacles and learn more about the MWT's mechanism of action, more field and laboratory research are also required.



Sustainable Farming through Drone Technology

Jinendra Birla and Dr. Santosh Pandey

Overview of the agricultural industry in India

The service sector is declared to be the most substantial contributor to India's GDP. Our country reigns the world as the most prominent producer of pulses, milk, rice, wheat, sugarcane, spices, etc. These also add generous value to the economy with their activities in the agrarian sector. The Indian agricultural sector contributes a tremendous 18% to India's GDP (Gross Domestic Product). It is considered the prime source of livelihood for approximately 58% of the country's population, mainly for rural areas. Indian agriculture sector, along with forestry and fishing, results in a Gross Added Value of around Rs 18.55 lakh crore (US\$265.51 billion) as of 2019. The agricultural sector expands with parallel industries at a growth rate of 2.1% (2019-20).

Regardless of Indian agriculture's contribution to the GDP, our country is yet to enhance productivity and efficiency in the sector to reach the highest potential. Several dimensions and concerns need to be identified, supported, and equipped with resolutions. Unsuitable methods for monitoring crops, water irrigation, using pesticides, and many other necessary farming activities are

currently adopted. Resources are inadequate, not allotted according to weather conditions, or have not been exploited to their maximum potential a reason why there is often a decline in the Return on Investment (ROI).

These hindrances have granted multiple opportunities for growth and development in the world of technology. The influence of technology in the agricultural sector has been invariably positive since its commencement. As governments and businesses across the country recognized the significance of food security and the consequences of environmental degradation, pollution, and water scarcity, the urgency to overcome certain obstacles arose.

Why adopt agricultural drones?

Drone technology has gotten most of the recognition in the industry because of its diversity and considered the future for the agrarian community. The military initially used them. However, other sectors quickly embraced unmanned aerial vehicles (UAVs) when they learned about its widespread applications.

How can drones support Indian agriculture?
Drones don't merely enhance overall performance

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but also encourage farmers to solve other assorted barriers and receive plenty of benefits through precision agriculture. With the market for agricultural drones reaching a whopping \$1.3 billion, UAVs (unmanned aerial vehicles) fill the gap of human error and inefficiency by traditional farming methods. The purpose of adopting drone technology is to exclude any guesswork or ambiguity and instead focus on accurate and reliable information.

External factors like weather, soil conditions, and temperature play a critical role in farming. Agriculture drone empowers the farmer to adapt to specific environments and make mindful choices accordingly. The gained data helps regulate crop health, crop treatment, crop scouting, irrigation, and carry out field soil analysis and crop damage assessments. The drone survey helps boost crop yields and minimize time and expenses.

According to experts, the predicted world population will be 9 billion by 2050. Agricultural consumption is also said to increase simultaneously by nearly 70%. Drone technology, equipped with artificial intelligence (AI), machine learning (ML), and remote sensing features, are rising in demand because of its advantages. The central government has acknowledged the importance of unmanned aerial vehicles (UAVs), machine learning, and artificial intelligence with their 'Digital Sky Platform' online. Drone startups in India have used this opportunity to accomplish better technological capacities.

How does drone technology work?

Only after complete recognition of drones characteristics can one gain in-depth knowledge about agriculture drones. Typically, drones include a navigation system, GPS, multiple sensors, high-quality cameras, programmable controllers, and tools for autonomous drones. The DJI is one such familiar drone utilized by the industry. Most farmers currently use satellite imagery as an introductory guide for farm management. Furnished with modern technology, Unmanned aerial vehicles (UAVs) can get more precise data than satellites for precision agriculture. They then process the data captured into agri-tech software to produce beneficial knowledge.



Drone Technology

Capturing data from agriculture drone takes place as in the following stages

(1) Analyzing the area: This identifies the territory being tested. Therefore, the first step includes establishing a boundary, analyses of the area, and then finally, uploading the technical GPS information into the drone's navigation system.

(2) Using Autonomous Drones: Since Unmanned aerial vehicles (UAVs) are independent, they enter flight patterns into their already established system to collect required data.

(3) Uploading the data: After capturing all the required data through sensors such as the multispectral sensor/RGB sensor, it is processed through numerous software for further analysis and interpretation.

(4) Output: After collecting the data, they format it so that farmers can understand the data with no hassle, bringing them a step closer to precision farming. 3D mapping or Photogrammetry are popular methods to display extensive data collected.

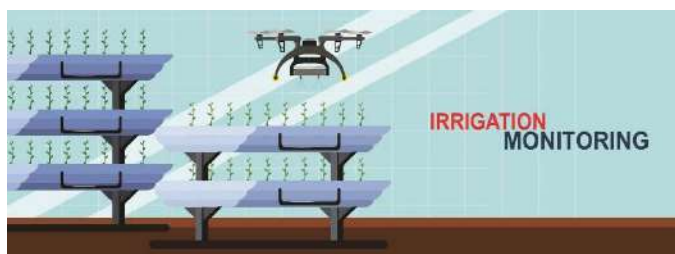


Data processing

Best drone practices

(1) Irrigation Monitoring

Drones, including hyper spectral, thermal, or multispectral sensors, recognize areas that are too dry or need improvement by the farmer. Drone survey helps improve water efficiency and disclose potential pooling/leaks in irrigation by providing Irrigation monitoring yields calculations of the vegetation index to help realize the health of crops and emitted heat/energy.



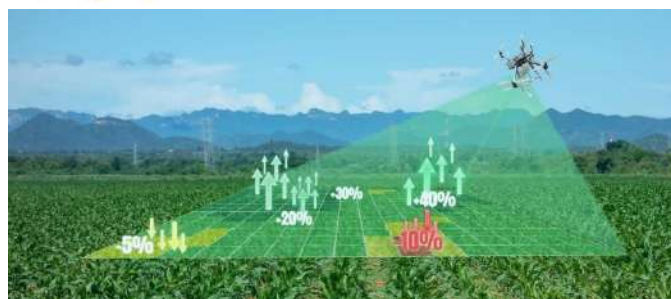
Irrigation monitoring

(2) Crop Health Monitoring and Surveillance

It is crucial to track the health of the vegetation and spot bacterial/fungal plagues in the early stages. Agriculture drones can see which plants reflect different amounts of green light and Near-infrared spectroscopy (NIRS) light. This data helps produce multispectral images to track crop health. Quick monitoring and discoveries of any defects can help save crops. In circumstances of crop failure, the farmer can also document the damages for accurate insurance claims.

(3) Crop Damage Assessment

Agricultural drones fitted along with multispectral sensors and RGB sensors also detect field areas inflicted by weeds, infections, and pests. According to this data, the exact amounts of chemicals needed to fight these infestations are known, and this helps diminish the costs inflicted by the farmer.



Crop damage assessment

(4) Field Soil Analysis

The drone survey allows farmers to obtain information about their land's soil conditions. Multispectral sensors allow seizing data useful for seed planting patterns, thorough field soil analysis, irrigation, and nitrogen-level management. Precise Photogrammetry/ 3D mapping permits farmers to

analyze their soil conditions thoroughly.

(5) Planting

Drone startups in India have invented drone-planting systems that allow drones to shoot pods, their seeds, and crucial nutrients into the soil. This technology doesn't only reduce costs by almost 85% but also increases consistency and efficiency.

(6) Agricultural spraying

Through drone crop spraying, human contact with such harmful chemicals is limited. Agri-drones can carry out this task much quicker than vehicles/airplanes. Drones with RGB sensors and multispectral sensors can precisely identify and treat problematic areas. Professionals say that aerial spraying is five times faster with drones when compared to other methods.



Pesticide spraying

Livestock tracking

The drone survey allows the farmers not to keep track of their crops only but also monitor the movements of their cattle. Thermal sensor technology helps find lost animals and detect an injury or sickness. Drones can carry out this function favourably, and this adds comprehensively to the production of vegetation.

Benefits of Drone Technology

As innovators introduce new technologies, their commercial uses increase day by day. The government has been easing restrictions for drone usage and is supporting startups to come up with novel ideas. As drone surveys become more common, they also become more cost-effective. In agriculture, they have a plethora of advantages. Some are as follows:

Enhanced Production: The farmer can improve production capabilities through comprehensive irrigation planning, adequate monitoring of crop health, increased knowledge about soil health, and adaptation to environmental changes.

Effective and Adaptive Techniques: Drone usage results in regular updates to farmers about their crops and helps develop strengthened farming techniques. They can adapt to weather conditions and allocate resources without any wastage.

Greater safety of farmers: It is safer and more convenient for farmers to use drones to spray pesticides in terrains challenging to reach, infected areas, taller crops, and power lines. It also helps farmers prevent spraying the crops, which leads to less pollution and chemicals in the soil.

10x faster data for quick decision-making: Drone surveys back farmers with accurate data processing that encourages them to make quick and mindful decisions without second-guessing, allowing farmers to save the time invested in crop scouting. Various sensors of the drone enable capturing and analyzing data from the entire field.

The data can focus on problematic areas such as infected crops/unhealthy crops, different colored crops, moisture levels, etc. The drone can be fixed with several sensors for other crops, allowing a more accurate and diverse crop management system.

Less wastage of resources: Agri-drones enables optimum usage of all resources such as fertilizer, water, seeds, and pesticides.

99% Accuracy rate: The drone survey helps farmers calculate the precise land size, segment the various crops, and indulge in soil mapping.

Useful for Insurance claims: Farmers use the data captured through drones to claim crop insurance in case of any damages. They even calculate risks/losses associated with the land while being insured.

Evidence for insurance companies: Agricultural insurance sectors use Agri-drones for efficient and trustworthy data. They capture the damages that have occurred for the right estimation of monetary payback to the farmers.

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Humic Acid

Kanik Kumar Bansal, Tashfeen Ajmal Natnoo, Faraaz Farooq and Bhart

Up to 80% of soil organic matter is comprised of humic compounds. The most common elements in humic compounds are carbon, oxygen, hydrogen, nitrogen, and sulphur. There are three types of humic compounds, based on their solubility: fulvic acid, humic acid, and humin. Humic and fulvic acids are soluble in sodium hydroxide, but not humin. The humic material mixture is treated with acid after it has been solubilized in sodium hydroxide, which solubilizes the fulvic acid portion and precipitates the humic acid portion.

Humic acids are the most prevalent naturally occurring organic compounds on the planet, and they are sometimes referred to as the “most crucial component of a good productive soil”. In alkaline conditions, humic acids are water soluble, but not in acidic conditions (Pettit, 2004). Carbon rings make up about 35% of the very varied structure of humic acid, with the balance being made up of carbon chains. Humic acids are made up of 53.8-58.7% carbon, 32.8-38.3% oxygen, 3.2-6.2 percent hydrogen, 0.8-4.3 percent nitrogen, and 0.1-1.5 percent sulphur in most cases.

Under acidic, neutral, and alkaline circumstances, fulvic acids are water soluble. Fulvic acids have more than twice the capacity of humic acids in terms of cation exchange.

Fulvic acids are smaller than humic acids or humins, making them easier to penetrate plant roots, stems, and leaves. Fulvic acids are “the most efficient carbon-containing chelating chemicals known” and are frequently used in foliar plant treatments. Regardless of the pH of the solution, the humin component of humic compounds is insoluble. Humin has the highest molecular weight of any humic molecule and is exceptionally resistant to decomposition. The presence of humin in the soil improves the soil's water holding capacity.

Composts, coal, and peat are used to make commercially available humic compounds. They come in two different forms: liquid and granular. Humic compounds in liquid form are applied to the soil or to the foliage of plants. Humic compounds in the form of granules are put to the soil's surface or integrated into the soil. Liquid application rates range from 0.4 to 12 litres per acre. The recommended granular application rate is 22-357 pounds per acre.

Although laboratory research suggest that the addition of humic compounds may boost nutrient absorption, field investigations have had mixed results. The molecular size of the humic material used, as well as other parameters, may influence the magnitude of the impact on nutrient uptake.

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The application of humic compounds with the lowest molecular size had the greatest influence on plant nitrate uptake, according to a 1992 study. The small size of humic acid molecules “allows them to reach the plant plasma membrane, where they efficiently impact nutrient digestion”.

Humic acids were recovered from two commercial products made from peat and leonardite sources, called CP-A and CP-B, respectively, in a 1998 study). The uptake of nitrogen, phosphate, and iron by tomato plants increased when humic acids from peat and leonardite sources were added to hydroponic solutions. The administration of humic acid in solid and liquid forms had no significant impact on the nutritional content of strawberry plants growing in calcareous soil in a greenhouse trial). The uptake of copper, zinc, and manganese was statistically significant after foliar application of 0.1 percent and 0.2 percent humic acid solutions to maize cultivated in calcareous soils). Humic acids derived from vermicompost were given to planting medium at rates ranging from 250 to 1000 mg kg⁻¹ in a study conducted in 2006. “In general, plant growth rose in response to humic acid treatments of 50-500 mg kg⁻¹, but dropped dramatically when humic acid concentrations in the container medium approached 500-1000 mg kg⁻¹”. When humic acid was sprayed to cucumber plants in field research, it resulted in improved plant growth and fruit yield.

Positive effects from the addition of humic acids on root growth have been discovered as early as 1950. Maize root length and number doubled

when 4-5 mg L⁻¹ humic acid was added to the solution in which it was cultivated, compared to corn produced in a solution without humic acid. Increased root elongation in germinating maize seed was linked to “interaction between plant hormones and a humic chemical treatment” in a 2008 study. Humic acids were recovered from two commercial products made from peat and leonardite sources, called CP-A and CP-B, respectively, in a 1998 study.

When compared to the control, tomato plants treated with CP-A (from peat) demonstrated statistically significant increases in root growth. When compared to the control, tomato plants treated with CP-B (from leonardite) demonstrated statistically significant increases in root and shoot growth. Root growth was found to be more affected than shoot growth in this investigation. Cucumber, wheat, maize, and pepper shoot growth have all increased in other trials.

Humic acids derived from vermicompost were applied to planting medium at rates ranging from 250 to 1000 mg kg⁻¹ in a 2006 study. The dry weight of marigold and pepper roots produced in the planting medium increased statistically significantly. Humic acids derived from vermicompost boosted root growth in banana, strawberry, and cowpea plants in previous tests.

In comparison to the untreated control, the treatment of humic compounds to creeping bentgrass resulted in a 26 percent increase in root mass in the top 10 cm. When humic compounds were applied, root masses grew at depths more than 20 cm, compa-

red to the untreated control (Cooper, 1998). In comparison to the untreated control, the application of granular humic compounds resulted in a larger maximum root length. When granular humate was put into the growing media rather than applied to the leaves, it resulted in greater root mass. This “may have been due to granular humate and its breakdown products coming in more direct touch with roots than humic acid treatments applied to foliage,” according to the researchers.

Humic acids derived from vermicompost were applied to planting medium at rates ranging from 250 to 1000 mg kg⁻¹ in a 2006 study. The fruit weights of tomatoes produced in the planting medium increased statistically significantly. There was also a statistically significant increase in the number of strawberries and pepper fruits growing in the planting medium. The researchers concluded that “humic acid had a similar effect on pepper plants similar to the effects of a plant growth regulator” because the number of flowers and fruits observed in peppers grown in the humic acid supplemented planting medium did not differ significantly from peppers grown in a planting medium supplemented with a plant growth regulator.

Fruit hardness, fruit length, and fruit diameter were not significantly affected in greenhouse research in which peppers were treated with soil and foliar humic acid treatments. The average fruit weight, sugar content, and sugar content have all increased significantly.

After applying humic acid to the soil and the leaves, a higher production of peppers was observed. The quantity of fruits per okra plant increased considerably in greenhouse research using humic acid in addition to the recommended fertiliser regime. There was no significant increase in the number of fruits per okra plant when the recommended fertiliser regime was reduced by 50% and humic acid was administered.

Humic compounds added to soils can have significant effects on the physical, chemical, and biological aspects of the soil. Organic matter, such as humic compounds, improves soil aggregation, water retention, infiltration rate, and water-holding capacity by increasing soil aggregation, water retention, and infiltration rate. “Adding humic compounds to soils with a variety of texture grades and mineral suites has been found to improve aggregation”. The effect on aggregation appears to be different depending on the source of the humic chemicals used. The quantity of tiny aggregates (1000 mm) increased when sandy and clay soils were treated with a peat- extracted humic material. The quantity of big aggregates (1500-2500 mm) increased when sandy and clay soils were treated with a manure- extracted humic material. High infiltration rates are promoted by aggregation, which reduces runoff and erosion. The application of humic compounds has an effect on the soil's cation exchange capacity. “Humus is responsible for 50 to 90% of the cation-absorbing capacity of mineral surface soils.

Humus colloids, like clays, store nutritional cations (potassium, calcium, magnesium, and so on) in an easily exchangeable state that plants may utilise but that is not easily leached out of the profile by percolating waters”. Humic compounds improve soil fertility through influencing the makeup of microbial communities from a biological standpoint.

Humic compounds offer potential for commercial crop development in laboratory tests; however, the level of beneficial crop response is difficult to predict. Field research has yielded mixed outcomes so far. Humic chemicals can affect plant development and soil characteristics, but the extent of the effect is determined by a number of factors, including the humic substance's source, plant species, application method, and soil type. The efficacy of humic compounds is also determined by how similar the applied components are to humic substances found in natural soil, which is influenced by the material's origin and processing procedures. We will have a better knowledge of how applied humic chemicals affect the environment with more field study.

A Sustainable Approach to Integrated Farming

Umesh Kumar Singh, Yashvant Singh, Hritik Srivastava and Dr. Pawan Kumar Goutam

Farmers struggle to make a living all across the world. Small farmers, however, found it challenging to make a living. They receive fewer rewards once they have paid for all of their inputs (seeds, animal breeds, fertilizers, pesticides, energy, feed, labor, etc.). Farmers have been able to create a different model to increase the viability of increasing their income from small farms thanks to the advent of integrated farming systems. To ensure that there is enough food for the growing population, modern technologies have been extensively deployed to raise production per acre of land.

The term “integrated farming system” refers to agricultural systems that combine the production of both fish and cattle as well as crops, and it is also frequently referred to as an “integrated bio-system”. The “waste” from one component of the farming system becomes an input for another component through the employment of an interrelated set of farming-related activities known as integrated farming. Thus, productivity and income are increased while input costs are decreased. In an integrated farming system, a farmer uses trash as a resource.

By doing this, they not only reduce waste but also guarantee an overall rise in production for the entire farming system. The goal of integrated farming is to mimic the way that plants and animals, including fish, birds, and other aquatic life, are used in nature to produce food.

The basic principle is to enhance the ecological diversity by integrated farming:

- ✓ Farmers can preserve ecological diversity by selecting the right cropping methodology using mixed cropping, crop rotation, crop combination, and intercropping so that there is less use of water, nutrition, and space, as well as by implementing eco-friendly practices.
- ✓ Farmers can adopt integrating subsystems by which the various components interact favorably, resulting in an increase in overall farm productivity.
- ✓ Farmers can use a multi-story arrangement to make the most of the entire available area and to ensure that there is a high level of interaction between biotic and abiotic components.

The integrated farming system is also a sustainable system which focuses on increasing farm

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productivity by increasing diversification, resource integration and creating market linkages. Thousands of small and marginal farmers in resource-poor regions have converted their farming to this sustainable farming system to diversify farm production, increase income, and improve the quality and quantity of food produced. It usually takes three to four years to establish a well-integrated farm with market linkages to ensure nutrition and the livelihood of a family.

Importance of integrated farming

- ✓ The integrated farming system brings a change in farming practices for optimum crop output and guarantees the best use of the resources available.
 - ✓ Used an integrated system to recycle farm waste for useful applications.
 - ✓ The farming operations can grow with the right combination of agriculturally linked businesses, such as dairy, poultry, piggery, fisheries, sericulture, etc., tailored to the specific agro-climatic conditions and socio-economic situation of the farmers.
 - ✓ One of the most significant advantages of an integrated farming system is increased productivity. Increased productivity is defined as yield improvements per unit area per unit of time as a result of crop and related agricultural enterprise intensification.
 - ✓ As productivity rises, so does the profitability factor. This is due to the fact that by recycling farm trash, we are employing the waste product or by-product of one enterprise as an input into another farming enterprise. One of the key advantages of an integrated farming system is the adoption of new technology.
 - ✓ Large farmers have the resources to easily adopt technologies. Small farmers typically lack funding, however. However, because of the integrated agricultural system, they have the chance to boost their farming profits and adjust to new technology.
 - ✓ Environmental Safety is ensured in integrated farming. How? As farmers are using the waste material of one enterprise as input into the production function of other type of enterprise, so waste pollution is minimized and hence environmental safety is ensured.
 - ✓ Fight against Deforestation can win by integrated farming. Planting timber and fuel wood along with the crops in field not only utilizes the free space of land but also supply wood for many purposes. Hence pressure on natural forests can be reduced and natural ecosystem is preserved.
 - ✓ Few other benefits are: Promotion of agro-industry, increased input efficiency, and cost minimization for input use, increased employment, fodder security for livestock, recycling, continuous income round the year, energy saving.
- Many farmers all over the world are implementing the integrated farming system, which uses techniques that take into account both current

and future climatic conditions, soil characteristics, population eating habits, and estimates the future food requirements of the constantly expanding human and animal population. The improved farming techniques used in the new integrated practices include crop rotation, zero tillage, integrated nutrient management, site-specific nutrient management, conservation technology, use of bio-fertilizers, and farm management. In order to mitigate global warming and improve food security, contemporary farming techniques can be adopted.



Scientific Cultivation of Pigeon pea (*Cajanus cajan* L.)

Umesh Kumar Singh, Yashvant Singh and Hritik Srivastava

Introduction

In the family of leguminous plants, the pigeon pea is a perennial pulse crop. Domestication began at least 3500 years ago on the Indian subcontinent. In India, behind chickpea, it is the second-most significant pulse crop. 100 g of pigeon peas have the following nutritional value: 335 calories worth of energy, 22.3 grams of protein, 1.7 grams of fat, 7.3 grams of calcium, 5.8 grams of iron, and 132 micrograms of vitamin A.

Area and distributions

In India regarding pigeon pea the current senerio is followings:

Area (Million ha)	Production (Metric tons)	Productivity (kg ha ⁻¹)
4.80	4.28	892

State wise distribution of pigeon pea

State	Area (M ha)	% to all India area	Production (Metric tons)	% of all India Production	Productivity (kg ha ⁻¹)
Maharashtra	1.24	25.74	1.28	29.87	1035
Karnataka	1.63	33.96	1.24	28.90	759
Telangana	0.43	8.91	0.33	7.77	778
Uttar Pradesh	0.30	6.16	0.29	6.83	988

Source: Directorate of Economics and Statistics

Climate: Pigeon peas are mostly an Indian crop grown in semi-arid tropical climates, hence climate is an important factor in their production.

Soil: Black cotton soil that is well-drained and has a

pH between 7.0 and 8.5 is the best type.

Package & Practices

Selection of Varieties

According to soil, climate are particular region may be recomendade followed varieties.

Variety	Type of varieties	Time of Maturity (Days)
Prabhat	Extra early	110-120
Upas 120	Short duration	110-120
ICPL11249	Super early	<100
ICPL 332 WR	Extra early	120-130
ICPL14003 (PRG 176)	Extra early	130
IPA 203 (Bahar x Ac)	Hybrid	160-170

Land Preparation: It is necessary to deep-ploughing with a soil-turning plough, harrow with two to three discs and then plank the ground without weeds.

Seed & Sowing

Selection of seed: Seeds must be free of physical contamination, weed seeds, insect pests, illnesses, and other pests.

Seed treatment: Fungicides: Tricoderma viridie 5-7 g kg⁻¹ of seeds or Thiram @ 3 gm and Culture: 20 g kg⁻¹ of seeds of Rhizobium and PSB culture.

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Seed rate: 12-15 kg ha⁻¹ is adequate in pure standing crops and in mixed cropping, where seed rates are modified based on the percentage of companion crops and arhar.

Geometry: 60-75 x 15-20 cm or according to kinds and the growth season, should be planted row to row.

Depth of seeds: No more than 5 to 6 cm of seed should be sowed.

Time of sowing: the end of June or the beginning of July, when the monsoon season begins.

Methods of sowing: Drilling should be used to sow seeds in a row, using a ferti-cum-seed drill (The application of fertilisers and seed sowing at a time). Or experimenting to keep your plant standing at its best and increase productivity.

Nutrients Management

Manure: Before a month has passed since sowing, apply 5 to 10 tonnes of well-rotten FYM.

Fertilizers: Fertiliser should be applied based on soil test report and recommendations.

Rained	15 kg N	25 kg P ₂ O ₅	15 kg K ₂ O	5 kg S	3 kg Zn ha ⁻¹
Irrigated	25 kg N	50 kg P ₂ O ₅	25 kg K ₂ O	20 kg S	5 kg Zn ha ⁻¹

To be most efficient, fertiliser should be placed on the soil at the base or as a sideband before sowing.

Cropping system

- ✓ Pigeon pea + Urd + wheat
- ✓ Maize + Pigeonpea
- ✓ Pigeonpea + Sugarcane

Water management

- ✓ Three irrigations are required in cases of severe drought.
 - a) 1st at branching stage
 - b) 2nd at flowering stage and
 - c) 3rd at the time of podding stage.

Weed management

- ✓ One mechanical weeding is performed between days 20 and 25 and the other between days 45 and 50 after seeding. Pendimethalin (Stomp ® *a.i.* 1.0-1.5 kg ha⁻¹) and metachlore (Dual ® *a.i.* 1 kg ha⁻¹) are the other pre-emergence herbicides. At the 2-4 leaf stage, flausifop-P butyl (Fusilate ® *a.i.* 0.2-0.4 kg ha⁻¹) is the post-emergence herbicide that is advised.

Diseases & Their Management

1. Wilt C.O. *Fusarium oxysporumf. sp.* Udu

Control: Grow resistant varieties like Amar, Azad, Asha (IPCL - 87119), Maruthi, C-11, BDN-1, BDN - 2, NP - 5, JKM – 189, BDN - 2 etc.

2. Sterility Mosaic C.O. Sterility Mosaic Virus

Control: Grow resistant varieties like Pusa - 885, Asha, Sharad (DA11), Narendra Arhar1, etc.; squirt Fenazaquin 10 EC (Magister) @ 1 ml litre⁻¹ of water on 45 and 60 DAS.

3. Cankers C.O *Dilopdia cajani*, *Collectotrichum cajani* and *Macrophoma cajanicola*

Control: Crop rotation and 2.5 kg ha⁻¹ Mancozeb 75%WP spray were then done.

Insect-Pest and Their Management

1. Pod borers: Nature of damage: After hatching,

the larvae eat on delicate leaves, twigs, and pods.

Control: use of a 12 ha⁻¹ pheromone trap for *H. armigera*. Additionally, the caterpillars are manually picked up and obliterated in kerosene oil.

2. Tur Pod fly: Damage of a more serious nature was done to pigeon pea. The symptoms are obvious and distinct and are evident on the seed's surface where the larvae feed.

Control: To control the insect population, spray 5% Neem seed kernel extract (NSKE) at the halfway point of the blooming cycle.

3. Pod-Sucking bugs: Damaged seeds have a shrivelled appearance, black spots, and green pods that have shed.

Control: it is possible to hand-pick and eliminate immature bugs. Spraying aromatic plant extract (e.g. gums, lantana and Neem-based pesticides).

Harvesting

In pulses, the pod shattering is a frequent issue. So when the pods are fully developed and two-thirds to three-quarters of the pods turn brown, the crop should be picked with a sickle (about 75-80 percent).

Yield

Pigeon pea can produce 25 to 30 q ha⁻¹ under irrigation and 15 to 20 q ha⁻¹ without irrigation with the adoption of enhanced agronomic package-practices. Early and very early types produce 20-30% less than late varieties.

Micro Irrigation's Importance in Modern Agriculture

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Introduction

Utilizing water in agriculture is crucial for crop production and lowering the danger of drought. The percentage of water used for agriculture worldwide is around 70%. The world's largest consumer of fresh water, irrigation is under pressure to improve its efficiency. Due to climate change, rising population, unsuitable irrigation practices, and competition from other commercial and environmental purposes, this is made worse as water supplies become more limited. It will be even more crucial in the future to use water more efficiently for food production. In the future, water usage in towns and industries will rise while falling for agriculture.

According to FAO, more effective irrigation water usage is required to boost irrigation's contribution to food production. The fact that water-saving technology, in particular drip irrigation, may boost yields and slow salinization is a significant benefit. Furthermore, brackish water may be utilized with either approach for crops that are not very sensitive to salinity because neither method brings water into touch with the leaves.

Micro-irrigation, which is the precise distribution of water on or below the soil surface at low pressure using small devices that spray, mist, bubbler, sprinkler, or drip water, is becoming more

alluring in light of irrigation efficiency and environmental concerns. Micro-irrigation has been widely used in recent decades as a consequence of rising sales and technological advancements. A typical type of micro-irrigation is drip irrigation. According to irrigation data, the number of acres irrigated using drip irrigation has increased quickly throughout several nations.

In under developed nations, a number of governmental and non-governmental groups are actively pushing micro-irrigation. Given the importance of agriculture to India's economy, the government places a high priority on investing in irrigation infrastructure and managing irrigation within the framework of integrated water management. As a result, pressured irrigation systems have been used more often recently in India. The pressurized irrigation systems' total investment cost has been covered to a 50 percent extent by the Ministry of Food, Agriculture, and Livestock.

This article discusses how micro irrigation affects the sustainability of soil, water, and contemporary agriculture.

Use of Micro-irrigation for Agriculture

(i) Effect of Micro-irrigation on crop yield and water saving

When compared to other irrigation techniqu-

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es, micro-irrigation may use less irrigation water. Less water is evaporated as a result of the smaller wetted area. There is virtually little surface drainage in these systems.

In comparison to traditional irrigation techniques, micro irrigation offers a steady supply of water in the crop zone and has been shown to boost crop output and water usage efficiency. In many situations, such as the watering of most vegetable crops, cotton, sugar cane, orchard and vineyard crops, drip irrigation has the potential to at least quadruple crop production per unit of water. According to a compilation of study findings from multiple Indian research institutes, drip irrigation often leads in water consumption reductions of 30-60% and yield improvements of 20-50% for a range of crops, including cotton, sugarcane, grapes, tomatoes, and bananas. According to some experts, switching from traditional surface irrigation to drip irrigation in India enhanced water production overall for a variety of crops, including banana, cotton, sugar cane, and sweet potatoes, by 42-255 percent. Micro-irrigation is being more widely employed as a solution to combat water shortage and poverty as a result of its high water usage efficiency. Farm productivity (crop production and output) increases along with farmer income and food security. Early harvests result in lower labour expenses. Drip-irrigated crop quality improvements have also been noted.

(ii) Environmentally Effects of Micro-Irrigation on Soil and Water Resources

The ability of the system to utilise water with a rather high salt content is another important benefit of micro-irrigation systems. Additionally, both treated and untreated wastewater can be used in a way that only targets acceptable crops. Because micro-irrigation does not produce aerosols or cause wastewater to come into contact with plant leaves, it is a better irrigation technique than other irrigation methods for the reuse of wastewater. Additionally, there are less issues with drainage, ponding, and odours. In addition, studies suggest that the nitrogen present in wastewater is better absorbed by plants and less likely to pollute ground water when applied directly to plant roots. When utilizing wastewater with micro-irrigation it is vital to guarantee that emitters do not clog. To guarantee a consistent application and complete operation, the system must be carefully monitored.

Contrarily, as compared to traditional irrigation, micro irrigation adds far less salt to the soil. By properly managing the micro irrigation systems, it is possible to keep the root zone moisture content close to field capacity throughout the growing season, creating a level of water and air balance that is almost optimal for plant development. Micro-irrigation can have a considerable impact on soil salinization during the dry season in humid locations or in arid climates. Additionally, there are no drainage issues. In addition to these indirect, societal benefits of drip irrigation, listed a few further direct, private benefits to adopters: Because water percolates only to a shallow depth in the soil, fertili-

ser and pesticide residues do not mix with the water table, which decreases soil erosion and non-point pollution. It also encourages more effective nutrient usage and better, longer moisture retention in the root zone.

Limitations in Micro-Irrigation

Despite the fact that technical advancement and simplicity have decreased the total cost of micro-irrigation systems, farmers still face high costs associated with the technology. Additionally, for effective system design, maintenance, and maximum efficiency, a high level of technical ability is needed. Farmers will find this technology more and more alluring as costs, labour requirements, and eases in system design and installation are all progressively reduced.

Small farmers in underdeveloped nations have been sluggish to embrace microirrigation systems due to the large initial expenditure needed to start using them or transition from traditional irrigation methods. The crop specificity linked to the existing micro-irrigation technology, as well as a lack of resources and experience, further lessen its appeal.

Micro-irrigation has the potential to benefit from the application of nanotechnology and biotechnology, notably in terms of improving water quality, filtering methods, and reducing emitter clogging. Soil fragments, organic debris, algae, bacterial slime, and chemical precipitates can all quickly block the microscopic apertures. These systems thus need very effective filtration.

Nanomaterial-based biosensors have the capacity to function on-site, in real time, and can identify, quantify, and monitor the presence of pollutants. Saline and poor-quality water can be used in micro-irrigation systems. However, during extended dry seasons, salt may build up at the boundaries of the wetted zone, which might cause a problem. These salts may be washed into the root zone by a little rain, which might harm the plants. An extra irrigation system (sprinkler or surface) may be required in dry areas when the annual rainfall is less than 250 mm in order to remove salt accumulation from the soil in between growing seasons.

Conclusions

Micro-irrigation has been especially effective for agricultural, horticultural, decorative, and landscaping applications. It has been used in a variety of topographical circumstances and climates, from humid to arid and semi-arid locations. Its benefits in terms of reduced labour requirements, improved fertiliser application, decreased salinization rates, eradicated wood and disease, and greater yields are widely known. The number of acres covered by micro-irrigation has increased as a result of improvements in emitter and dripper technology, the creation of low-cost sand and screen filters, the introduction of drip tape, and other factors.

Applying drip irrigation technology to the production of cereal crops is a substantial difficulty, especially in underdeveloped nations. There are a number of social, technological, and institutional

obstacles that must be addressed in different regions of the world. Accelerating education and knowledge transmission is necessary. Utilizing micro-irrigation devices will thus be crucial for the sustainability or conservation of soil and water resources.



Nutrient Management in Horticultural Crops

Moomal Bharadwaj and Dr. Vinod Yadav

Abstract

India has a wide variety of climate and soil on which a large range of horticultural crops such as fruits, nuts, vegetables, root tubers, palms, spices, cashew, cocoa, ornamental crops, and medicinal and aromatic plants are grown. The policymakers have realized that the horticultural crops need promotion for achieving sustainability of smallholdings, crop diversification, increasing employment, providing an enormous export potential, improving the environment, and more than anything achieving nutritional security. As a result, horticulture has received due emphasis during the last few decades. Due importance of nutrients is essential as these affect the productivity, quality, and profitability of horticultural crops. To obtain desired yields in horticultural crops sufficient amounts of readily available essential plant nutrients need to be supplied to the plant. Soil nutrients, like all agricultural inputs, need to be managed properly to meet the fertility requirements of horticultural crops. Appropriate nutrient management practices for horticultural crops vary widely due to cropping, topographical, environmental, and economic conditions. With the variety of factors complicating the fertility management in horticultural crops, it is nearly impossible to recommend a single set of best management practices uniformly to all horticultural farms. Nutrient management practices for maintaining or improving farm profitability must be tailored to the unique conditions of individual farms. Several options for improved nutrient management are available for horticultural crops and are discussed in this paper.

Introduction

Nutrient management is the process of utilizing agricultural nutrients as effectively as possible to increase productivity while safeguarding the environment. The fundamental premise of nutrient management is to balance soil nutrient inputs with crop demand.

Nutrient management is the science and art of linking soil, crop, weather, and hydrologic factors with cultural, irrigation, and soil and water conservation practices to maximize nutrient use efficiency, yields, crop quality, and economic returns while reducing off-site transport of nutrients that may have an impact on the environment.

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Fertilizer management, particularly in horticultural crops, is the skillful process of matching a specific field, soil, climate, and crop management circumstances to rate, source, time, and place of nutrient administration often referred to as the 4R nutrient stewardship. Some important factors that need to be considered when managing nutrients include

- (a) the application of nutrients seeing crop quality and achievable optimum yields;
- (b) Application, timing, and management, of nutrients, using a budget based on all sources and sinks active at the site; and
- (c) the management of soil, water, and crop to minimize the off-site transport of nutrients from nutrients leaching out of the root zone, surface runoff, and volatilization (or other gas exchanges). Because of variances in nutritional paths and dynamics, there may be possible interactions. Practices that limit off-site surface transport of a certain nutrient, for example, may increase leaching losses of other nutrients. These complex processes place nutrient managers in the challenging position of combining soil, crop, weather, hydrology, and management methods to establish the optimal balance for increasing profits while contributing to the protection of our biosphere.

Soil Sampling and Testing

For soil testing to be expressive, the soil sample must be representative of the root zone of a

field/plot for which the fertility evaluation is desired. Proper soil sampling saves time, energy, and money. Soil testing helps in the formulation of recommendations for cost-effective nutrient management practices among farmers. In its simplest form soil testing means a measure of available nutrients during the immediate growing season in terms of the degree of sufficiency, deficiency, or toxicity and of correction if any to grow a crop of desired yield and quality. However, soil testing is normally performed (i) when new crops are proposed to be grown on land; (ii) to monitor soil fertility to grow crops at the desired level of quantity and quality; and (iii) to assess the extent of deterioration in terms of acidity, salinity, alkalinity or development of any other forms of deficiencies or toxicities. The practice of soil testing involves four important steps: (i) soil fertility research, (ii) soil sampling and sending to the soil testing laboratory or concerned extension agency, (iii) preparation of soil sample and its analysis, and (iv) interpretation of analysis and making recommendations. Any soil fertility evaluation program can be no stronger than the research base on which it is built. Such research must be problem-oriented, inter-disciplinary, must consider economics, must be of high quality, and should provide maximum useful information.

Interpretation of Soil Test Values for Fertiliser Recommendations a soil test value for all nutrient

A soil test value for all nutrients is an index of the availability of that nutrient to plants in the soil being tested. In India, soil testing laboratories report,

the soil test results as kg per ha for N, P, K, and parts per million (ppm) for micronutrients and should be thought of as an index of the relative level (kg ha^{-1} or mg kg^{-1}). The probability of response to applied fertilizer can conceptually be determined from relative soil test levels. The higher the soil test level, the lower the probability of response to applied fertilizer. Conversely, a low soil test level would have a high probability of response to applied fertilizer. For preparing the fertilizer recommendation norms for each class of soil test values (low, medium and high) crop response curves are to be prepared. This may be prepared for a particular situation or maybe the average of the number of experiments in which climate, soil, and the operator are variable. From the response curve, the actual amount of fertilizers can be calculated to give the maximum profit per hectare. In the absence of a crop response curve, the fertilizer needed for maximum yield can be evaluated with maximum field experiments.

Use of Manures, Fertilisers and Bio-fertilisers

Fertilizers supply plant food and help to increase the yield of different crops through the improvement in soil fertility. Manures not only supply plant nutrients but also improve the soil's physical environment influencing plant growth. Bio-fertilizers are about to make a significant contribution toward the development of strategies for productivity improvement which do not lead to an exponential rise in the consumption of nonrenewable forms of energy. Plant roots absorb the nutrients

from the soil solution in the ionic (inorganic charged) form. Larger molecules can also be absorbed by roots, but their rate of absorption is slow. Thus, if a fertilizer (organic or inorganic) is applied, it must first be broken down to its simplest forms to be used efficiently by plants. The number of plant nutrients in a fertilizer program can be reduced if organic manures are used. The nutrient content of manures varies with the type of livestock and methods used in storage, handling, and application. As a general rule, the suggested rates of N, P_2O_5 and K_2O can be reduced by 5.5, 2.2, and 5.5 kg for each tonne of wet manure applied per hectare respectively. Therefore it is essential to evolve and adopt a strategy of integrated nutrient supply by using a judicious mix of chemical fertilizers, organic manures, and bio-fertilizers of their importance, possible reactions in soils, etc.

Importance of Balanced Fertilisation in Horticultural Crops

Conceptually integrated nutrient management would essentially mean rational use of fertilizers and organic manures for the supply of nutrients for production in such a manner that would ensure (i) maximum efficiency of fertilizer use, (ii) harnessing the best possible positive and synergistic interactions amongst the various factors of production (planting material, water, agrochemicals, etc.), (iii) least adverse effect on the environment by minimizing nutrient losses, (iv) maintaining soil productivity, and (v) sustaining high yields commensurate with the biological potential of the

crop variety under the unique soil, climate and agro-ecological set-up. Integrated nutrient management for crops/cropping systems is the only viable strategy advocating accelerated and enhanced use of fertilizers with matching adoption of organic manure and biofertilizers so that productivity is maintained for sustainable agriculture. Balance has to be maintained in the soil-crop system and it has also to take care of all other factors of production and make allowances for residual effects of past fertilizer applications, N fixation, etc., and to ensure that there is no toxicity/deficiency of any element. Perennial fruit crops are quite a bit different from annual crops. Annual crop growers can almost predict what their final yield will be from the number of fertilizers they apply. In the case of perennial fruit crops more than 90% of the absorbed nutrients get locked up in the woody part of the tree and the current application will not influence the yields of the current season. It is because of this, that yield predictions to applied nutrients are difficult in perennial fruit crops. However, the deep root systems help them to bring in nutrients from a large volume of soil and can store nutrients in the vegetative part and resume them again and again during later growing seasons. Thus the annual crops (vegetables, flowers, etc.) and perennial crops need to be tackled differently under integrated nutrient management strategies. Because of the complex nature of perennial fruit crops growers seem to worry most about, whether they are applying enough fertilizers. How can we balance nutrient applications under these complex situations?

Growers believe that if they spend money to add fertilizers to spray some foliar nutrient mixtures then their yields would increase. However, an immediate benefit in such a case is not seen. This also leads to imbalanced use of nutrients and leads to many complications in fruit production. Too many nitrogen fertilizers result in excessive vegetative growth and reduce reproductive growth which otherwise is needed to maintain large yields of fruits. Excess nitrogen can result in soft fruits with poor colour in apple and predispose vegetables to attacks by pests and diseases. It will delay the ripening of grapes. A thick vegetative canopy increases diseases by slowing the drying. Too much potassium can cause bitter pit in apples and mango by upsetting calcium uptake. The ultimate effects of these are that yields do not increase. Hence in crop production, one should know the concentration of nutrients in plant tissue before fertilizing the trees and for mid-term corrections in vegetables.

Methods to Enhance Nutrient Use Efficiency Source

Commonly used prilled urea is modified to improve its use efficiency by making it slowly soluble through physical transformation (eg. Urea super granules (USG), coated with lac, etc.,) and chemical/biological modifications (sulphur-coated, neem oil/extract-coated, guar- gum-blended, tar-coated, etc.). Urea is also useful for foliar application and fertigation. Ammonium sulphate is not recommended in high rainfall areas due to its high residual acidity. Calcium ammonium nitrate is useful

where a supplement with calcium is necessary. Single superphosphate and DAP are the most common phosphatic fertilizers used. Muriate of potash is a widely used potassic fertilizer. In crops like potato and grape in which chlorides interfere with quality, sulphate of potash is recommended. The latter is also convenient for foliar application and fertigation. Several compound/complex fertilizers are available that contain more than one major nutrient but need to supplement with straight fertilizers to meet the exact needs of the crops.

Time and Method of Application

The key to enhancing fertilizer use efficiency is to synchronize the time of fertilizer application with the growing need of the crop and period of high root activity. It is useful to increase the number of split applications provided the cost of application is not prohibitive. In fruit crops, it is best to apply fertilizers before vegetative flushing, usually as pre- and post-monsoon applications. In vegetable crops, it is best to complete the application of all the splits before the grand growth/flowering stage. Although the same is recommended for potassic fertilizers, split applications are found to be beneficial in bananas and some long-duration vegetable crops like chili, capsicum, and tomato. It is best to apply fertilizers as a band close to the zone of high root activity followed by proper incorporation into the soil. In most vegetable crops application of fertilizers at 5 cm below the seed/ plant row ensures maximum utilization of the applied fertilizer and may economize on N and P input in some crops. In fruit

crops, placement of fertilizers in a band of 15-90 cm width midway between the trunk and drip circle ensures application close to the zone of high root activity and thereby enhanced utilization of the fertilizer nutrient.

Foliar Fertilisation

An appropriate time to consider foliar fertilization would be when a shortage of a nutrient is evident as indicated by tissue analysis or visual symptoms. In these situations, foliar fertilization provides the quickest means to correct the problem. Certain soil conditions, such as high pH, excess moisture, or cool temperatures, may render a nutrient or nutrients unavailable to the plant root. If these conditions exist, the problem may be more effectively corrected by foliar applications compared with soil applications. Two to three sprays of micronutrients are needed to meet crop demands. Nutrients applied to the leaves can be absorbed and utilized by the plant. However, for nitrogen, phosphorus, and potassium the quantity absorbed at any one time is small relative to the larger levels required for growth by the plant. Foliar application of these three nutrients cannot be expected to supply the total amount required for crop production.

Drip Irrigation and Fertigation

Drip irrigation, often known as trickle irrigation, is a method of irrigation in which water is delivered at low pressures straight to or near the plant's root zone. Water is transported via plastic tubing and released via tiny apertures. Drip irrigation is frequently used with plastic mulch.

Drip irrigation has several advantages, including improved foliar disease management and more effective water and nutrient usage. When compared to an overhead sprinkler system, drip irrigation can save up to 50% more water. This irrigation system is ideal for high-value crops such as tomatoes, peppers, vine crops, and cole vegetables. Fertigation is the use of irrigation water to apply water-soluble fertilizer. Using appropriate injection equipment, nutrients in a concentrated solution are injected into the irrigation water. Providing fertilizers by irrigation allows for greater flexibility in a fertilizer scheme. The type of system selected will depend on the crop being grown and the resources available. Nitrogen is the primary nutrient applied through the system. Urea is the most economical source of nitrogen to apply; potassium nitrate and ammonium sulphate are soluble and can also be used. Calcium nitrate is also water-soluble but may precipitate if injected into high pH water. Drip irrigation, in combination with plastic mulch, allows for precise timing (spoon-feeding) of nitrogen. Small amounts can be applied daily (0.5-1.0 kg N/ a) or weekly (2.5-5.0 kg N/a) to meet the growing demands of the crop. Potassium can also be injected without any precipitation problems, although in most soils, a broadcast and starter application can meet plant requirements. Phosphorus may precipitate with micronutrients or with calcium and magnesium in the irrigation water resulting in clogging problems. Some micronutrients such as copper, iron, manganese and zinc may also precipitate

in high pH water. For most situations, P and micronutrients, if needed, should be applied to the soil before planting. These elements can be injected alone into the drip system without precipitation problems. For P application through a drip system phosphoric acid should be used. For micronutrients, chelated forms should be applied to soils. Clogging problems in drip lines can be corrected by injecting acids into the line to dissolve precipitates. If bacteria or algal growth causes clogging, then chlorine should be mixed with water. In all cases, the cause of clogging should be determined before treatment, and injection rates of chlorine or acid should be carefully monitored to avoid damage to the system and the plants.

Application for young Fruit trees

- ✓ Non-bearing young fruit trees need nitrogen for their fast growth.
- ✓ The nitrogen-carrying manures and fertilizers such as FYM, groundnut or castor cake, ammonium sulphate, urea, etc. are applied in split doses during the vegetative growth period *i.e.* during June-July, October-November, and January- February.
- ✓ They are applied in the active root area and mixed well with the soil.
- ✓ Phosphoric fertilizer should be applied once a year in one's dose and deeper in the soil in the active root zone.

Conclusion

This manuscript provides a summary of general nutrient management practices for horticult-

ural crops. It is not a complete inventory but rather an overview of soil fertility management options available to horticultural crop growers for improving the profitability of a horticulture farm. The selection of appropriate nutrient management practices for individual horticulture farms needs to be tailored to the specific conditions existing at a site. The science and art of nutrient management have progressed immensely during the last decade because of the integration of new developments in the areas of computers, simulation models, GIS, GPS, and other in situ sensors. Technology will continue to advance and help integrate these multiple factors for agricultural sustainability and profitability. Independent of new technologies, nutrient management will be driven by the basic principles of intensive and solid research about sinks, sources, methods of management, and applications that will maximize yields and in some cases crop quality while reducing off-site transport. Nutrient management is the key that will maximize nutrient use efficiency and minimizing off-site transport. Consideration of the right source, rate, time, and place for integrated nutrient management allows the objectives of sustainable cropping to be addressed. These 4R principles should be based on locally adapted horticultural and soil fertility research, with appropriate stakeholder input. When this is done, both the benefits and risks of fertilizers can be balanced for sustainable crop production.

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Mixed Cultivation of Different Vegetables alongwith Aman Paddy in West Bengal

Malay Kanti Modak and Dr. Shadan Kumar Das

In the world people needs food to survive vis-a-vis need people for cultivation and produce crops. In present time, all over the world, the population size is increasing day by day; the area of cultivation land being decreased due to human invasion. In this scenario of needs for increase in production level in limited land area, productivity per unit area through sustainable land management is of prime importance. New technological intervention, which is not only technologically feasible, but also eco friendly as well and easily adoptable by marginal farmers, is required to get highest agri produce from unit land area. Such a new technology has been introduced in the village of Ula under Barasat-1 block through the "ATMA" project of the Department of Agriculture, Government of West Bengal. This method is 'Mixed Cultivation of Different Vegetable Crops with Aman Paddy in West Bengal'. Farmers may be interested in this method as it provide higher net return due to decrease in production cost.

Few years ago, agricultural researchers from Vivekananda Institute of Biotechnology, Sri Ramkrishna Ashram Nimpith, have made farmers in Ula village well aware in "Good Agriculture

Practices (GAP)" method (Modak *et al.*, 2018, 2021). GAP involves application of soil test based recommended dose of chemical fertilizer, 25% reduction of chemical fertilizer with biofertilizer, Integrated Pest Management with priority on cultural, mechanical and biological management, avoiding application of WHO banded highly toxic Class 1A, 1B & Class 2 pesticides and safety measure during purchase, transport, storage, application and disposal of chemical pesticides. Thus agri produces of this practices are free from residual chemicals and have a potentiality for higher market acceptability. In this background, GAP in termed as *Nirmal Krishi* in Bengali.

➤ Dual cultivation of vegetables in *aman* paddy field was introduced in this village following Good Agricultural Practice having protocol:

1. Land preparation and sowing of seeds

Aman paddy is cultivated in all types of high, medium and low lands during monsoon season. 15 to 16 kg of fine paddy, 16 to 20 kg of medium paddy and 22 to 24 kg of coarse paddy are sown per acre for making seedbed of *aman* paddy (Nayban, 2001). If the environment is normal, it is advisable to plant

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seedlings in mud seedlings in 3 to 4 weeks and dry seedlings in 5 to 6 weeks in the main field.

When preparing paddy land, jute bags were placed at a certain distance in the land, so that in case of pumpkin cultivation about 360 jute bags per acre can be planting in the land, on the other hand in case of gourd cultivation about 240 jute bags can be given per acre. Jute bags was cut to such a size that the height of each jute bag is higher than water level of paddy field. The height of the jute bags were determined according to the height of water accumulated in the land, it was noted that the two mouths of the bag are open. After placing the jute bags, bury them in the ground like a bucket with a bamboo stick at the end of the row so that the bag and bags do not overturn next time. At the very bottom of the burlap bags, that is, in the part adjacent to the land, first the layer of water hyacinth plant is to be prepare. Then you have to fill it with some soil. In this way, once again the soil layer and once again the vermicompost layer should be packed in jute bags and all should be covered with soil. Seed of leaf vegetables may be sown immediately after transplantation of rice seedlings. It should be kept in mind that in order to get good price of pumpkin, gourd and bean, it is necessary to sow pumpkin, gourd or bean seeds between 1st weeks of September. Then 3 to 4 seeds are sown each jute bag.

2. Irrigation (Nayban, 2001)

This method of cultivation requires less irrigation we can save ground and pond water.

3. Fertilizers (Nayban, 2001)

On the basis of soil test, chemical fertilizers, organic fertilizers and Bio-fertilizers should be applied in the *aman* paddy lands as required, but care should be taken to use excess fertilizers as required, which may result in loss of paddy cultivation.

4. Pest and Disease

With the treatment of seeds, the infestation of diseased insects has been reduced through the treatment of seedbeds.



Jute bag fill up process

5. Benefits

The benefits of cultivating vegetables with *aman* paddy are discussed below.

- i) Single agronomical practice in a single season produces at least two crops.
- ii) The vegetables produced in elevated land in rainy season have higher market value.
- iii) Multiple cropping may have benefit for Integrated Pest Management with lower pesticide application which has a positive impact on environmental safety.
- iv) Due to mixed farming, less irrigation is required, which results in less use of ground water as well as less water wastage, which is good news for the

Table 1: Solo Pumpkin cultivation and mix cropping *aman* paddy with pumpkin cultivation per acre (Data collected 2020 at farmer field from ula, N 24 pgs)

Solo cultivation of pumpkin				Mix cultivation of pumpkin with paddy				Increase of Income/acre
Farmer money investment	Cost of selling price	Net income	B:C ratio	Farmer money investment	Cost of selling price	Net income	B:C ratio	
Total cost - Rs. 19080.00 1. Fertilizer a. Chemical (130-150 10:26:26) kg Rs. 3700.00 b. Organic Rs. 1000.00 2. Eight times irrigation Rs. 6480.00 (Rs. 120 per hour, total time required 54 hour) 3. Labor 18 (per day Rs. 300) Rs. 5400.00 4. Other (fungicide, pesticide and pheromone trap) Rs. 2500.00	Approximately - Rs. 38500.00 (starting price Rs. 10/kg end time Rs. 8/kg) 1 st harvest 450 kg x 10 =Rs. 4500.00 2 nd harvest 700 kg x 10 =Rs. 7000.00 3 rd harvest 3000 kg x 8 = Rs. 24000.00 4 th harvest 375 kg x 8 =Rs. 3000.00	Net income (38500.00 - 19080.00) = Rs. 19420.00	2.02	Total cost - Rs. 24360.00 1. Old jute bag Rs. 17/ piece, 180x17= Rs. 3060.00 2. Fertilizer/Manure - (a) Chemical (90-110 kg 10:26:26), Rs. 3000.00 (b) Organic (Rs. 15/kg, required 400 kg vermicompost) Rs. 6000.00 3. Six time irrigation (Rs. 120 per hour, total time required 40 hour) Rs. 4800.00 4. Labor mandatory 20 (per day Rs. 300) Rs. 6000.00 5. Other (fungicide, pesticide and pheromone trap) Rs. 1500.00	Approximately - Rs. 50205.00 (starting price Rs. 15/kg end time Rs. 8/kg) 1 st harvest 177 kg x 15 = Rs.2655.00 2 nd harvest 450 kg x 15 = Rs. 6750.00 3 rd harvest 700 Kg x 12 = Rs. 8400.00 4 th harvest 3000 kg x 8 = Rs. 24000.00 5 th harvest 900 kg x 8 = Rs. 7200.00 6 th harvest 150 kg x 8 = Rs 1200.00	Net income (50205.00 - 24360.00) = Rs.25845.00	2.06	(Aman paddy with pumpkin Net income - Solo Pumpkin cultivation Net income) 25845.00 - 19420.00 =Rs 6425.00

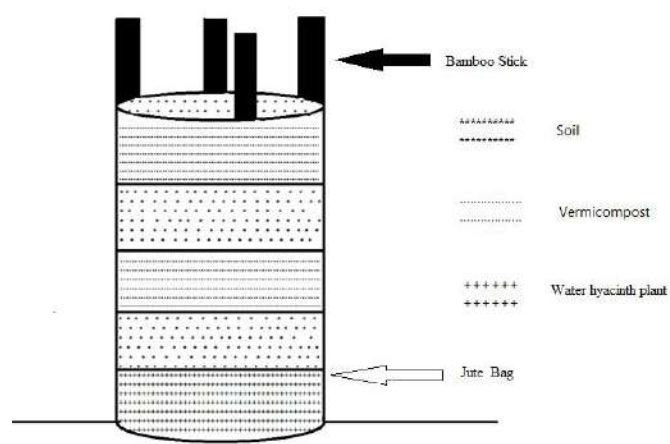
Table 2: Solo Bottle Gourd cultivation and mix cropping *aman* paddy with Bottle Gourd cultivation per acre (Data collected 2020 at farmer field from ula, N 24 pgs.)

Solo cultivation of Bottle Gourd				mix cultivation of Bottle Gourd with paddy				Increase of Income/acre
Farmer money investment	Cost of selling price	Net income	B:C Ratio	Farmer money investment	Cost of selling price	Net income	B:C Ratio	
Total cost - Rs. 26380.00 1. Fertilizer Chemical (130-150 10:26:26) kg Rs. 3700.00 a. Organic Rs. 1000.00 2. Eight times irrigation Rs. 6480.00 (Rs. 120 per hour, total time required 54 hour) 3. Labor 24 (per day Rs. 300) Rs. 7200.00 4. Other (fungicide, pesticide, pheromone trap, bamboo, bamboo stractur) Rs. 8000.00	Approximately - Rs. 62960.00 (starting price Rs. 25/kg end time Rs. 6/kg) 1 st harvest 300 kg x 25 =Rs.7500.00 2 nd harvest 500 kg x 20 = Rs.10000.00 3 rd harvest 800 kg x 12 = Rs. 9600.00 4 th harvest 3500 kg x 8 = Rs. 28000.00 5 th harvest 900 kg x 6 = Rs. 5400.00 6 th harvest 410 kg x 6 = Rs. 2460.00	Net income (62960.00- 26380.00) = Rs. 36578.00	2.39	Total cost - Rs. 32840.00 1. Old jute bag Rs. 17/ piece, 120x17= Rs. 2040.00 Fertilizer/Manure (a) Chemical (90-110 kg 10:26:26), Rs. 3000.00 (b) Organic (Rs. 15/kg, required 400 kg vermicompost) Rs. 6000.00 3. Six time irrigation (Rs. 120 per hour, total time required 40 hour) Rs. 4800.00 4. Labor mandatory 30 (per day Rs. 300) Rs. 9000.00 5. Other (fungicide, pesticide, pheromone trap, bamboo, bamboo structure) Rs. 8000.00	Approximately - Rs. 84600.00 (starting price Rs. 35/kg end time Rs. 6/kg) 1 st harvest Rs. 200 kg x 35 = Rs.7000.00 2 nd harvest 250 kg x 30 = Rs.7500.00 3 rd harvest 300 Kg x 25 = Rs. 7500.00 4 th harvest 500 kg x 20= Rs. 10000.00 5 th harvest 800 kg x 12 = Rs. 9600.00 6 th harvest 3500 kg x 8 = Rs 28000.00 7 th harvest 2100 x 6 = Rs. 12600.00 8 th harvest 400 x 6 = Rs. 2400.00	Net income (84600.00- 32840.00) = Rs. 51760.00	2.58	(Aman paddy with Bottle Gourd Net income - Solo Bottle Gourd cultivation Net income) 51760.00 - 36578.00 =Rs 15182.00

world's agricultural community in the future.



Aman paddy with pumpkin cultivation



Conclusion

From the above result, it can be concluded that production of vegetables in submerged paddy field on jute bag not only increases the harvesting index in a given area, but also provides higher price of the produces as these are produced early in the season. Cultivation of other vegetables may be tried following this model.

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Pradhan Mantri Fasal Bima Yojana (PMFBY): A Brief Introduction

Mrs. Priyanka Rana

India is the land of farmers where the maximum proportion of rural population depends on agriculture. Hon'ble Prime Minister Shri Narendra Modi unveiled the new scheme Pradhan Mantri Fasal Bima Yojana (PMFBY) on 13th January, 2016. This scheme will help in decreasing the burden of premiums on farmers who take loans for their cultivation and will also safeguard them against the inclement weather. It has also been decided to make the settlement process of the insurance claim, fast and easy so that the farmers do not face any trouble regarding the crop insurance plan. This scheme will be implemented in every state of India, in association with respective State Governments. The scheme will be administered under the Ministry of Agriculture and Farmers Welfare, Government of India.

Highlights of the scheme



- ✓ There will be a uniform premium of only 2% to be paid by farmers for all Kharif crops and 1.5% for all Rabi crops. In case of annual commercial

and horticultural crops, the premium to be paid will be only 5%.

- ✓ The premium rates to be paid by farmers are very low and balance premium will be paid by the Government to provide full insured amount to the farmers against crop loss in any natural calamities.
- ✓ There is no upper limit on Government subsidy. Even if balance premium is 90%, it will be borne by the Government.
- ✓ Earlier, there was a provision of capping the premium rate which is low claims being paid to farmers. Now this is removed and farmers will get claim against full sum insured without any reduction.
- ✓ The use of technology will be encouraged to a great extent. Smart phones, Remote sensing drone and GPS technologies will be used to capture and upload data of crop cutting to reduce the delays in the claim payment.
- ✓ Allocation of the scheme presented in budget 2016-2017 is Rs. 5,550 cores.
- ✓ The insurance plan will be handled under a single insurance company, Agriculture Insurance Company of India (AIC).
- ✓ PMFBY is a replacement scheme of National

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Agriculture Insurance Scheme (NAIS) and modified National Agriculture Insurance Scheme (MNAIS) and hence exempted from the service tax.

Objectives of the Scheme

- ✓ To provide insurance coverage and financial support to the farmers in the event of failure of any of the notified crop as a result of natural calamities, pests & diseases.
- ✓ To stabilise the income of farmers to ensure their continuous process in farming.
- ✓ To encourage farmers to adopt innovative and modern agricultural practices.
- ✓ To ensure flow of credit to the agriculture sector.
- ✓ Compulsory Component: All farmers availing Seasonal Agricultural Operations (SAO) loans from Financial Institutions (i.e. loaner farmers) for the notified crops would be covered compulsorily.
- ✓ Voluntary Component: The Scheme would be optional for the non-loaner farmers.
- ✓ Special efforts shall be made to ensure maximum coverage of SC/ ST/ Women farmers under the scheme. Budget allocation and utilization under this should be in proportion of land holding of SC/ ST/ General along with Women in the respective state cluster. Panchayat Raj Institutions (PRIs) may be involved for the implementation and also obtaining farmers feedbacks on these crop insurance schemes.



Coverage of the farmers

All farmers including sharecroppers and tenant farmers growing the notified crops in the notified areas are eligible for coverage. The non-loaner farmers are required to submit necessary documentary evidence of land records prevailing in the State Records of Right (RoR), Land possession Certificate (LPC) etc. moreover, applicable contract, agreement details, other documents notified permitted by concerned State Government.

Nutritional and Medicinal Properties *Celosia argentea* (Plumed cockscomb)

Kanneboina Soujanya, B. Anila Kumari and E. Jyothsna

Introduction

India is one of the richest biodiversity countries containing 12,600 plant species and which contributes to 8% of the world's biodiversity. Diverse soil and climatic conditions of Indian subcontinent favours the growth of different plant species. In developing countries, 60-70% of people depend on forest resources to meet their daily requirements especially in tribal communities (Kannan *et al.*, 2015).

Celosia argentea is commonly known as plumed cockscomb belongs to *Amaranthaceae* family. The plant was cultivated by small scale farmers of Nigeria to satisfy their food needs and it was a leading vegetable of South West Nigeria and also used in other countries like west and central African countries, America, tropical and subtropical Asia. *Celosia argentea* is an important leafy vegetable with high nutritional value and so, various parts of the plant are used in preparation of soups, sauces and used with other vegetables. *Celosia argentea* is commonly called as soko yokoto, it is one of the leading vegetables of Nigeria. Soup prepared from the leaves were consumed with rice, maize, yam or cassava (Fayaz *et al.*, 2019).

Celosia argentea L. is an herbaceous and branched plant with pinkish leaves, globular fruits, cylindrical shaped roots and minute black seeds. It is commonly known as sunishannaka, safed murga, silver cock's comb, quail grass and wool-flower. It is distributed throughout India, Sri Lanka, Indonesia, America, Yemen and West Indies. It is commonly cultivated in rainy forest area of Nigeria, Cameroon, Gabon and Togo (Manokari *et al.*, 2016).

Morphological Characteristics

The plant of *Celosia argentea* is a simple, erect, coarse, branched, smooth annual herb usually grows up to height of 0.5 to 1.5 m but sometimes grows much taller. Leaves are alternatively arranged with light green colour. Plant has few branches, long flowering shoots with white or pinkish flowers. The flowers of the plant are small in size, dense, 8-12mm in length, 1.5-2 cm in thick without petals. It had membranaceous fruits and seeds are black in colour with 1mm diameter. It is very common in West Africa, from Sierra Leone to Nigeria. It is also known in Ethiopia, Somalia, Kenya, other parts of East Africa, Mexico and Central Africa. It is grown as a weed during rainy season all over India and tropical regions of the world like Indonesia, America, Sri

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Lanka, Yemen and West Indies (Divya *et al.*, 2019).



Nutritional Composition

Nutritional composition of leaf, stem and flower of *Celosia argentea* L. was evaluated by Fayaz *et al.* (2019). Nutritional content of leaves per gram was starch-16.2 mg, total sugar-63.2 mg, free sugar-27.1 mg, protein-71.4 mg, lipids-13.77 mg, moisture-81.2%, potassium-37.66 mg, magnesium-67.18 mg, calcium-86.6 mg, iron-0.522 mg, sodium-0.99 mg, zinc-0.06 mg and manganese-0.643 mg. Sangekar *et al.* (2018) studied the nutritional composition of leaves, stem, and roots of *Celosia argentea*. The study shows that the leaves had 11.0% ash, 6.8% moisture, 2.9% total sugar, 1.6% reducing sugar, 5.3% nitrogen, 0.319% potassium, 3.1% calcium, 9.1% phosphorus, 22.3% crude protein and 2.1% total free amino acids.

Phytochemistry

Fayaz *et al.* (2019) and Gaibimej *et al.* (2018) screened phytochemicals in leaf, stem and flowers of *Celosia argentea*. Results showed the presence of alkaloids, saponins, tannins, flavonoids, carbohydrates, proteins, steroids and amino acids. All the phytochemicals above stated was found in stem and leaves whereas in flower phytochemicals like carbohydrates, proteins, steroids and alkaloids were found.

Phytochemical and antioxidant activity of methanolic extracts of *Celosia argentea* was studied by Urmila *et al.* (2013). It was found that methanolic extracts of plant found the presence of glycosides, saponins, carbohydrates, tannins, flavonoids and phenols. DPPH values of *Celosia argentea* was $233.3 \pm 20.73 \mu\text{g ml}^{-1}$ (%inhibition), Nitric oxide scavenging activity was $521.4 \pm 4.061 \mu\text{g ml}^{-1}$ and hydrogen peroxide scavenging activity was $494.2 \pm 5.465 \mu\text{g ml}^{-1}$.

Pharmacological Properties

Celosia argentea was a source of phenols, saponins, flavonoids, alkaloids, carbohydrates, tannins, glycosides, gum, mucilage, protein and vitamins. The plant was used to treat gastrointestinal problems. It has antipyretic, anti-inflammatory, antioxidant, wound healing activity, antidiabetic activity, antidiarrheal activity, antimicrobial, immunomodulating, antifungal, IgE suppression activity, hepatoprotective activity, antitumor, antiurolithiatic and antimitotic activity (Kanu *et al.*, 2017).

Wound healing property: Wound healing activity of alcohol extracts of *Celosia argentea* on rats or 15 days were evaluated and the results were increased the collagen and hexsoamine content of the granulation tissue at a faster rate in the treated wounds (Priya *et al.*, 2008).

Hepatoprotective activity: Ethanolic extracts of *Celosia argentea* at the dose of 250 mg kg^{-1} and 500 mg kg^{-1} , showed a remarkable hepatoprotective activity against paracetamol induced hepatotoxicity

as judged from the serum marker enzyme (Hari babu *et al.*, 2014). In another study the aqueous extracts of *Celosia argentea* inhibited the elevation of serum enzymes like GPT, GOT, LDH and bilirubin levels on carbon tetrachloride (CC1(4))-induced liver damage in rat and also protected against recombinant human TNF alpha (rhTNF-alpha)-induced liver injury in Dgalactosamine sensitized mice (Hase *et al.*, 1996).

Antiuro lithiac activity: Joshi *et al.* (2012) evaluated the antiuro lithiac activity of ethanolic extract of seeds of *Celosia argentea* in rats found that the groups treated with 250 kg and 500 kg of *Celosia argentea* extract showed significant anti urolithiatic activity compared with the standard. The study concluded that *Celosia* has the potent prophylactic effect on formation of kidney stone.

Anti-inflammatory: A flavonoid isolated from the leaves exhibited anti-inflammatory activity in carrageenan induced rat paw edema and cotton pellet induced chronic inflammatory models in a dose dependant manner in both models. The study provided the scientific evidence for the use of plant in inflammatory conditions (Bhujbal *et al.*, 2008).

Antifungal activity: Diemeleou *et al.* (2013) observed that seed extracted oil of *Celosia argentea* exhibited antifungal activity against *Aspergillus fumigatus*, *Candida tropicalis* and *Trichophyton mentagrophytes* with minimal inhibitory concentration of 50%. So, the seeds oil can be best used for the applications in the food supplement, pharmaceutical and cosmetic industries. Alcoholic

extracts of leaves of *Celosia argentea* reported antidiarrheal activity in experimentally castor oil induced rats (Sharma *et al.*, 2010).

Antidiabetic activity: The chronic administration of alcoholic extracts of *Celosia* seeds exhibited anti diabetic activity in alloxan-induced diabetic rats for two weeks and also prevented a decrease in their body weight. The ethanolic extract of the root lowered blood glucose in basal conditions and after a heavy glucose load in normal rats by 73.43% at 250 mg kg⁻¹ body weight on 15th day). And reduced the increase of blood sugar found in diabetic rats at 500 mg kg⁻¹ body weight on 15th day). The reduced levels of cholesterol, triglycerides and urea, decreased level of proteins and liver glycogen in streptozotocin-induced diabetic animals and inhibited the body weight reduction induced by streptozotocin administration (Kanu *et al.*, 2017).

Conclusion

Celosia argentea is valued for its use as food, cultural and medicinal importance. The whole plant is used in the traditional medicine to treat a number of pathological conditions. It's used for the treatment of diarrhoea, bleeding nose, piles, inflammation, disinfectant, diabetes mellitus, uterine diseases, rheumatoid arthritis, wound healing, immunological, anti-inflammatory, anticancer, hepatoprotective, antioxidant, diuretic, antibacterial, and antidiabetic properties.

Intercropping of Mungbean in Ber Orchard: Food Security and Socioeconomic Aspect

Ananya Ghosh, Arindam Ghosh, Piyali Dutta and Arunima Konar

Introduction

Agricultural diversification is an important instrument for the economic growth of farm households. As per the Ashok Dalwai Report on doubling Farmer's income (2017), crop diversification and intensification are being hailed as one of the most crucial components for achieving the goal of doubling farmer's income by year 2024 (Bakshi *et al.*, 2019). India is facing a big challenge in balancing its dual objectives of nutritional security and crop diversification to increase farm income. Neglected or underutilized crops have the potential to play a number of roles in the improvement of nutritional security in India. Studies has been advocating that 'small farmers are going to feed India' therefore, it is important to mobilize them to words underutilized crop and help them to diversify to meet the increasing domestic demand of agri-horticultural products. Intercropping makes it feasible to have continuous flow of income from farming. Suiting to soil, climate and market demand,

a farmer, after selecting a compatible crop combination with a fruit crop can make farmers' income a continuum.

Ber-Mung Intercropping

Ber crops are perennial in nature. Usually, they commence bearing after long waiting period of 2-3 years. During this period, fallow inter and intra spaces between trees rows can be befittingly utilized for intercropping with legumes. If the leftover spaces are not utilized judiciously, they undergo degradation. In present context, when the land on per caput basis is decreasing, there is a need to make agri-horti venture more profitable. It is only possible when resources and inputs are utilized efficiently and maximum outputs are realized at the cost of per unit use of inputs.

Ber

Ber has been a popular fruit of the rural India and called as poor man's fruit due to its wide cultivation. Ber is a less perishable fruit, and costs lower than other major fruits. It is not fastidious to its

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soil and climatic requirements, hence, is grown throughout India. Jujube tree is hard, drought-resistant and can thrive in poor alkaline tracts without much irrigation and care, and can also survive on soils where other fruit trees cannot. With the selection of high yielding cultivars with good quality fruits, it has become a commercial crop of Punjab and adjoining areas. It contains 13 to 20 percent TSS and 0.2 to 1.0 percent acidity along with Vitamin C (120 mg 100g of pulp), protein (0.94%), calcium (0.03%) and phosphorus (0.036%), iron (1.14%) and p-carotene (Vit. A) 80 ug/100 g. Pulp also contain about 5.50% sucrose, 1.50 glucose and 2.0% fructose sugars. Ber trees are used for rearing lac insect, the leaves along with tender shoots are used as fodder, wood is used as fuel and for medicinal purposes. 'Ber fruit is usually eaten fresh. It can be used for the preparation of murabba, candy and chutney. Squash or nectar can be prepared from the pulp. The fruits of wild varieties particularly malah ber (*Z. numularia*) are dried in sun and are sold during off season. Planting of ber in India is done in square system. The spacing adopted is 6 m x 6 m in rainfed condition and 7 m x 7 m or 8 m x 8 m in irrigated condition. In this interspace intercropping can be done effectively.

Mungbean

In order to meet 'zero hunger' and 'malnutrition', Government of India has enacted the National Food Security Act in 2013 (Global Hunger Index, 2016). The primary focuses were on the pursuit of food and nutritional security to everyone and supply of adequate quantity and quality of food.

Pulses are cheapest source of dietary protein, energy, fibre, vitamins (thiamine, riboflavin), amino acid, minerals like Zn, Fe, etc. The mung bean is a major edible legume seed in Asia (India, South East-Asia and East Asia) and is also eaten in Southern Europe and in the Southern USA. The mature seeds provide an invaluable source of digestible protein for humans in places where meat is lacking or where people are mostly vegetarian (AVRDC, 2012). Afzal *et al.*, (2008) have reported 24-26% proteins, 51% carbohydrates, 4% minerals, and 3% vitamins in mungbean seeds. This crop is mainly grown as a short duration crop matures within 75-80 DAS.

Advantage of Ber-Mungbean intercropping

Stability, Uniformity and Increase in production

One of the main reasons of intercropping around the world is more production than a pure cropping from same land amount (Caballero and Goicoechea, 1995). Willey, 1990, considers intercropping as an economic method for higher production with lower levels of external inputs. This increasing use efficiency is important, especially for small-scale farmers and also in areas where growing season is short (Altieri, 1995). In young ber orchards, growing mungbean in inter spaces can compensate the fruit production.

Greater use of environmental resources

Ber and mung will be a complementary intercropping option in terms of resource use due to differences in morphology, physiology, and competitiveness. Use of the resources more effectively than a pure cropping, results increased

yield (Jensen, 1996).

Food security

Intercropping enhances soil carbon and nitrogen, Global Food and Nutrition Security. Intercropping, the simultaneous cultivation of multiple crop species in a single field, increases aboveground productivity due to species complementarity. Reduces the risk of crop failure due to crop diversification. Provide nutritional security to the family as both ber and mungben are highly nutritious.

Efficient pest control

It is well known that the weeds interfere with crops causing serious impacts through either competition (for light, water, nutrients and space) or allelopathy. In monocropping systems (specially in orchards) rarely, all available natural source such as moisture, nutrients and light are used by plant, consequently released niches are captured by the weeds. Being a smoother crop mungbean can control weed efficiently. Although intercropping does not always reduce pest or pathogen, but most reports have pointed to reduced populations of pests and diseases in the intercropping (Fujita *et al.*, 1992).

Improve soil fertility and increase in nitrogen

Maintains soil fertility as the nutrient uptake is made from layers of soil. Additionally, mungbean can fix atmospheric nitrogen which supports ber growth and productivity. Rhizobium bacteria are able to have a symbiotic relationship with plants of leguminosae family, and thereby can fix atmospheric nitrogen into available nitrogen form for plants'

uptake. There are several reports indicating that increasing the nitrogen content in non-legume plants, due to the intercrops of these plants with plants of leguminosae family (Eskandari *et al.*, 2009; Fujita *et al.*, 1992).

Economic stability of farmer

Efficient utilization of resources helps in increasing productivity. Higher production with less cost can be achieved from this intercropping system. In young ber orchards, growing mungbean in inter spaces give financial support to the grower during first few years.

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Promotion of Agricultural Extension through Technology Innovation

Arindam Ghosh, Ananya Ghosh, Arunima Konar and Piyali Dutta

Introduction

Agriculture development in India is basically a state subject. But the crucial role the agricultural sector plays from the perspective of ensuring food security of its large population, the Union Government play a major role in formulating policies that has direct bearing on the growth of agricultural sector. The Union Government mainly provides road map through its policies, programmes and budgetary support to the sector. The programmes conceived at national level are mainly implemented by the states through its development departments. Besides, states also formulate region specific development programmes. Similarly, Indian Council of Agricultural Research (ICAR) is an apex body at the national level that supports research and extension activities to evolve effective Transfer of Technology (TOT) models. The State Agricultural Universities also contemplates to develop extension models suitable to take up transfer of technology besides implementing the models evolved by ICAR system. Agricultural extension mainly deals with the farmers

and most of the farmers in India belongs to marginal category. The Socio-economic condition of the farmer is not very well. There is a gap exist between their actual situation and their desirable situation. Agricultural Extension will minimize that gap by innovation and diffusion of proper science and technology in the farmer's field (Sagar Mondal, 2017).

Technology Transfer

Technology is the result of scientific knowledge and application of skills, methods, and processes used in production and scientific research. Technology is embedded in the operation of all machines, with or without detailed knowledge of their function, for the intended purpose of an organization. Transfer of technology is an important mechanism for dissemination of appropriate technology in the farmer's field. From technology generation to technology transfer is a time-consuming process but through government as well as non-governmental intervention it makes very easy to transfer the technology from lab to land of the farmer.

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Different organization involved in this technology dissemination process. KVK plays an important role to conduct front line demonstration, On-farm trial of that particular technology. ICAR, an apex organization involved in all agricultural activity in India, launched a programme known as Lab to Land Programme for transfer of technology in an effective manner.

Agricultural Innovation

By 2050, the demand for food will surge 70%, in line with rapid population growth. A UN study found that about 9.9% of the world's population still goes hungry, so the thought of feeding almost 10 billion mouths will be a clanging task. With environmental changes hard to predict, we must turn to innovation in agriculture technology. These technologies will be helpful to change the way farmers grow, transport, store, and manage their produce.

1. Bee Vectoring Technologies

The BVT inoculum delivery system is integrated into the shell of a commercial wasp nest (Sakshi Saxena *et al.*, 2017). BVT uses commercially reared bees to deliver targeted crop controls through pollination, replacing chemical pesticides with an environmentally safe crop protection system. The system doesn't require spraying water or the use of tractors. Instead, the scientifically designed bumblebee hive allows bees to pick up a trace amount of pest control powders on their legs to spread as they travel within the field. This innovation in agriculture technology supports improved sustainable farming, crop yield, and soil quality. BVT's solution is suitable

for many crops, including blueberries, sunflowers, apples, and tomatoes, and it also works for farms of all sizes.



Bee vectoring technology

2. Precision Agriculture

Precision agriculture is a key component of the third wave of modern agricultural revolutions. (Ashish Dwivedi *et al.*, 2017) Precision agriculture is an agricultural resource management strategy that collects, processes, and evaluates data and offers insights to help farmers optimize and increase soil quality and productivity. Management decisions count on precision agriculture data points to improve farmland and farm produce across several key areas, including: Resource use efficiency, Sustainability, Profitability, Productivity, Quality.



Precision farming (Application of drone technology in Agriculture)

3. Indoor Vertical Gardening

This Indoor vertical farming grows farm produce stacked above another in a closed and controlled environment. The technology uses growing shelves mounted vertically to increase crop yield in limited spaces. This don't require soil they are either hydroponic or aeroponic: Currently hydroponic cultivation is gaining popularity all over the world because of efficient resources management and quality food production (Nisha Sharma *et al.*, 2018). Hydroponics is a gardening practice that grows plants in water and nutrient solutions. Aeroponics is a promising soilless farming method for solving future food crisis and is relatively a new way of growing plants that is getting increasingly popular with many people because of the speed, cost and novelty (Reena Kumari *et al.*, 2019). Aeroponics suspends the roots of the crops in the air, with emitters intermittently spraying them with water and nutrients.



Hydroponics



Aeroponics

Conclusion

It is found that lack of technology innovation and technology dissemination is the main drawback of Indian Agriculture. Technological innovations have greatly shaped agriculture throughout time.

Government tries to introduce new technologies for the betterment of the farming community. Several schemes and programmes were launched to promote this technology. Time to time Monitoring and evaluation is also an important task to disseminate such technology in the farmer's field. This technology is trying to provide new dimension in agriculture sector by securing high return from their production, by securing self-sufficiency in food and also by improving their socio-economic condition. Besides this technology global positioning system (GPS) driven precision farming equipment, humans have developed new ways to make farming more efficient and grow more food. Livestock farming technology provide farmers with data-driven insights, allowing them to streamline farm management, improve animal care, and boost productivity. Farm management software is also an integrated platform that provides real-time data and information, like a digital checklist, to assist farmers with tracking daily activities. With this monitoring and reporting software, farmers can improve decision-making throughout all operations. So, we can conclude that technological intervention is very much important task to promote agricultural activity. It will help the farming community to improve their family income, to improve their production as well as it will also improve their socio-economic condition.

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Micropropagation

Manmohan Lal

Introduction

Micropropagation is the clonal propagation of plants in closed vessels under aseptic conditions. Inside the vessels, the plants are grown on culture media that contain nutrients and growth regulators, and are described as “*in vitro*,” which means “in glass.” In contrast, soil-grown plants are described as *in vivo*. Plants that are propagated *in vitro* are smaller than *in vivo* plants, hence the term micropropagation. This method has obtained greater momentum for commercial application in the field of plant propagation. A general phenomenon of plant tissue culture is the ability to produce organs, tissues, embryoids, etc. Regeneration of the plant is accomplished by explants from shoot tips, leaves, stems, cotyledons, and microsporocytes. The initial explant used is the most important determinant of plant multiplication and quality of regenerated plants. Micropropagation is primarily used to regenerate elite and rare species as an alternative to traditional vegetative propagation methods. However, micropropagation of mature trees with vegetative explants has been a difficult task due to various factors, viz., presence of phenolic compounds, exogenous and endogenous infection, maturity, juvenility, slow growth habit, and long genetic variations.

Micropropagation techniques have been used for the rapid and large-scale propagation of some fruit crops in the last few years. This technique is also used for somatic hybridization, genetic manipulation, and virus eradication.

In the early 1960s, plant tissue culture was revolutionised with the development of a defined culture medium by Murashige and Skoog (1962). At the moment, MS medium is the best and most popular way to grow different kinds of plants. The government of India identified micropropagation of fruit plants as an industrial activity under the Act of 1951, made effective in 1991, and several subsidies and incentives are offered. Large scale promotion of this technology was taken up during the VIII plan under the centrally sponsored scheme on Integrated Development of Horticulture (IDH). Under this scheme, assistance is being provided worth Rs. 2.1 million for establishing tissue culture labs in the public sector as well as for the private sector. The assistance is worth 20% of the cost, with a maximum of Rs. 1.1 million per unit. At the moment, this method is known in plant science for its success in micropropagation and improving plant species, which has led to its use in business.

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Stages of Micropropagation

Stage I (Culture Establishment)

The explants are established in a suitable culture medium. This stage involves the following steps:

- ✓ Isolation of the explant
- ✓ Surface Sterilization
- ✓ Washing
- ✓ The explant is established on an appropriate culture medium.

Stage II (Shoot Multiplication)

This stage involves the rapid multiplication of shoots or rapid somatic embryo formation in a defined culture medium.

Stage III (Rooting)

In this stage, the shoots are transferred to a medium for the development of roots. The shoots are either transferred directly to the soil for root development or transferred to a nutrient medium in the laboratory.

Stage IV (Hardening)

In this stage, the plantlets are established in the soil. The shoots from the laboratory are transferred to a greenhouse under controlled conditions of temperature, humidity and light.

Methods of Micropropagation

Meristem Culture

In meristem culture, the meristem and a few subtending leaf primordia are placed into a suitable growing medium. An elongated rooted plantlet is produced after some weeks and is transferred to the soil when it has attained a considerable height.

A disease-free plant can be produced by this method.

Callus Culture

A callus is a mass of undifferentiated parenchymatous cells. When a living plant tissue is placed in an artificial growing medium with other conditions favorable, a callus is formed. The growth of callus varies with the homogenous levels of auxin and cytokinin and can be manipulated by the endogenous supply of these growth regulators in the culture medium. The organogenesis or embryogenesis of a callus can be thought of as the third stage.

Stage I: Rapid production of callus after placing the explants in the culture medium.

Stage II: The callus is transferred to other medium containing growth regulators for the induction of adventitious organs.

Stage III: The new plantlets are then exposed gradually to the environmental conditions.

Embryo Culture

In embryo culture, the embryo is excised and placed into a culture medium with the proper nutrients in an aseptic condition. It is transferred to the soil for quick and optimum growth. It is especially important for making hybrids between different species and different genera and for getting rid of the embryo.

Protoplast Culture

In protoplast culture, the plant cell can be isolated with the help of wall-degrading enzymes and grown in a suitable culture medium in a controlled environment for regeneration of plantlets.

Under suitable conditions, the protoplast develops a cell wall, followed by an increase in cell division and differentiation, and grows into a new plant. The protoplasts are first cultured in a liquid medium at 25° C to 28° C with a light intensity of 100 to 500 lux or in the dark, and after undergoing substantial cell division, they are transferred into a solid medium for congenial or morphogenesis. Many horticultural crops respond well to protoplast culture.

Advantages of Micropropagation

- ✓ Production of millions of clones in a year. It would take a great deal of time to produce an equal number of plants using conventional methods.
- ✓ It provides a good alternative for those plant species that show resistance to conventional bulk propagation practices.
- ✓ Micropropagation is an alternative to vegetative mass propagation. Rapid plant growth is possible. Any variety can be mass-produced, and new variety development is halved.
- ✓ Large numbers of plants can be maintained in small spaces. This helps to save endangered species and the storage of germplasm.
- ✓ The micropropagation method produces plants free of insects, pests, disease and virus. Hence, disease-free varieties are obtained through this technique by using meristem tip culture.
- ✓ Proliferation of in vitro stocks can be done at any time of the year. Also, a nursery can produce fruit, ornamental and tree species throughout the year.

- ✓ Fast international exchange of plant material without the risk of disease introduction is provided. The time required for quarantine is lessened by this method.
- ✓ It is also useful for seed production in certain crops as the requirement of genetic conservation to a high degree is important for seed production. Through somatic embryogenesis, the production of synthetic artificial seeds is becoming popular nowadays.

Table 1: Ms Media composition

Component	Chemical Formula	Required Conc. (mg l ⁻¹) 1 ^x
Calcium chloride	CaCl ₂ .2H ₂ O	440.0
Potassium dihydrogen phosphate	KH ₂ PO ₄	170.0
Potassium nitrate	KNO ₃	1900.0
Magnesium sulphate	MgSO ₄ .7H ₂ O	370.0
Ammonium Nitrate	NH ₄ NO ₃	1650.0
Cobaltous chloride	CoCl ₂ .2H ₂ O	0.025
Copper sulphate	CuSO ₄ .5H ₂ O	0.025
Boric acid	H ₃ BO ₃	6.200
Potassium iodide	KI	0.830
Manganese sulphate	MnSO ₄ .H ₂ O	16.90
Sodium molybdate	NaMoO ₄ .2H ₂ O	0.250
Zinc sulphate	ZnSO ₄ .7H ₂ O	8.600
Ferrous Sodium EDTA	FeNaEDTA	36.7
Thiamine HCL	C ₁₂ H ₁₇ CIN ₄ OS.HCL	1
Nicotinic acid	C ₆ H ₅ NO ₂	0.5
Pyridoxine HCL	C ₈ H ₁₁ CINO ₃ .HCL	0.5
Myo-Inositol	C ₆ H ₁₂ O ₆	100
Glycine	C ₂ H ₅ NO ₂	2

Key Points of Micropropagation

- ✓ It is the propagation of plants by growing plantlets in tissue culture and then planting it out.
- ✓ It helps to produce plants with desired character-

istics.

- ✓ A large number of plants are produced from a single explant in a stepwise process.
- ✓ The plants produced are genetically identical to their parent plant.
- ✓ The plants are produced in the following stages including the establishment of the explant, multiplication of the explant in a culture medium, transfer of growing shoots into a medium for shoot development, transferring the plant in the soil for root growth, and allowing the growth and development of plants under optimum conditions.

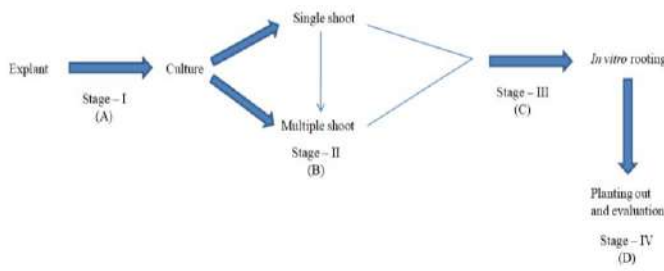


Figure 1: *In vitro* cloning procedure in fruit crops (A) Culture establishment (B) Shoot multiplication (C) *In vitro* rooting (D) Planting out and evaluation

Gene Knockout

Kavita and Lalit Kumar

Introduction

In recent years, many lower eukaryotes and plant genome has sequenced, discloses the protein coding genes *i.e.* gene rich regions. Such genes, recognized as open reading frames (ORF'S) generally have unidentified functions. To determine functions to these ORFs is next sound step in functional genomics *i.e.* genome annotation. Beside gene annotation there are further completely different approach such as gene knockouts "Gene knockout" approach, abbreviated as KO is a reverse genetics tool utilized to identify the function of a gene. "By means of either artificial mutagenesis or gene editing, loss of function of a gene can be induced to determine the function of a specific gene is known gene knockout method." In this method an organism is engineered to carry genes that have been suppressed and organisms having such genes are known as simple knockouts or knock out organisms. When two genes are eliminated simultaneously in an organism is known as double knock out (DKO). Similarly, three or four knockout genes are referred to as triple knockouts (TKO) or quadruple knockouts (QTO), respectively.

Procedure of gene knockout

1) Selection of target gene

The first stage in every genetic engineering

experiment is to choose the target, here, the target is a gene whose function we want to study and understand. The structure, length, and other aspects of our gene of interest are then investigated during some further dry lab work. After that, the desired gene is identified and mapped on a chromosome.

2) Vector construction

The extrachromosomal DNA of a bacterium utilised in genetic engineering operations is called a plasmid. A plasmid is generally used as the vector, which is a tool for delivering our gene of interest or any other DNA sequence to our target cells. Gene knockout techniques generally used BAC- bacterial artificial chromosome vector. Suppose, we have removed some of the ORFs- open reading frames from the gene and inserted an altered gene into the BAC. Now, on the safe side, a marker DNA sequence is also added to it to authenticate our results; usually, an antibiotic resistance gene is selected for it. Along with it, various other essential DNA sequences are also introduced into the plasmid, including the origin of replication, promoter sequence, and recognition sequences. "A marker gene is introduced only to make the insert detectable for reporting the results, it works as a reporter." One of the frequent reporter or marker sequences used in gene knockout research is the NeoR gene (neomycin resistance gene).

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Our plasmid is now ready for transformation

3) Insertion into ES cells

Our plasmid is now implanted into the embryonic stem (ES) cells utilising artificial techniques like electroporation, sonication, or microinjection because embryonic stem cells can divide faster and produce all different types of cells. The ES cells have the potential to develop into the mature mice tissues. The electrophoration approach, in which a gene is injected into the cell while being subjected to an electrical current, is one of the finest techniques used by scientists to knock down genes.

4) Identification of insert

When we grow our cells under in vitro conditions, it is possible that some cells may be transformed or others may not. Now using the polymerase chain reaction, the insert can be validated. For that, DNA is obtained from the cultured cells. A set of primers specific to our marker DNA sequence is used for ensuring amplification. If the amplicons are present means cells are transformed otherwise our study is failed.

5) Implanting into the embryo

Now pick transformed cells and place them into the growing embryo of our model organism. Let it develop normally.

6) Breeding

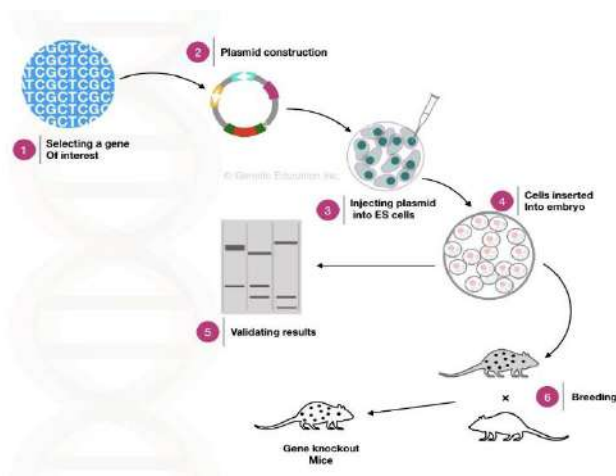
Now that the cell population in the embryo of our model organism consists of both wild-type and transformed cells, the animal is called chimeric. Now our chimeric animal has undergone genetic modification, we can breed it with a normal animal to produce offspring with either a homozygous normal genotype or a homozygous changed genotype (and heterozygous as well).

7) Examination

Scientists can now analyse our gene knockout animal for analyzing distinct parameters associated to our gene of interest. Genetic, biochemical or physical parameters related to our gene can be studied. The outcomes of gene knockout can then be verified using the PCR amplification technique.

Knockology

- Knockdown:** Refers to reduced gene expression results from the insertion of T-DNA into a promoter or 3' untranslated region.
- Knockon:** are typical mutations where the T-DNA construct contains a constitutive promoter that can drive the expression of genes nearby the site of insertion.
- Knockabout:** include T-DNA insertion in the coding area, resulting in partial suppression of gene expression.



Sources: Ranjan T. (2019)

- d. **Knock- knock:** include T-DNA insertion in the promoter or coding area, resulting in many knockouts in a same plant.
- e. **Knockworst:** include such T-DNA insertion events that include major chromosomal rearrangements. Such T-DNA mediated rearrangements have been observed in *Arabidopsis*.

Methods of gene knockout

- A. **Gene silencing:** RNAi or RNA interference is cells natural mechanism used for post-translational modification such are gene silencing or suppressing gene expression. Smaller double stranded-RNAs such as shRNA or siRNA are used for mRNA-target specific gene silencing. Using artificial methods or liposome, siRNA or shRNA can be introduced in the cell which is recognised by the cells defence mechanism and processed in the RISC. The “Ago” endonuclease helps to separate the guided-strand and passenger strand in which the guided strand binds to the target mRNA and inhibits protein formation. Either the guided-strand binds to exact complementary sequences on the mRNA or on the 3’ untranslated region of the mRNA and prevents gene expression.
- B. **Conditional knockout:** The conditional knockout methodology is utilized to inactivate the gene in a specific tissue at a specific time for a specific function. In addition, homologous recombination is used to knock out in the adult animal as opposed to the embryonic stage.

The conditional gene knockout method can be used with mammalian model organisms to study severe diseases like cancer.

- C. **Homologous recombination:** Homologous recombination is one of the traditional and mostly utilised techniques for studying gene knockout in genetic engineering. Through homologous recombination, nucleic acids are exchanged across identical or homologous sequences. And researchers are using this concept to replace the gene of interest for the target gene. Using artificial techniques like electroporation, microinjection, or sonication, identical DNA sequences of up to 2 Kb are inserted in the vector along with the antibiotic resistance gene and then incorporated in the target genome. Once the vector is introduced into the cell it recombined with the target DNA sequence thus our desired DNA with the antibiotic resistance gene place in into the target genome. This method is one of the simple and efficient methods used since long, however, the effectiveness is very low.
- D. **Gene editing:** In modern genetics, one of the emerging techniques is gene editing, where researchers use nucleases to alter nucleic acid by homologous recombination. Gene-editing nucleases utilised in genetic engineering include ZFNs, TALENs, and CRISPR-CS9. All three techniques use a site-specific nuclease to create a double-stranded cut in the DNA, which is then restored by the cell's own DNA repair system

using non-homologous end-joining. ZFN and TALEN are the conventional and outdated method, although the CRISPR-CAS9 is more effective and efficient CRISPR stands for clustered regularly interspersed short palindromic repeats, which are found naturally in bacteria. Using CAS9 protein-nuclease, it cuts the foreign nucleic acid to safeguard the bacteria.

E. Gene knockout by mutation: A loss of function mutation can assist to suppress gene function by inducing a mutation. Scientists can induce mutation in a gene using either physical or chemical mutagens, but the specificity and accuracy are quite poor.

Applications

- ✓ The development and utilization of gene knockout mice has marked a significant advancement in the biomedical and pharmaceutical fields and given researchers a highly effective tool for examining how genes work both during normal development and in diseases.
- ✓ In addition to this, gene knockout method is also used in the production of drugs for the treatment numerous diseases.
- ✓ Gene function assignment and identification in Arabidopsis following genome sequencing.
- ✓ RNAi gene knockdown technique is currently being used by researchers to identify the genes involved for the blue colour of rose petals.
- ✓ Additionally, it is utilized in the plant genomic research. Different knockout plant species can be

generated for testing numerous stress resistance phenotype.

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Role of Modern Farming Technology in Agriculture

Jyoti Sihag and Poonam Yadav

Introduction

There is drastic transformation of agriculture over the past 40 years. The practices are evolving to embrace new technology. Agricultural sector is the backbone of every economy in the world. There is high demand of food and this is a challenge because there are constraints in supply due to climate change and high labor cost. Every decade, there is a continuous revolution of technology in agricultural industry. Modern agricultural technology increases employment, efficiency in production of food, saving on time and reduction in cost. Farmers gain significant benefits from high innovation of technology. Farming is part of entrepreneurship and a business that fully depends on the nature. However, agriculture is not all about success, farmers are also faced by challenges that are unavoidable. These problems are caused by enormous changes in climate because of increase in greenhouse emissions that lead to global warming, use of fossil fuel, deforestation and other factors.

Recent trends in agricultural growth technology

Modern irrigation

Farmers are embracing new technology by use of irrigation on their crops (Fig. 1A). By the help of the state developing boreholes and dams in dry

regions to assist the farmers pump clean water to irrigate the plants. This increases the production and supply of food throughout the year.

Soil and water sensors

Perhaps the equipment having the most immediate effect is soil and water sensors. These sensors are durable, unobtrusive and relatively inexpensive. Even family farms are finding it affordable to distribute them throughout their land, and they provide numerous benefits. For instance, these sensors can detect moisture and nitrogen levels and the farm can use this information to determine when to water and fertilize rather than rely on a predetermined schedule. That results in more efficient use of resources and therefore lowered costs, but it also helps the farm be more environmentally friendly by conserving water, limiting erosion and reducing fertilizer levels in local rivers and lakes (Fig. 1B).

Weather tracking

Although we still make jokes about our local meteorologists, the truth is that computerized weather modeling is becoming increasingly sophisticated. There are online weather services that focus exclusively on agriculture, and farmers can access these services on dedicated onboard and handheld farm technology but also via mobile apps

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that run on just about any consumer smart phone (Fig. 1C). This technology can give farmers enough advanced notice of frost, hail and other weather that they can take precautions to protect the crops or at least mitigate losses to a significant degree.

Satellite imaging

As remote satellite imaging has become more sophisticated, it's allowed for real-time crop imagery (Fig. 1D). This isn't just bird's-eye-view snapshots but images in resolutions of 5-meter-pixels and even greater. Crop imagery lets a farmer examine crops as if he or she were standing there without actually standing there. Even reviewing images on a weekly basis can save a farm a considerable amount of time and money. Additionally, this technology can be integrated with crop, soil and water sensors so that the farmers can receive notifications along with appropriate satellite images when danger thresholds are met.

Pervasive automation

Pervasive automation is a buzz term in the agriculture technology industry, and it can refer to any technology that reduces operator workload. Examples include autonomous vehicles controlled by robotics or remotely through terminals and hyper precision, such as RTK navigation systems that make seeding and fertilization routes as optimal as possible. Most farming equipment already adopts the ISOBUS standard, and that puts on the precipice of a farming reality where balers, combines, tractors and other farming equipment communicate and even operate in a plug-and-play manner (Fig. 1E).

Mini-chromosomal technology

Perhaps one of the most exciting advents in agriculture technology is coming in a very tiny package. A mini-chromosome is a small structure within a cell that includes very little genetic material but can, in layman's terms, hold a lot of information. Using mini-chromosomes, agricultural geneticists can add dozens and perhaps even hundreds of traits to a plant. These traits can be quite complex, such as drought tolerance and nitrogen use. However, what is most intriguing about mini-chromosomal technology is that a plant's original chromosomes are not altered in any way (Fig. 1 F). That results in faster regulatory approval and wider, faster acceptance from consumers.

Farm machinery

Farmers have been facing high cost of labor, which demand for better methods to minimize the cost of labor. The innovation of machinery such as combined harvesters and planters simplifies the task and reduces the cost of labor. The automation of autopilot sprayers and tractors boost efficiency of the farm production.

Modern greenhouse

The heat from the sun is used by plants (solar radiation) to grow. The heat from sun is used to generate optimal temperature for the crop growth. Greenhouse farming generates favorable climate for production of horticulture, such as vegetables and flowers throughout the year. With automated irrigation systems and soil sensors is used to figure out the problems arising from green house.

The increasing demand of food requires high growing of the crops. Greenhouse technology helps in availability of production of food and makes full use of the available resources (Fig. 1G).

Artificial intelligence

It helps in precision agriculture. Artificial intelligence helps the farmers to detect diseases, controlling pests in crops and monitor soil PH. Like human intelligence, the machine can accomplish tasks that are complex. It has become so difficult for the farmers to predict the climate due to global warming (Fig. 1H). The farmers cannot determine the sowing period, but with the aid of artificial intelligence farmers can smile. They can know the weather changes by the use of weather forecast.

Indoor vertical farming

Our population is growing rapidly and the demand of food is also increasing, there is need of high supply (Fig. 1I). To feed the billions of people it requires more innovative ways of growing food. Vertical farming is one of the best innovations. Crops are grown vertically stacked layers, which allow preservation of space and high productivity. It is practiced in urban areas due to very limited space.

Conclusion

The evolving technology in agriculture is gaining substantial benefits in high productivity, less cost of production, increase in efficiency and increase in income. There is high demand of food due to the increasing population. The farmers face difficulties in climate change and high cost of production, but it will never stop them from produc-

ing. The modern technology is important for the farmers to minimize the constraints. Farming is not only about weather and high production but also involves data collection and embracing the modern technology. As technology continues advancing agriculture becomes progressively worthwhile. Modern agriculture will not only help the farmers to automate their activities but helping farmers to shift to precision agriculture.

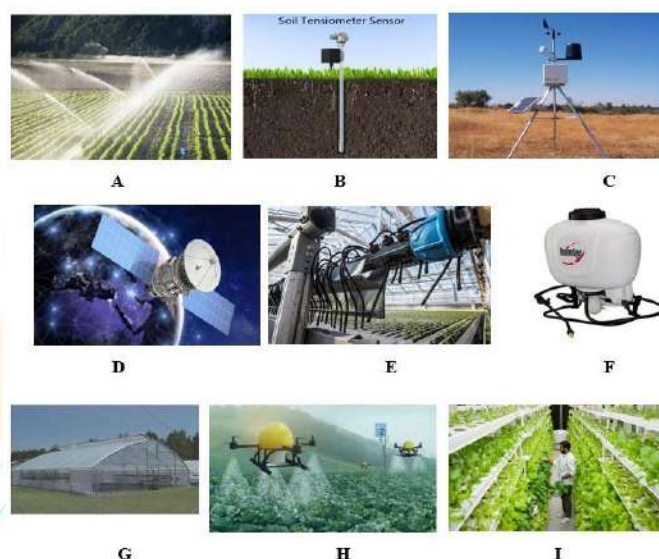


Fig. 1. Recent trends in agricultural growth technology. A) Modern irrigation; B) Soil and water sensors; C) Weather tracking; D) Satellite imaging; E) Pervasive automation; F) Mini-chromosomal technology; G) Modern greenhouse; H) Artificial intelligence; I) Indoor vertical farming

Organic Carbon in Soil: The Untapped Resource

Kanik Kumar Bansal and Boreddy Jayachandra Reddy

Introduction

Carbon (C), one of the most abundant elements in the universe, is found practically everywhere on Earth, including the air, seas, soil, and rock. As part of the geologic record, rock includes carbon, notably old deposits that gave birth to coal, oil, and other contemporary energy sources. Furthermore, carbon is a component of all plants and animals on the earth and is required for life to exist. Because of its unique bonding characteristics, it can mix with a wide range of other elements. Soil organic carbon may be found in soil organic matter. It includes both relatively inert carbon in plant-derived compounds like humus and charcoal, as well as immediately accessible carbon in the form of fresh plant residues. Soil organic carbon is a quantitative component of soil organic matter. There are two types of carbon in soil: inorganic and organic. Soil inorganic carbon is made up of mineral forms of carbon that arise as a result of weathering of parent material or reactivity of soil minerals with atmospheric CO₂. In desert settings, carbonate minerals constitute the major type of soil carbon. Soils hold a considerable amount of the carbon consumed in the contemporary cycle of this element.

Soils have a Pg C content of 1,500 (1 Pg = roughly 10¹⁵ g) and may function as net CO₂ generators or sinks over the earth. Soil organic matter (SOM), of which 58 percent is carbon (C), accumulates when an ecosystem develops as a result of interactions between biota (such as autotrophs and heterotrophs) and external influences (e.g., temperature, moisture). Soils have become net carbon dioxide producers in the atmosphere due to major land use changes and agricultural activity during the last 200 years.

The Indian situation

According to estimates, the total SOC pool in Indian soils is 21 Pg to a depth of 30 cm and 63 Pg to a depth of 150 cm. The SOC pool in Indian soils is 2.2% of the global pool at 1 m deep and 2.6% at 2 m depth (Lal, 2004c). 500 million domestic animals live there, and it is home to 1.1 billion people, or 16% of the world's population. There are 329 million hectares of land resources, but only 161.8 million hectares are arable land (11.8 percent of the world), 68.5 million hectares are forest and woodland (1.6 percent of the world), 11.05 million hectares are permanently pasture (0.3 percent of the world), and 7.95 million hectares are unproductive land of perm-

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anent crops (6.0% of the world). Around 12 million hectares of land are degraded in one or more ways as a result of salt, alkalinity, wind erosion, water erosion, etc. The extensive land base has the ability to reduce C emissions, increase productivity, and boost environmental quality. Thus, SOC sequestration is a circumstance where everyone benefits.

Factor van Bemmelen

The primary constituent of soil organic matter that can be quantitatively quantified is carbon (C). By multiplying the value for organic-C by the standard "Van Bemmelen factor" of 1.724, values for the organic-C content of soils can be represented as such or given as total organic matter. All quantitative estimates of organic carbon start with techniques for calculating the total carbon in soils via wet or dry combustion.

Organic carbon role in agriculture and its importance

The Carbon Cycle and Agriculture Carbon is an essential element and contributor to good soil conditions as well as soil function and productivity. Whether the carbon stays in the soil or is released into the atmosphere is heavily influenced by soil management. Agricultural activities can have an effect on the quantity and make-up of soil organic carbon, as well as the soil's physical, biological, and chemical state, which together characterize soil health. Therefore, agricultural methods that alter carbon have an impact on soil resilience (the soil's capacity to withstand extreme weather), agricultural

production, and the carbon cycle itself. Organic Carbon in Soil Farmers have a genuine interest in conserving and raising soil organic carbon for specific areas since soil and yield tend to improve when the level of soil organic carbon grows. Farmers have the capacity to influence the carbon cycle on a massive scale, frequently through the release of carbon. Increased tilth or soil structure is a result of higher soil organic carbon, which increases physical stability. This lowers the risk of erosion and nutrient leaching while increasing soil aeration (the amount of oxygen in the soil) and water drainage and retention. The fertility and nutrient-holding capacity of a field are both influenced by the chemical composition and biological productivity of the soil, which also includes soil organic carbon. By "sequestering" more carbon in the soil, the chance of other nutrients being lost to erosion and leaching is decreased. While physical disturbances of the soil can result in a net loss of carbon into the environment due to the generation of carbon dioxide, an increase in soil organic carbon often results in a more stable carbon cycle and increased overall agricultural output (CO₂). Since there is twice as much carbon in the soil as there is in the atmosphere, soil serves as a significant carbon storage area. The advantages of SOC are directly related to the functions it performs as a nutrient repository, a source of soil fertility, and a contributor to soil aeration, hence reducing soil compaction. Soil organic matter plays an important role in many physical, chemical and biological processes in soil.

How much of the soil organic carbon that enters soil stays there?

Up to 90% of the organic carbon that enters a soil as organic wastes is broken down by microorganisms. They breathe the carbon back into the atmosphere as carbon dioxide as a result. Depending on the soil type and temperature, up to 30% of organic inputs may eventually be transformed to humus; however, in Australian agricultural soils, this proportion is frequently much lower. The ability of a particular soil type to retain SOC is primarily influenced by three elements. Clay-rich soils typically hold onto organic matter longer than sandy soils, and can therefore hold onto more organic carbon. SOM may be impacted by soil type, climate, and management, and is essentially determined by inputs minus losses. SOM rises when inputs exceed losses, and vice versa. Although soil amendments or animal byproducts from production may also result in inputs, plant biomass production accounts for the majority of inputs. Organic matter decomposition and, in some situations, soil erosion both result in losses.

Root effects on soil organic carbon

Generally speaking, soil organic carbon (SOC) dynamics are controlled and influenced by plant roots, who predominantly add organic C to the soil in the form of root litter and rhizodeposition. Especially when plant roots encourage SOC stabilization, this C intake increases SOC. Roots, on the other hand, might potentially encourage SOC destabilization, exposing previously protected C to

microbial breakdown that results in SOC loss. The majority of the time, the contribution of plant roots to SOC stabilization has been examined separately from their contribution to destabilization. Plant roots weaken SOC and hasten its deterioration.

Impact on agriculture

The foundation of sustainable agriculture is soil organic carbon. In order to enhance soil health and yield, farmers are interested in maintaining and growing soil organic carbon for specific fields. The ability of soil organic carbon to preserve soil fertility is one of the primary causes of this. SOC increases drainage, microbial development, soil aeration, and water retention capacity. Carbon is "sequestered" (long-term storage) when soil carbon content rises, lowering the danger of nutrient loss from leaching and erosion. A better climate for plant growth is created when the amount of carbon in the soil is raised since this lowers the amount of carbon dioxide that is present in the atmosphere. A more stable carbon cycle and greater overall agricultural output are the outcomes of increasing soil organic carbon.

Practices to Promote Soil Carbon Storage

A crucial ecosystem service is soil carbon storage. Due to inappropriate soil management practises including excessive tillage, higher irrigation rates, increased use of chemical fertilisers, etc., soil carbon is lost on agricultural land.

- ✓ One of the most effective methods for leaving the soil undisturbed is the practice of zero-tillage.
- ✓ Soil fertility can be maintained by introducing

proper management strategy for grazing and by reducing the use of chemical fertilizers. Replacing chemical fertilizers with organic fertilizers and manures will help to restore the soil health.

- ✓ Erosion of top soil which brings down the amount of carbon present in soil can be controlled by maintaining the ground cover. Growing cover crops like eucalyptus can reduce the wash away of top soil.
- ✓ Excessive irrigation can deteriorate soil health. So the amount of water supplied to the plants should be according to its needs, not more, not less.
- ✓ Another method of increasing carbon storage is by growing high yield, high biomass crops.
- ✓ The amount of carbon present in the soil will increase if the crop frequency of a place is maximum.

Depletion of Soil Organic carbon

In contrast, it has been reported that good farming practices like balanced fertilization and the addition of crop residues either maintain or cause a buildup or depletion of soil organic carbon (SOC) stock. There is clear evidence of a decline in the organic carbon (OC) contents in many soils in India as a result. The process of nutrient depletion, soil erosion, and other processes of land degradation speed up the fall of organic matter.

In India, the addition of organic matter was regarded as being so crucial that many studies using organic manures were carried out in the early 1970s.

Numerous negative ecological and economic effects follow from its decline. Crop yield and productivity rise along with an increase in SOC in both fertilized and unfertilized fields. The production of both micro- and macro-soil aggregates depends in large part on the soil organic carbon pool. SOC concentration directly correlates with the level of aggregation and the stability of aggregates. Significant effects on soil structure and, consequently, on water infiltration, water holding capacity, aeration, soil strength and resistance to root growth, and surface crusting result from the role of SOC in the creation of stable soil aggregates. The biggest impact of SOC can be on these physical components of soil fertility in conditions where soil moisture or soil strength are significant constraints on plant growth.

Soil organic carbon content is affected mostly by climate, texture, hydrology, land use and vegetation.

Climate: Since organic matter decomposes more quickly at higher temperatures, warmer-than-colder regions typically have soils with lower levels of organic matter.

Soil texture: The organic content of fine-textured soils tends to be higher than that of coarse-textured soils, and they are better at holding water and nutrients, which promotes plant growth. Because oxygen is present, organic matter decomposes more quickly in coarse soils because they are better aerated.

Soil hydrology (drainage): Because there is less

oxygen available for organic matter to decompose in moister soils, more organic matter builds up.

Land use (tillage): Increased rates of organic matter decomposition are a result of tillage, which introduces oxygen into the soil and increases its average temperature. Additionally, organic matter is lost because erosion removes topsoil and humus. Overall, compared to natural vegetation, cropping returns less organic matter to the soil.

Vegetation: The organic matter in soil is greatly increased by roots. Deep roots that rot deeply in the soil are produced by grassland. In contrast, forest soils predominantly rely on surface litter degradation as an organic matter source. Compared to roots, crops produce greater biomass above ground. The amount of organic matter added to crops depends on the methods used to manage the land, including whether crop residues are removed or not.

How to Achieve This?

An essential step in preserving the soil organic carbon content is to monitor the field to determine whether the change in management is replenishing or depleting the carbon resource. Remote sensing technologies can be used to do this. Since soil varies from site to site, even within the same field, quantitative and qualitative estimation of soil using the standard method is challenging. Remote sensing is a quick and efficient way. The FARMONAUT software creates a SOC image using remote sensing technologies to provide a colour map of the percentage of organic matter present in the chosen field. The area shows dark green on the colo-

ur map if the SOC concentration is greater than 5%, and red if the SOC content is less than 1%. Remote sensing is also used in FARMONAUT to track changes in SOC content over time. This gives farmers exact information that enables them to act appropriately, when appropriately, and where appropriately, ensuring productivity and soil health. Farmers can have soil testing done on those places and give the necessary nutrients to those regions to rejuvenate the soil organic matter levels once Farmonaut data has identified specific sites as having reduced SOC levels. Better yields will result from this in the end.

Alternate Wetting and Drying: A Water saving Production System

Kanik Kumar Bansal and Kanwaljit Singh Sandhu

Rice (*Oryza sativa* L.) is the single most important crop, feeding more than half of the world's population and meeting 35-60% of daily calorie requirements in Asia. Rice farming has reached 167 million hectares (mha), the most of which is farmed under perpetually flooded circumstances. Rice is often regarded as a high delta crop, which explains why it is traditionally farmed in lowland areas under continuously flooded (CF) conditions. Rice, on the other hand, may be cultivated effectively with less water if resource saving practises are used. DSR and AWD are the most appealing water-saving strategies, and they are used in many places of the globe.

The potential benefits of an AWD system include: requiring 23-33% less water, improving grain quality by reducing total As (by 50%) and Hg content in rice grains, reducing anthropogenic GHG emissions by 45-90 percent (Linguist *et al.*, 2015), improving water use efficiency (WUE), and maintaining or even increasing grain yield. In rice, intermittent watering with AWD was efficient in reducing insect pest (92%) and disease (100%) infestation.

Although data on irrigation management to avoid floods in rice and its impact on rice producti-

vity are still contradictory, the use of AWD systems has greatly reduced the global warming potential (GWP) and water usage. For example, there have been reports of increased and decreased yield under the AWD system vs the CF system. These disparate findings highlight the necessity to evaluate and apply site-specific irrigation management solutions that take soil characteristics, drainage frequency, flooding cycle length, and variety adaptation into account. By lowering the GWP, a combination of water-saving production systems and water-saving irrigation systems may assist boost water productivity, water usage efficiency, and economic returns.

What is AWD?

Alternate Wetting and Drying (AWD) is a water-saving method that farmers may use to minimise irrigation water consumption in rice fields without reducing production. Irrigation water is supplied a few days after the ponded water has disappeared in AWD. As a result, the field alternates between being flooded and not being inundated. The number of days of non-flooded soil between irrigations may range from one to more than ten based on a variety of variables such as soil type,

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weather, and crop development stage.

How should AWD be implemented?

AWD may be securely used by employing a 'field water tube' ('pani pipe') to monitor the water depth on the field. The water depth will gradually drop after irrigation. When the water level has decreased to around 15 cm below the soil's surface, irrigation should be used to re-flood the area to about 5 cm. The field should be maintained wet from one week before to one week after blooming, topping up to a depth of 5 cm as required. After blooming, throughout grain filling and ripening, leave the water level to fall to 15 cm below the soil surface before re-irrigating.

After transplantation, a field tube in flooded field AWD may be initiated a few weeks (12 weeks). When there are a lot of weeds, AWD should be delayed by 23 weeks to let the ponded water control the weeds and boost herbicide potency. Fertilizer recommendations for flooded rice may be followed. Apply N fertiliser shortly before watering, especially on dry soil.

The field water tube (Pani pipe)

The field water tube should be made of 30 cm long plastic pipe or bamboo with a diameter of 10-15 cm so that the water table is plainly seen and dirt can be easily removed within. Perforate the tube on both sides with several holes to allow water to flow freely in and out of the tube. Hammer the tube into the earth until it protrudes 15 cm above the soil surface. Take cautious not to go through the plough pan's bottom. Remove the dirt from within the tube until the bottom

is visible.

Water 15 cm below the soil surface: It's time to re-irrigate the field

When the field is flooded, make sure the water level within the tube is the same as the water level outside the tube. If it is not the same after a few hours, the holes are most likely closed by compacted earth, and the tube must be carefully re-installed. The tube should be put in an easily accessible portion of the field near a bund so that the ponded water depth may be easily monitored. The position should be typical of the field's average water depth (i.e. it should not be in a high spot or a low spot).

Root and shoot growth

The AWD system promotes root and shoot growth and development. When the AWD approach is used in areas with an impermeable soil layer, root multiplication may be limited, limiting plant root and shoot development. A subsurface drainage system might improve oxygen availability to roots under these circumstances.

AWD system adoption and economics

End-users (farmers) embrace agricultural technologies based on their economic feasibility, ease of use, and environmental effect. Rice is critical to the economies of many nations throughout the globe. Rice farming employing the AWD irrigation technology improves the system's economic viability.

Conclusions

Alternate soaking and drying is a productive, economic, and environmentally beneficial approach

for rice farming worldwide. Efforts are being made to market it in water-stressed regions. When compared to CF, the use of mild/safe-AWD lowers total water inputs while maintaining or improving yield. Severe-AWD, on the other hand, decreases overall water inputs at the penalty of yield loss. The use of AWD on non-critical growth stages and thick textured soil yields increased yields.



Indigenous Technical Knowledge (ITKs) in Organic Farming

Sudhanshu Singh

Introduction

Indigenous Technical Knowledge (ITK) is the actual knowledge of a given population that reflects the experiences based on tradition and includes more recent experiences with modern technologies. Indigenous agricultural practices (IAPs) are an unwritten body of knowledge. There is no systematic record to describe what they are, what they do and how they do what they do, how they can be changed, their operations, their boundaries and their applications. It is held in different brains, languages and skills in as many groups, cultures and environments as are available today (Atte, 1989). Hence, there is immense pressure on the people of India to collect, preserve, validate and adopt IAPs so as to reduce dependence on external inputs, to reduce the cost of cultivation and to propagate eco-friendly agriculture (Sundramari and Ranganathan, 2003).

Indigenous Technical Knowledge is the local knowledge - knowledge that is unique to a given culture or society. It contrasts with the international knowledge system generated by universities, research institutions and private firms. It is the basis for local-level decision making in agriculture, health care, food preparation, education natural resource management and a host of other activities in rural

communities (Warren, 1991). ITK is the information base for a society, which facilitates communication and decision making. The advent of the concept of sustainable agriculture in late eighties in Indian agricultural scenario has evoked interest on indigenous technical knowledge (ITK) that has the element of use of natural products to solve the problems pertaining to agriculture and allied activities.

Characteristic of ITKs

1. The basic characteristics of the ITKs provide for conservation and efficient utilization of resources by being eco-friendly, less capital intensive, cost effective, and efficient byproduct and waste recycling and use.
2. Most of the ITKs are location - specific, using locally available materials and are products of informal research.
3. ITKs are found to be socially desirable, economically affordable, sustainable, and involves minimum risk to users and widely believed to conserve resources.
4. ITK provides basis for problem solving strategies for local communities. In addition, the use of ITK assures that the end user of specific development projects are involved in develop-

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ing technologies appropriate to their

Role of ITKs in the traditional non-chemical agriculture

Successes in agricultural front with high production levels, especially in food grains have indeed been achieved. But more energy in the form of mineral fertilizers, chemical pesticides and farm machinery are required every year to produce the same quantity of farm products. The yield plateau of crops in Punjab, Haryana, Western Uttar Pradesh and other states strongly indicate that there is a disturbance in our natural resources management and the present practices are not conducive to sustainable agriculture. Area covered by soil degradation has increase by almost 800 lakh hectares. Soil degradation has already consumed 57 per cent of the country's area. Apart from soil erosion, in-situ degradation like water logging, salination and nutrient depletion is responsible for a loss of up to 26 per cent of the annual agricultural output. Another major cause of concern, particularly in the core Green Revolution belt, has been the decrease in genetic diversity of major HYV crops, which has increased the potential danger for sudden widespread loss of crops from unknown / uncontrollable diseases.

Depletion of natural resource base due to deforestation, over grazing, desertification, excessive agricultural intensification, over fishing and agriculture on marginal lands leads to decline in agricultural production potential leading to decrease in the sustaining / carrying capacity of agriculture. Natural resources (soil, water, nutrients) have bound-

aries and improved management is needed to reverse the degradation of this resource base and develop agricultural production systems that sustain our ecosystem. It is estimated that without conservation measures on the rainfed lands for soil erosion by wind or water, salination or alkalination, depletion of plant nutrients and organic matter, deterioration of soil structure and pollution total productivity loss will amount to 29%, and loss of 544 million hectares of cropland all over the world. Thus, sustainable agriculture involving sustenance of our agricultural systems should be the major emphasis for all technological innovations involving land and water use so that there is no adverse effect on the biological productivity of the resource base in the long run. Sustainable agriculture is the sustainable exploitation of renewable natural resources including annual and perennial cropping, agro-forestry and livestock as well as the conservation measures needed for long term maintenance of resources. The intensive agriculture resulted in depletion of nutritional status of soils, erosion of biodiversity, natural habitats, forests and water resources. Indiscriminate use of chemical pesticides and fertilizers affected the agro ecosystems, caused pollution of soil and water resulting in human and animal health hazards and contributed significantly to destabilize the traditional systems of agriculture. When the farmers practiced integrated crop management, integrated nutrient management and non-pesticidal management which are the major components of sustainable agriculture, the cost of

cultivation reduced by 6.7 percent, and net income increased by 57 percent in Pigeon pea; in Paddy due to adoption of sustainable agriculture practices, the cost of cultivation reduced by 15.2 per cent and net income increased by 98 per cent in vegetables, the cost of cultivation reduced by 27.5 per cent and the net income increased by 36.3 per cent needs.

Some Famous ITKs developed by progressive organic farmers which have been scientifically validated by universities/ organizations



1. Bijamrut

Ingredients

Cow Dung- 5 kg, Cow urine- 5 L, Cow milk- 1 L, Lime- 250 g and Water- 100 L

Method of use: Sprinkled over the seeds before they are sown as seed treatment.

Scientifically Validated by: TNAU, Coimbatore and CSKHPKV, Palampur

2. Sanjivak

Ingredients

Cow urine-100 L, Cow dung-100-200 kg, Jaggery- 500 g and Water-300 L Kept for 10 days (Fermentation)

Method of Application: (Diluted 20 times before

use)

- ✓ Along drip irrigation
- ✓ Foliar spray
- ✓ To enrich soil with microorganisms for quick residue decomposition.

Scientifically Validated by: University of Stellenbosch, South Africa

3. Jivamrut

Ingredients

Cow dung- 10 kg, Cow urine- 10 L, Jaggery- 2 kg, Flour of gram (Tur, Moong, Cowpea, Urad) - 2 kg and Live soil (Healthy soil)- 1 kg and Water- 200 L

Uses

- ✓ Promoting growth and flowering along with acting as a yield enhancer (@5-10% spray with water)
- ✓ Soil fertility enhancer (applied along with irrigation water)

Scientifically Validated by: TNAU, Coimbatore, CSKHPKV, Palampur and UAS, Bangalore

4. Amritpani

Ingredients

Cow dung- 10 kg, Honey- 500 g (can be replaced by 500 gm jaggery), Cow desi ghee- 250 g or 250 ml mustard oil and Water- 200 L

Uses

Soil fertility enhancer (@ 200 ltrs per acre along with irrigation water)

Scientifically Validated by: NEERI (CSIR Institute), Nagpur

5. Panchagavya

Panchagavya is an organic product having

the potential for promoting growth and providing immunity in plant system.

Ingredients

Cow dung slurry- 4 kg, Fresh cow dung- 1 kg, Cow urine- 3 L, Cow milk- 2 L, Curd- 2 L and Cow butter oil-1 kg

Method of Application

Three litres of Pachagavya diluted in 100 L water

Uses

- ✓ Seed and seedling treatment
- ✓ As a soil fertility enhancer by applying through irrigation water

ITK in Organic Farming

There are many practices of ITK out of which some are discussed here: Pre-sowing practices - Soil and water management practices - Pest and disease management - Post-harvest management

- ✓ Effective for weed mgmt → these mulches act as organic matter to enhance the crop → Tree leaves (karanj-pongamia ponnata) and paddy straw are used as mulch materials. This conserves the soil moisture and simultaneously keeps the soil cool which provides favourable conditions → Mulching
- ✓ Jhum cultivation/Slash & the trees are slashed well suited to the heavy rainfall areas of the north east India. Burn cultivation/Shifting cultivation. After cultivating for 2 - 3 years, fields go into fallow. Then, the farmer moves on to the next plot or forest area to protect the soil and allow for buildup of nutrients. Soil erosion is controlled and fertility maintained by constru-

cting contour bunds often May reduce the incidence of soil born diseases. Burned and the seeds are sown only after the 1st rainfall.

- ✓ Irrigation practices- Bamboo drip irrigation: Bamboos divert water from perennial springs on hilltops to the lower reaches by gravity. Used to irrigate the betel leaf or black pepper crops.

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E-Pashuhaat: Online Portal for Livestock Trading

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Abstract

‘E-Pashuhaat’ is an online portal created by the government of India to encourage farmers and entrepreneurs to take up the dairy business, where people can buy or sell livestock, frozen semen, and embryo. Currently, there is no organized market for livestock trading. Therefore, this electronic market will help farmers not only buy or sell live cows and buffalos but also frozen semen and the embryos of livestock. E-Pashuhaat portal is playing an important role in connecting farmers & breeders to trade in disease-free germplasm in the state, central, co-operative, milk federations, & private agencies. It forms links between ‘farmer to farmer’ & ‘farmer to institutes. Therefore, it minimizes the participation of intermediaries.

Introduction

In order to increase dairy productivity in India by organizing the livestock market, the Department of Animal Husbandry, Dairying and Fisheries (DADF) of the Indian government created the website E- Pashuhaat. It is India’s first online market for livestock. Through this portal, farmers can now buy livestock, frozen semen, and frozen embryos and get services at their doorstep. The farmer needs to visit website and login for the trading of required livestock across state.

Need for online market

In recent times dairy production has appeared to be going down largely. Farmers who are involved in livestock trading are facing a lot of problems these

days as they are not receiving enough livestock to grow their production. Looking at such a situation the central government has decided and launched an online portal for the farmers across the nation through which the farmers can trade their livestock, buy and sell embryos, semen, and a lot of supplies to boost daily production.

Benefits of E- Pashuhaat

- ✓ This is an online portal and farmers do not requisite to run from one place to another to get the livestock they want.
- ✓ With this portal farmers from one state can trade with farmers from another state.
- ✓ There is a home delivery facility under this portal.

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- ✓ Farmers who are buying livestock from the portal can get them at their access without going anywhere.
- ✓ There is a proper transportation system under the e-Pashuhaat to transfer the animals from one state to another.

Services provided by E- Pashuhaat

Number of services provided by portal. Interested buyers can apply for them after successful online payment. The list of services is as follows:

- ✓ Training
- ✓ Animal certificates services
- ✓ Certification verification services
- ✓ Nutritional advisory service
- ✓ Good care practice
- ✓ Health card services
- ✓ Fodder services
- ✓ Disease screening and testing
- ✓ SMS reminder services
- ✓ Mail reminder services

Beneficiaries

Farmers who are engaged in livestock and dairy productions are the main beneficiaries of the scheme. E-Pashuhaat also certified livestock traders are also eligible to trade over the e-Pashuhaat.

Operations of E- Pashuhaat

The portals are operated across the country. E-Pashuhaat is an online portal anybody from India can use the portal and register under it. The portal is available in every city and region of the country. E-Pashuhaat has the transportation facility that deliver the livestock at any place within the boundary of the

nation.



How to use the portal

There are few steps that the farmers need to be followed to use the website and trading opportunities.



Step 1: Visit the official website <http://www.epashuhaat.gov.in/>. In the home page farmer will get a tab that says “Seller login”, click on the tab.

Step 2: Once He/she clicks on the tab, you will be directed to the online login form that is available on the website. This form is for the existing members to login to the portal. You will get a tab ‘register’ alongside the login tab, click on the register tab.

Step 3: Enter the details that are required. The details such as whether you are a farmer or a certified trader, name, address, and district including your address and contact information.

Step 4: Submit the form along with the required documents. A login ID and password will be generated after successfully registering with the portal. That login ID and password will be your official ID for using the e-Pashuhaat.

Step 5: Once you are registered you can start to exchange the livestock, frozen embryos, and semen of the dairy animals.

Major outcomes of the E- Pashuhaat:

- ✓ Propagation of quality-controlled germplasm
- ✓ Availability of disease-free semen with known genetic merit
- ✓ Price evaluation available to the buyer
- ✓ One-stop portal for bovine breeders
- ✓ No involvement of middlemen in trading of animals
- ✓ Sale only of labelled animals with an animal health card
- ✓ Dissemination of indigenous bovine breeds in the country
- ✓ Increase in milk production and productivity

Conclusion

The explosion in social media and internet marketing has been embraced by the animal husbandry sector, giving rise to an increasing number of online livestock “buy and sell” sites. These sites are free to advertise on, so prospective buyers should weigh up the risks and benefits before purchasing animals through these sites. The portal will provide detailed information to farmers about bovine animals. Farmers by opening this portal can get to know information like certified animals’

pictures, their parents’ information, breeding, the volume of milk given by bovine animals etc. Also, provide information about animal fodder varieties, their volume, and price information will also be made available at this portal. The portal will also assist farmers to buy advanced breeds of bovine animals at a reasonable price as well as to buy cattle frozen semen and embryo as per their requirements.

Biochar: Noval Option for Carbon Sequestration

Gourisankar Pradhan, Bishnuprasad Dash and Birendra Kumar

Abstract

Biochar, or charcoal used to amend land and sequester carbon, is gaining popularity. Its unique physical/chemical/biological properties, such as high water-holding capacity, large surface area, cation exchange capacity, elemental composition, and pore size/volume/distribution, have well-known effects, particularly on microbial communities. These are investigated in terms of agriculture, composting, and land remediation/restoration. Mycorrhizal associations are given special attention because they are critical to the use of biochar in environmental technologies. The properties of biochar, its availability for nutrient availability, such as the beneficial and potentially negative/inhibitory effects, as well as the necessary multidisciplinary analysis (physicochemical, microbiological, and molecular) to study these in-depth, are investigated.

Introduction

Carbon is the most abundant element in living things, accounting for roughly half of the total mass of plants and animals. It is well understood that the global C cycle is inextricably linked to global climate change, owing to anthropogenic carbon dioxide (CO₂) emissions from fossil fuel use and land use change (IPCC, 2007). CO₂ concentrations in the atmosphere have increased from 280 ppm in the preindustrial era to 419 ppm in 2021 (+37.549.64 %) and are currently increasing at a rate of 2 ppm yr⁻¹ or 3.5 Pg yr⁻¹ (1Pg =10¹² g) (IPCC, 2007). The global potential for C sequestration in agro-ecosystem soils

is approximately 2.1 billion tonnes of C year⁻¹ (Lal, 2010). Because a portion of the photosynthesized plant material is transformed into stable humic substances with a long longer residence time in soil, a rise in the soil C pool reduces CO₂ concentrations in the atmosphere. There are several approaches to carbon sequestration in agro-ecosystems but the most recent is the soil application of biochar, charcoal produced by low-temperature biomass pyrolysis under anaerobic environments (Zimmeman, 2010). Biochar is a highly carbonized material with varying C content based on feedstock and production conditions. Biochar is gaining popul-

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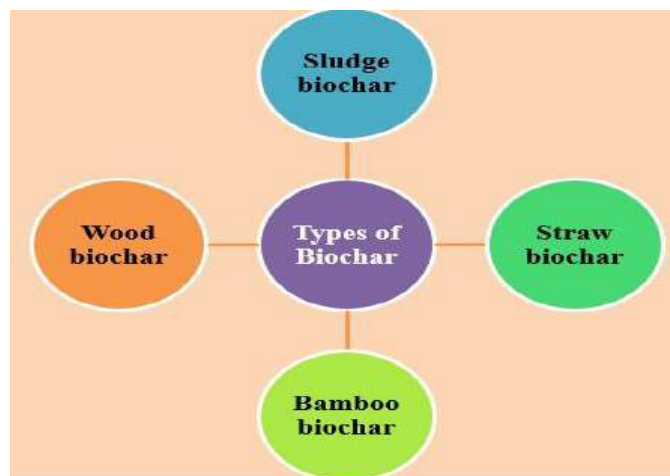
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arity as a possible tool for mitigating climate change via long-term biological carbon sequestration. The application of biochar for soil organic carbon sequestration has the potential to be 1 billion tonnes C year⁻¹ or greater (Sohi et al., 2010). If biomass is allowed to decompose in the open air, nearly all of the carbon is released into the atmosphere within a few years. Approximately half of the carbon in biomass is converted into biochar during pyrolysis. Around 2/3rd of the remaining 50% can be released as useful energy. Thus, 1 Mt of dry biomass sequesters (stores) 0.3 MT of carbon, which is equivalent to 1.2 MT CO₂ (Laird et al., 2010).

Carbon sequestration

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide over time (Sedjo et al., 2012). Carbon sequestration is the long-term storage of carbon dioxide or other forms of carbon to reduce or postpone global warming. It has been proposed as a method of slowing the accumulation of greenhouse gases in the atmosphere and oceans caused by the combustion of fossil fuels. Soils are the world's largest land-based carbon sink. Soils are the third largest global C pool, with 2 separate components: (i) soil organic C (SOC) pool approximated at 1550 Pg and (ii) soil inorganic C (SIC) pool approximated at 950 Pg, both to one-meter depth (Lal, 2004). Soil C sequestration refers to the long-term storage of C in soil, which could be achieved by using biochar as a soil amendment (Purakayastha et al., 2015).



Different types of biochar

Biochar used as a carbon sequestration

The incorporation of biochar into soils has been recognized as an essential strategy for mitigating the consequences of climate change by sequestering CO₂ into soils, thereby reducing the load of excess atmospheric CO₂. To achieve this goal of carbon sequestration in larger agro-climatic situations, we must keep the following two points in mind. First, we must persuade growers to cultivate the plants and appropriate crops while they are being charred because the actual step of sequestering atmospheric CO₂ with biochar is solely dependent on photosynthesis in plants. It has been widely reported that plant biomass synthesized in plants through the photosynthesis process on an annual basis can emit carbon into the atmosphere quickly due to faster decomposition. Plant biomass decomposition is incompatible with the biochar process and plays a critical role in the climate change process by releasing the majority of carbon in the atmosphere that is fixed.

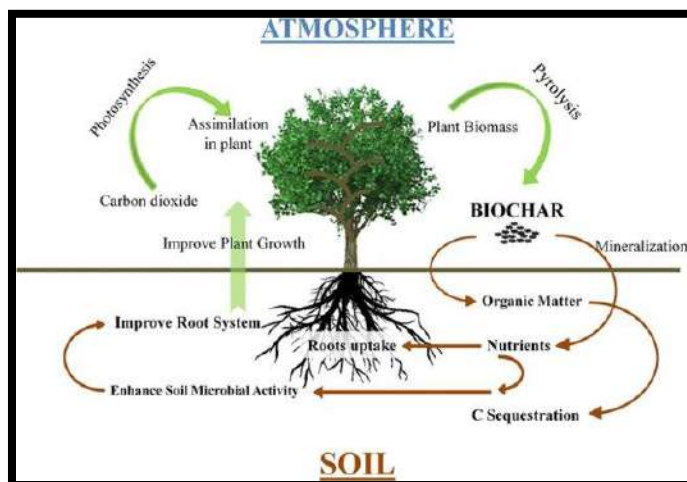


Figure 2 Carbon sequestrations through biochar

Effect of biochar on native soil organic carbon

The application of biochar has been widely reported to contribute to the soil's recalcitrant C pool (Glaser *et al.*, 2001). As a result, it's a promising alternative tool for sequestering more C when compared to traditional agricultural practices that involve direct incorporation of plant biomass in the form of crop residues, which results in rapid mineralization of C and higher CO₂ emissions into the atmosphere (Bruun *et al.*, 2011).

Conclusion

Soil biochar application increases crop productivity (yield and aboveground biomass) for up to 2 years, but it is unclear how long this benefit will last and whether soil C inputs will also increase. Biochar's effects on SOC balance, in particular, have not been thoroughly evaluated. However, biochar can help to mitigate climate change by sequestering SOC at deeper soil depths. To reduce the interaction of atmospheric CO₂ with the climate, mitigation requires that biochar results in a net removal of C relative to the atmospheric CO₂ pool in soil over long

periods of time (millennia).

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Role of Women in Agriculture and Allied Sector

Mrs. Priyanka Rana

To sensitize the learners regarding contribution of farm women in agriculture and allied areas. To create awareness among the learners about importance of women in agriculture.



Introduction

“Gender equality is more than a goal in itself. It is a precondition for meeting the challenges of reducing poverty, promoting sustainable development and building good governance”. Kofi Annan. The Indian farm women have extensive workloads with triple responsibility for farm, household and community. Gradually their work is becoming harder due to climate change, degradation of natural resources, natural calamities, male migration and changing agricultural technologies. Women are extensively involved in crop production, horticulture, livestock management, post-harvest operation, fisheries, agroforestry and household activities. Majority of their time is devoted towards collection of fuel, fodder and water, growing vegetables in homestead and rearing backyard poultry. They also considerably contribute for house

hold income as agriculture wage earners and through cottage industry.

Participation of Women in Agriculture

According to the Census of 2011, population ratio of India is 943 females per 1000 males, national literacy rate is 74.04 percent, but the workforce participation rate for females is 25.51% against 53.26% for males. Women remain as a backbone of agricultural workforce and represent 43% of the global agricultural labor force. They devote 45 - 50% of their time to agricultural activities, 79% of women continue to be engaged in agriculture and allied activities as against only 63% of men (Courtesy: Gender Reference Manual, 2016, ICAR-CIWA). While considering participation in agriculture, 89.5% of the total female employed in rural areas, is engaged in agriculture and allied sectors and about 70% of farm work is performed by women. India grows a variety of cereals, pulses, millets, oilseeds, cash crops, plantation crops and horticultural crops based on its regions where women play important roles. Dr. Swaminathan, the eminent agricultural scientist, describes that it was women who first domesticated crop plant and initiated the art and science of farming. Women play a key role in conservation of natural resources like land, water, flora and fauna. A recent study conducted by Women

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and Population Division of FAO revealed that in developing countries women provide 70% of agricultural labor, 60-80% labor for household food production, 100% labor for processing the basic food stuffs, 80% for food storage and 90% for water and fuel wood collection for households. They produce between 60 to 80% of the food in most developing countries and are responsible for half of the world's food production. Women involve themselves in almost all the agricultural practices such as: sowing, transplanting, weeding, other inter-cultural operations, harvesting, value addition and marketing.

Women in Animal Husbandry

Animal husbandry is the life line of Indian agro-based economy, by contributing 28% to GDP whereas dairy sector alone is contributing 15% of the Gross National Income. In the global scenario, India ranks first in milk production, 3rd in egg and 5th in chicken production. In animal husbandry, women play multiple roles with regional differences. In dairy sector, their roles ranges from cleaning of animal sheds, care of animals, milking, feeding, watering, grazing, fodder collection, chaffing and storage of fodder, cleaning of milking utensils, processing dung and milk into ghee, butter, khoa, etc. They also take health care of pregnant and sick animals and new born or young calves. Women make compost from dung and carry to the field. Sometimes they prepare cooking fuel by mixing dung with twigs and crop residues. Although women have negligible control over livestock and its products, still they play a significant role in livestock management and produ-

ction.

Women in Sericulture

In India, sericulture being one of the most important cash crops, are essentially a village based industry where women are mostly found as the major activist. Globally, Asia is regarded as the main producer of silk as it produces over 95 % of the total output. India has been ranked as the second largest producer of silk in the world and has 18% share in global raw silk production with an annual silk production of around 28,000 Metric Tons. Out of 6.39 lakh villages in India, sericulture is being practiced in about 69,000 villages (Central Silk Board, 2002; Geetha and Indira, 2011; Lakshmanan *et al.*, 2011), engaging nearly 60% women of the total work force in sericulture. In mulberry garden, they work in cultivation of silkworm food plants, inter-cultivation, weeding, application of Farm Yard Manure, leaf harvest& their transportation, pruning and silkworm larvae rearing for production of raw silk.

Women in Horticulture

Women play significant role in horticulture including production, post-harvest operation and value addition. In fruit cultivation, they are involved in weeding, irrigation, collection, sorting and grading. Participation of women in vegetable production is in field preparation, seed cleaning, seed sowing, transplanting of seedlings, weeding, harvesting, sorting and grading of vegetables. Sometimes they also go for manure application.

Women in Fishery

In India, out of the total 5.4 million active fishers, 3.8 million are fishermen and 1.6 million fisherwomen. According to FAO (2015), 70% of the global aquaculture workforce is female. In developing and developed countries, women are the bulk workers in postharvest, product transformation activities (FAO 2017). In Malaysia, women are 10% of the total aquaculture workforce, mainly in freshwater aquaculture & hatchery operations and in Sri Lanka, women workers constitute 5% (shrimp farms) and 30% (ornamental fish). India is among the top ten fish producing countries in the world.

Women in Forestry

Indian rural and tribal population are highly dependent on forests. In India, depending upon the socio-cultural variations, women are the major collectors and users of Non-timber Forest Products (NTFP). They collect fruits, nuts, roots, tubers, vegetables, mushroom, saps, gums, medicines, seeds, household items, building materials, horns, eggs, honey, furs, wild leaves and farm implements as they are aware of the properties and potential uses of these products.

Women in Rural Production

Indian rural women are engaged in wage labor, non-farm or off-farm income generating activities. Their involvement in major activities are through livestock, small enterprises, agriculture processing and home gardens. They process NTFPs for development of small-scale enterprises like basket, broom, rope and mat making, silk cocoon

rearing, bamboo works, lac cultivation, oil extraction and leaf plate making etc. Women also act as accelerators in transformation of economic, environmental and social changes.

Women in Food Security

Women play crucial role in ensuring food and nutritional security. They act as food producers of major grains and minor millets and processors of livestock and fishery products.

Women in Home Management

Women play traditional roles as wife, mother, friend, protector, baby sitter and so on. In many cases, women are the bread-winners and do most of the under reported and unrecognized household chores. Women spend more time on housework, wakes up first in the family and goes last to sleep. Rural women being the resource managers, are responsible for efficient household management.

Conclusion

Considering the significant contribution of farm women in agriculture and the gender issues they are challenged with, the Programs/schemes, tools & implements, technologies and research projects should be developed from women perspective. Care should be taken for improving women's access and control over productive resources. The agricultural activities performed by farm women should be kept reserved only for them, to provide year round employment to them. Empowerment of women should start from individual households, considering their mental and intellectual level. On the other hand, women folk should develop a strong network to max-

imize the benefits of empowerment to make themselves self-sufficient in all aspects, which will lead to less gender inequality and deprivation and help maintain a quality life.

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Problems Faced by Women Entrepreneur in Rural Areas

Mrs. Priyanka Rana

Personal Challenges

In developing countries like India women work long hours daily, carrying out family chores such as cleaning, cooking, bringing up children along with concentrating on their income generating activities. Such family responsibilities prevent them from becoming successful entrepreneurs. Ex: a choice between family and career.



Social Challenges

The biggest problem of a woman entrepreneur is the social attitude and the constraints in which she has to live and work. Despite constitutional equality, there is discrimination against women. In a tradition-bound society, women suffer from male reservations about a woman's role and capacity. In rural areas, women face resistance not only from males but also from elderly females who have accepted inequality.

Financial Challenges

When it comes to financing, women in deve-

loping nations have little access to finance because they are concentrated in poor rural communities with few opportunities to borrow money. Lack of access to credit is still worsened by a lack of information on where credit can be sought and requirements for loans. According to a report by the United Nations Industrial Development Organization (UNIDO), despite evidence that women's loan repayment rates are higher than men's, women still face more difficulties in obtaining credit often due to the discriminatory attitudes of banks and informal lending groups. Women and small entrepreneurs always suffer from inadequate financial resources and working capital. They lack access to external funds due to the absence of tangible security and credit in the market. Women also generally do not have property in their names.

Marketing Challenges

Because of inefficient arrangements for marketing and selling their products, women entrepreneurs are often at the mercy of the intermediaries who pocket large chunks of profit.

Managerial Challenges

Often high cost of production undermines efficiency and restricts the development of women enterprises.

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Competition Challenges

Many of the women enterprises have imperfect organizational setup. They have to face severe competition from organized industries and male-centric entrepreneurship.

Lack of Mobility Challenges

One of the biggest handicaps for women entrepreneurs is mobility or traveling from place to place. Women on their own also often find it difficult to get accommodation in smaller towns.

Educational Challenges

In India, literacy among women is very low. Due to lack of education, the majority of women are unaware of technological developments, marketing knowledge, etc. Lack of information and experience creates further problems in the setting up and running of business enterprises.

Shortage of Raw Materials

Women entrepreneurs find it difficult to procure raw materials and other necessary inputs. The failure of many women cooperatives in 1971 such as those engaged in basket making was mainly due to the inadequate availability of forest-raw materials. The prices of many raw materials are in any case quite high.

Low Ability to Bear Risk

Women have comparatively a low ability to bear economic and other risks because they have led a protected life.

Low Need for Achievement

Need for achievement, independence, and

autonomy are the prerequisites for success in entrepreneurship. However, women are often found (and limited) to be only proud of the achievements of their parents, husbands, sons, etc.

Other Challenges

In addition to the above problems, inadequate infrastructure, shortage of power and technical expertise and other economic and social constraints have retarded the growth of women entrepreneurship in India.

Soil Resilience and Degredation

Neha Khardia, Sonal Sharma and Hansa Kumawat

Soil resilience refers to the intrinsic ability of a soil to recover from degradation and return to a new equilibrium similar to the antecedent state. Soil resilience can also be defined as the ability of the system to recover its “functional and structural integrity”.

- ✓ Functional integrity signifies the capacity of the soil to moderate/improve dynamic functions (e.g., fate and decay of organic compounds, microbial activity, immobilization and transformation of chemicals, provision and recycling of nutrients).
- ✓ Structural integrity signifies the intrinsic capacity of the soil to improve its structural properties itself (e. g., soil aggregation, porosity) and return to the initial conditions.

The concept of soil resilience can be as complex as the soil system. The theory of soil resilience allows the understanding of soil functioning in relation to soil stability and productivity. The concept of soil resilience is gaining importance in the context of increased risks of soil degradation and growing concerns about the climate change. How will a soil respond to change in climate? This is an unanswered question that necessitates an urgent consideration. The climate-induced changes in soil temperature, rainfall amount,

and drought would directly affect soil structural resilience. While some studies have suggested that moderate increases in soil temperature would enhance plant growth and biological activity, thereby increasing soil organic matter, extreme events such as intense rain storms, flooding and droughts may severely diminish the ability of a soil to recover (Blanco-Canquia and Lal, 2019).

Factors affecting soil resilience

Soil resilience is affected by the same factors that also govern soil formation. Factors of soil resilience refer to the biophysical parameters including parent material, soil intrinsic properties, soil geomorphology, vegetation, and climate, which interact and revolve over time. One factor could be more influential than the other, depending on the soil type.

Soil characteristics	Landscape characteristics and biota	Climate and time
✓ Parent material (residual, colluvial, alluvial, marine, lacustrine, glacial, eolian, and organic)	✓ Land topography (aspect, gradient, length, and shape)	✓ Precipitation (e.g., rainfall, snow)
✓ Soil physical properties (e.g., texture)	✓ Soil biota (flora and fauna)	✓ Temperature (maximum and minimum)
✓ Soil chemical properties	✓ Land use and management	✓ Radiation
✓ Soil biological properties (e.g., microbial biomass)	✓ Level of landscape disturbance	✓ Relative humidity
		✓ Length of soil degradation and restoration
		✓ Rate of soil formation

Soil processes and resilience

Processes affecting the magnitude and rate of soil recovery include physical, chemical, and biological mechanisms. These mechanisms interact

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and occur simultaneously, influencing various interrelated soil functions. Processes such as decomposition of soil organic matter and activity of microorganisms are more dynamic and rapid than weathering of minerals. Biological processes are responsible for nutrient cycling, absorption and release of nutrients, and processing of organic and inorganic components (Blanco-Canquia and Lal, 2019). Thus, soil resilience may mainly apply to biological processes which are reversible, sensitive, and rapidly affected by soil management unlike slow processes such as weathering of rocks or parental material.

Physical	Chemical	Biological
✓ Physical weathering (e.g., freezing or thawing, exfoliation, crystallization)	✓ Weathering (e.g., cation, solution, hydration, hydrolysis, oxidation)	✓ Biological weathering (e.g. burrowing)
✓ Soil water, air, and heat fluxes	✓ Immobilization	✓ Root growth
✓ Macro-and micro aggregation	✓ Transformation	✓ Activity of macro- and micro-organisms
✓ Flocculation	✓ Nutrient cycling	✓ Soil organic matter decomposition and accumulation
✓ Shrinking and swelling	✓ Buffering capacity	✓ Biodegradation and biotransformation
✓ Clay formation	✓ C sequestration (e.g. formation of organo-mineral complexes)	

Indicators of soil resilience

Changes in soil physical, chemical, and biological properties are used as indicators of soil resilience. These properties must be monitored from the onset to the end of the restoration period to determine the rate and magnitude of recovery.

Physical properties	Chemical properties	Biological properties
✓ Horizonation	✓ Soil pH	✓ Microbial biomass
✓ Color and depth	✓ Essential nutrients	✓ Microbial activity
✓ Clay content	✓ Total organic C	✓ Earthworm population and activity
✓ Bulk density and porosity	✓ Total N content	✓ Above- and below-ground biomass
✓ Water-stable aggregates	✓ C:N ratio	✓ Rooting depth
✓ Soil temperature and air	✓ Particulate organic matter	✓ Root abundance
✓ Permeability	✓ Particulate P	✓ Biodiversity
✓ Water infiltration	✓ Cation exchange capacity	✓ Plant growth and population
✓ Water retention capacity	✓ Oxidation and reduction	
✓ Cone index and tensile strength	✓ Sodicity	
✓ Coefficient of linear		
✓ Extensibility and plastic limit		

Land degradation and resilience

Land degradation refers to the reduction in the producing capacity of land due to wind and water erosion of soil, loss of soil humus, depletion of soil nutrients, secondary salinization, diminution and deterioration of vegetation cover as well as loss of biodiversity. Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climatic vicissitudes and human activities is also referred to as desertification (Lal, 1997). About 97.85 million ha, 29.77% of the Total Geographic Area (TGA) of the country is undergoing land degradation during timeframe 2018-19. Land Degradation of Rajasthan state reveal that 62.06% (21.23 million ha) of the total geographical area is undergoing Desertification / Land Degradation (DLD) during timeframe 2018-19 (SAC, 2021).

Management Strategies to Promote Soil Resilience

Soils can be able to develop a self-regenerating system against degradative processes thorough adoption of restorative management systems. (Blanco and Lal, 2008). The key to improving the resilience of soils is the adoption of practices that increase the input of soil organic matter. Organic matter improves the soil pore structure, increases water infiltration, and reduces soil compaction and runoff and soil erosion. Soils under reduced tillage or no-till management have higher resilience because of higher soil organic matter content and activity of soil organisms. In general, cropping systems that enhance soil resilie-

nce are associated with conservation tillage. Systems that incorporate legumes and high residue producing crops are beneficial to improving soil resilience. Complex and diverse crops rotations integrated with cover crops are preferable over monocultures to enhance soil resilience. Soil resilience is usually higher under pastures and planted fallow systems than under annual crops. Crop residues, green manures, livestock manures, poultry manure, compost, and other organic amendments are effective strategies to improve soil resilience, especially when managed properly. Use of organic amendments not only improves the resilience of the soil to mechanical stresses but makes the soil more malleable or friable. Soils amended with organic materials have higher ability to rebound once the mechanical stresses (e.g., tillage operations) are removed (Diacono and Montemurro, 2010).

Conclusion

Debate on global soil degradation, its extent and agronomic impact, can only be resolved through understanding of the processes and factors leading to establishment of the cause-effect relationships for major soils, eco-regions, and land uses. Systematic evaluation through long-term experimentation is needed for establishing quantitative criteria of (i) soil quality in relation to specific functions; (ii) soil degradation in relation to critical limits of key soil properties and processes; (iii) soil resilience in relation to the ease of restoration through judicious management and discriminate use of essential input.

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Different EdTech Companies Boom and Its Plausible Role in Boosting Agricultural Education: A Case Study in India

Ananya Jarh and Sudhanand Prasad Lal

Introduction

Nearly every area, particularly the education sector, has undergone significant reform as a result of the recent surge in technology and the availability of affordable internet access. The term “education technology,” often known as “Edu-Tech” or “EdTech,” has brought about a dramatic change in how education is delivered throughout the nation (Chandana, 2021). In terms of livelihood, agriculture and related industries are crucial in India. The World Bank Collection 2020 estimates that 65.07 percent of the population resides in rural areas, which means that more than 50 percent of people depend on agriculture or that agriculture plays an important part in the Indian economy. The Indian government has launched an endeavour to digitalize agriculture in this age of information technology. Big data and edtech provide options that might not otherwise be available. It is possible to analyse and apply data gathered from the knowledge of thousands of specialists and the experiences of millions of farmers to create new improvements in agriculture (Mehra, 2018).

EdTech & Digital University in Indian sub-continent

The term “EdTech” used for educational technology and the Digital University includes multiple number of universities around India connected by a single unit on virtual platform, by this way students from anywhere across the country can access their degree through online mode ,which is referred in “Table 1” (Singhania, 2022). India currently has two digital universities, first one is Indian Institute of Information Technology and Management, Kerala (IITM-K) and second digital university is at Jodhpur, Rajasthan, displayed by “Plate 1” (News 18, 2022).



Plate 1: Digital University in Kerala, IITM-K and Digital University at Jodhpur

5G Spectrum to boost Edtech agricultural ecosystem

AgMOOCs is an online platform created to aid individuals, groups, and organisations in gaining and enhancing knowledge and abilities in the field of agriculture, showed in “Fig 1”.

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The website offers free access to several top-notch courses taught online by famous instructors from the top universities in the nation. Through these MOOCs, it is hoped to connect with thousands of students and give them access to higher agricultural education but still few students at far-flung area face connectivity issues.

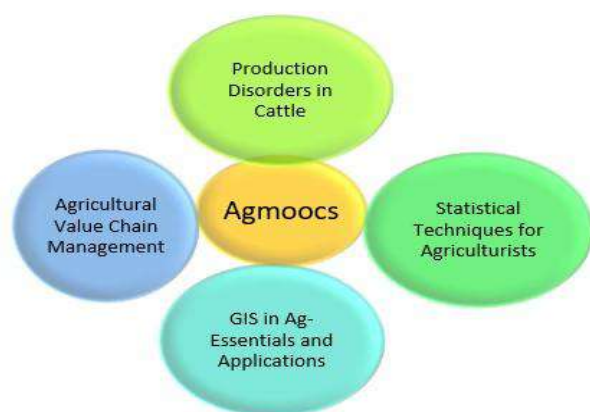


Fig 1. Current courses offered by AgMoocs

Table 1: List of Biggest Edtech Companies in India

S.No	EdTech	Logo & Link	Founders	Year
1.	Byju's	 https://byjus.com/	Byju Raveendran & Divya Gokulnath	2011
2.	Vedantu	 https://www.vedantu.com/	Vamsi Krishna And others	2014
3.	UPGRADE	 https://www.upgrad.com/	Ronnie Screwvala And others	2016
4.	CueMath	 https://www.cuemath.com/	Manan Khurma	2014
5.	Meritnation	 https://www.meritnation.com/	Pavan Chauhan	2009

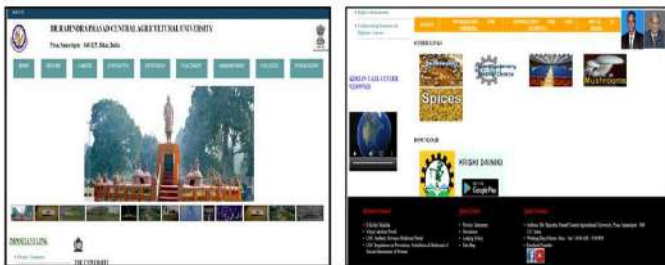
On July 26, 2022 the 5G spectrum auction will start. This would include the auction of 72 GHz of spectrum, estimated to be worth at least Rs 4.3 lakh

billion. On 29th & 30th July, the Department of Telecommunications will practise drills. Many telecom companies are trying to be the forefront of bringing 5G connectivity to India with its formidable network and this would boost India's digital-first economy". At the same time, the few new players recently announced that it would compete for telecom spectrum. Additionally, it stated that in order to fund its operations, it will employ telecom spectrum as a private network from airports. New players are taking part in the 5G spectrum auction to offer improved cyber security and private network solutions for logistics, power production, transmission and distribution, as well as a variety of manufacturing processes (Zee News Desk, 2022). According to Edger Dale's cone of experience, if one only read something then s/he can remember only 10% what s/he read but , by watching a video or seeing the demonstration done on location one can remember 50% of what s/he see and hear (Dwyer, 2010). So, we can say by the collaboration of strong 5G network and online study platform will boost the knowledge of students and farmers which helps to amplify the agricultural ecosystem and improve the rural life.

Training on programming language for B.Sc. community science students of RPCAU, Pusa

ICTs are the best allies to help the country's Agricultural Extension system expand its reach. Not only in Agriculture but also in other allied sector like community science is indulged in internet based methods. In March-April 2022, Group of 10 students

of Extension Education of Community science batch 2018-2022 of RPCAU, Pusa got training at NIIT, Patna in the course of HTML 5, Cascading Style Sheet (CSS), and JAVA Script, a programming language used to make a dynamic or interactive web page. By the help of this course they are now able to create brand new website, animated photo gallery and much more; which may help to boost the agribusiness and awareness of rural youth.



Clone website of Dr. RPCAU, Pusa made by 1st author in the team of ten students of community science

Conclusion

From the time of COVID-19 EdTech companies play an important role in case of education, agriculture and allied sectors to teach the students and farmers. CROPIN TECHNOLOGY of Karnataka is an Earth Observation and AI-driven AgTech company that equips farmers to use data to reimaging agriculture. By fusing pixel-level data acquired from satellite imaging with IoT and field intelligence, Cropin is dedicated to assisting players in the global ag-ecosystem to sustainably optimize their per-acre value, on other hand 5G Spectrum and online study platform like AgMoocs will help to uplift the knowledge of agricultural students as well as livelihood of farmers.

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Breeding Strategies for Drought Resistance in Cotton

Rajvinder Singh, Manuj Saini and Amit Kumar

Introduction

Cotton (*Gossypium* spp.) $2n=2x=26$, $4x=52$ belongs to the family Malvaceae and tribe Gossypieae. Cotton is one of the most widely grown crop in the world and is produced cheaply and its items are often affordable. The various species of cotton grown but 4 species are widely grown as agricultural crops native to tropical and sub tropical parts of the world and were domesticated independently multiple times. The most popular natural fibre in the world, cotton has a significant impact on both the agricultural and industrial economies. Among the four cultivated species, *G. hirsutum* and *G. barbadense* are grown for world fibre production in modern days and diploid cotton species *G. herbaceum* and *G. arboreum* are known for its inherent ability to sustain biotic and abiotic stresses.

Drought

Cotton is relatively drought resistant economic crop and the fibre is valuable source material for textile. Drought has been one of the most significant abiotic stresses on crop growth because of the effects of climate change and the severe lack of fresh water. Drought has been one of the most critical

abiotic stresses influencing the growth of plants. Even though cotton originates from arid and semi-arid regions of the tropics and sub-tropics, it is not identified as a drought tolerant crop. This leads to reduced yield in the field, even in cotton. Thus, there is an urgent need to improve drought resistance of cotton, not only through the use of irrigation but also through genetic improvement programmes.

Drought resistance: Drought resistance refers to systems that reduce yield loss in a drought situation. There are four mechanisms through which cotton might reduce the yield loss caused by drought stress:

Drought escape: Drought escape refers to the situation in which a drought-sensitive variety performs well in a drought environment simply by avoiding the drought period. Early maturity is an important feature of drought resistance, making it suitable for environments prone to late-season drought stress. Early varieties typically have a lower leaf area index, lower total evapo-transpiration, and lower yield potential.

Drought avoidance: It is a plant's ability to retain a relatively higher level of hydration in the face of soil or atmospheric water stress. Dehydration can be avoided by either reducing transpiration (water

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savers) or increasing water uptake (water spenders). Reduced transpiration, osmotic adjustment and concentration of ABA play an important role in drought avoidance.

Drought tolerance: Dehydration tolerance of a genotype means that it exhibits significantly fewer changes than another genotype when both are subjected to the same level of dehydration. The following are various measures of dehydration tolerance: i) low levels of solute leakage maintain membrane integrity. ii) seedling growth parameters such as seedling survival or recovery, seedling growth, seed germination under osmotic stress caused by Polyethylene glycol (PEG), stem reserve mobilisation, awn presence in cereals, and high proline accumulation. Plant drought response mechanisms and key characteristics

Drought resistance: It refers to the ability of a plant to survive in the absence of water or in deficiency of water.

Mechanism associated with drought tolerance

Morpho-physiological mechanism: Drought stress causes a wide range of morpho-physiological and biochemical changes that have a negative impact on cotton development and productivity. Generally, drought stress, severely limits cotton growth and development, affecting plant height, leaf dry weight, stem dry weight, leaf area index, node number, fibre quality, canopy and root development. Specifically, during drought conditions, cotton leaves decreases net photosynthetic rate, transpiration rate, stomata conductance, carboxylation efficiency and water

potential significantly. Cotton has evolved several common morpho-physiological drought stress resistance strategies, which have been discussed as below:

Stomata regulation

Reduction of water loss through the leaves is an important phenomenon in drought-stressed cotton plants. Wilting and rolling of leaves reduce radiation which reduce water loss. Stomata regulation is critical for gas exchange between tissues and the environment. It is one of the primary mechanisms by which plants generate energy and maintain cellular function. 90% of plant water losses (transpiration) occur through stomata openings (Wang *et al.*, 2009).

Root development

All root traits have the potential to be important in drought stress; however, hydraulic conductance and plant allometry have more interest of the researchers. Several scientists have examined the potential role of roots under drought stress. More profuse (higher root length density) and deeper root systems in the soil are frequently proposed as desirable drought adaptation characteristics.

Photosynthesis

Drought stress causes stomata to close, resulting in decreased CO₂ intake, which affects photosynthesis rate and, as a result, growth and yield. As the water deficit in the cotton field increases gradually, photosynthesis and growth suffer. For example, it was discovered that drought conditions influenced both photosynthesis and transpiration in cotton.

Osmotic adjustment

Osmotic adjustment is a critical adaptation for crop plants to reduce the effects of drought-induced damage. Plant defence mechanisms also include osmoprotectants or osmolytes, which regulate homeostasis on a cellular level after drought and salinity stress. Drought stress disrupts osmotic balance, so plants accumulate various organic and inorganic substances to reduce osmotic potential in response to drought stress.

Biochemical and molecular mechanism: Plants also have a defence mechanism like animals that allows them to respond to biotic and abiotic stresses. The drought tolerance mechanism is extremely complex because it is a multigenic system linked to a variety of morphophysiological, biochemical and molecular processes. Cotton has evolved several signal hormones in response to drought stress, in addition to morpho-physiological mechanisms. These are as follows:

Absisic acid (ABA)

ABA is a key stress hormone that plays a role in a variety of critical physiological processes throughout the plant life cycle, including stress responses, development, and reproduction.

Jasmonic acid (JA)

Another phytohormone derived from α -linolenic acid is jasmonic acid (JA). JA and its active derivatives, known as jasmonates, play an important role in regulating plant stress responses to various biotic and abiotic stresses. JA is involved in root growth, fruit ripening, tendril coiling, and viable

pollen production, in addition to plant growth and development.

Calcium

Calcium regulates many cellular and physiological processes in higher plants. Calcium (Ca^{2+}) is a universal second messenger in signal transduction pathways that regulates a variety of physiological processes in cotton plants.

Marker assisted selection based on drought related QTLs/genes

Several minor genes, or polygenes, have a greater additive effect on drought tolerance than other biotic and abiotic stresses. Thus, quantitative trait loci are sections of DNA (loci) located on chromosomes carrying these genes (QTL). *e.g.* 323 *G. hirsutum* germplasms were studied using 106 microsatellite markers, and 15 markers were found to be related to drought tolerance. In terms of drought tolerance, 12 markers had negative allele effects, while the remaining markers had positive allele effects (Jia *et al.*, 2014).

Transgenic approach

Plants respond to multiple abiotic stress conditions at the molecular level by changing gene expression (up or down regulation), which in turn regulates a number of proteins, affecting a variety of biological functions (Deeba *et al.*, 2012). One of the key factors in plants that cope with abiotic stresses and improve tolerance to these conditions is the regulation of genes involved in the stress response. Plants contain thousands of genes, many of which are involved in drought stress.

Conclusion

- ✓ The effectiveness of a resistant breeding programme is dependent on the availability of efficient screening procedures, the identification of appropriate sources of resistance, and the knowledge of inheritance of resistance.
- ✓ Morpho-physiological, biochemical and molecular modifications occur in resistant plants which are responsible for drought resistance.

Future perspectives

- ✓ Drought is a complicated phenomenon. However, rapid advances in omics technologies will allow a system biology approach to be used to understand cotton plant response.
- ✓ Molecular techniques were mostly studied in a greenhouse or tested in the field at a smaller scale under artificial water-deficit conditions. Thus, it could be studied in a more realistic environment to improve drought tolerance.
- ✓ The use of CRISPR/Cas9 in cotton genome editing will be beneficial in inducing drought tolerance.
- ✓ Molecular markers will be very useful in future cotton genetic breeding. Specific chromosome regions with important QTLs can be identified and used to select drought-tolerant traits efficiently.

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Seaweeds: A Sustainable Future Crop

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Abstract

Use of seaweeds is as old as 2500 years ago. Seaweeds are integral part of the ecosystem and contributes sustainable development of the rural coastal regions. Some Asian countries consume seaweeds as food but their use in the phycocolloids production is widespread globally. As a rich source of valuable chemical components, seaweeds are used for various industries like cosmetics, Fuel, water treatment, food, energy, medicine. These versatile plants identified the presence of anticancer, anti-inflammatory and antioxidant properties. Seaweeds exhibited curative properties against tuberculosis, arthritis, colds and influenza and are part of folk and traditional medicine. Seaweed played a milestone in pharmaceutical industries as well as modern biology during the year 1980 to 1995. In India, use of seaweed as food is low due lack of consumer awareness regarding potential health benefits.

Introduction

Currently the world is looking for alternative food resources that will support and supplement the growing food needs of increasing population with minimal environmental impact. Many recent studies reported the importance of seaweeds in context of food needs and ecological benefits of farming. Seaweeds are valued for their use as food, feed, agro-based products, phycocolloids, biofuels and extensively used in medicinal, nutraceutical and food industries. Many countries consume seaweeds in the form of soups, salads and other preparations. Global production of seaweeds has been estimated at 30.1 million wet tons in 2016 (FAO, 2018).

The top seven countries that account for global production of seaweeds are China, Japan, Korea, Indonesia, Philippines, Malaysia and Vietnam. In India, Gujarat and Tamil Nadu have abundance of seaweeds. Both the states are home to almost 366 seaweeds and that constitutes half of the India's total seaweed diversity. Instead of being a major global producer and exporter, India remains an importer of macro- algal products. The principal cause for this gap between the commercial cultivation and processing of macroalgae is the lack of clearly enunciated policy on cultivation and utilization of seaweeds. Seaweeds are highly useful wonder plants of the sea. But the word seaweed gives wrong impr-

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ession of useless of these plants. Seaweeds are macrophytic algae with lack of true stems, roots and leaves. Seaweeds grow in shallow waters. About four types of seaweeds (blue, green, red and brown) are identified based on the pigments. Most seaweeds belong to one of three divisions the chlorophyta (green algae), the phaeophyta (brown algae) and the rhodophyta (red algae). There are about 900 species of green seaweed, 4000 red species and 1500 brown species. Red seaweeds are found abundantly in tropical and subtropical areas and brown type grown in cooler waters. Out of 221 species used commercially, 145 species are used for food and 110 species for phycocolloid production.

Classification of seaweeds

Seaweeds can be classified into three broad groups based on pigmentation: brown (Phaeophyceae), red (Rhodophyceae) and green (Chlorophyceae). They are as follows:

Brown seaweeds are large, and range from the giant kelp that is often 20 m long, to thick, leather-like seaweeds from 2–4 m long, to smaller species 30–60 cm long.

Red seaweeds are usually smaller, generally ranging from a few centimetres to about a metre in length; however, red seaweeds are not always red: they are sometimes purple, even brownish red.

Green seaweeds are also small, with a similar size range to the red seaweeds.

Sources of cultivation in India

Seaweeds are found abundant in coastal areas of Tamil Nadu and Gujarat and around Lakshadweep

and Andaman & Nicobar Islands. Rich seaweed beds occur around Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam and Pulicat in Tamil Nadu, Andhra Pradesh and Chilka in Orissa.

Seaweed cultivation

For commercial cultivation, southeast areas of India are most suitable because of favourable conditions like shallow, wide and flat coastal shorelines with moderate wave action, and rich in nutrients including phosphorus and nitrogen. Salinity and temperature requirement of the area is advantageous for the cultivation year around except during the monsoon season.

Vegetative propagation method is followed for traditional seaweed farming, which require a large amount of seed stock biomass. Thallus aging, epiphyte colonisation are critical challenges and the strains also decrease their vigour and production after successive 2-3 years of cultivation. So, an alternative, mass culture utilizing spores requires only a few grams of reproductive material. Geminating spores can generate thousands of plantlets which can be used for mass propagation. Large scale cultivation from isolated spores has been successfully developed to provide raw material for the phycocolloid industry.



Heath benefits and applications of seaweeds in industry

Seaweed as a whole food

Seaweeds are continuously bathed in nutrient rich seawater; therefore, they absorb high level of nutrients and thus form important source of food, feed, fertilizer and chemicals. Every day, most of the people use seaweeds directly or indirectly in the form of processed food items like processed dairy, meat and fruit products and domestic commodities like paint, toothpaste, solid air fresheners, cosmetics, etc. Seaweeds are excellent source of vitamins A, B 1, B12, C, D & E, riboflavin, niacin, pantothenic acid and folic acid as well as minerals such as Ca, P, Na, K. Their amino acid content is well balanced and contains all or most of the essential amino acids needed for life and health. They have more than 54 trace elements required for human body's physiological functions in quantities greatly exceeding vegetables and other land plants.

Dietary intake of seaweeds provides soluble (alginic acid, agars, furoan, laminarin and porphyrin) as well as insoluble fibers (cellulose, mannans and xylan), which have many physiological benefits.

Seaweed lipid contents are polyunsaturated fatty acids with omega-3 and omega-6 acids which are important to prevent cardiovascular diseases, diabetes, and osteoarthritis. Green algae contain alpha-linolenic acid, while brown and red algae are rich in eicosapentaenoic acid and docosahexaenoic acid.

Application in food industry

Seaweed polysaccharides are used in a number of applications like it is used as thickening agent in in sweet and savoury sauces and condiments. It is also used to stabilise food products against degradation, staling and heating or cooling/freezing. These applications also act to improve the consumer acceptability of such products, as well as extending the shelf-life. It is used as fat replacer, improves moisture retention and consistency, low viscosity fractions of the indigestible carbohydrate material from seaweeds could be used to develop food products with higher fibre content.

The highest quality of agar and its derivative called agarose comes from red algae belonging to family Gelidiaceae. Agar agar is used in cakes, chocolates, candies, jellies, jams, juices, coffee, wafers, liquors, salad dressing etc. As a stabilizer, it is being used in sauces, a solidifying agent, emulsifier and laxative.

Alginate is used to improve the quality of paper texture. It is being used as a potential ingredient in frozen foods, stabilizer in ice creams, reactive base in reactive dye printing of textiles. Alginates also widely used in many pharmaceutical industries as a stabilizer. It acts as an emulsifier for many food products in food industries such as an additive in instant food drinks, to keep food particle liquid in the mixture. The usage of carrageenan for food applications started almost 600 years ago. Due its long history of usage US FDA, considered it as

food additive. Mannitol is an important sugar alcohol which is present in many species of brown algae, especially in *Laminaria* and *Ecklonia*. It is used in pharmaceutical industry, in making chewing gum, in the paint and varnishes Industry, in leather and paper manufacture, in the plastic industry and in the production of explosives. It is used in a variety of foods, candies and chocolate flavored compound coatings because it replaces sucrose to make sugar free compound coatings. Sugar free chocolates are especially popular for people with diabetes, a growing problem in modern society

Seaweeds as food: Many of the countries like Japan, China, Korea, Malaysia, Thailand, Indonesia, Philippines and other South East Asia consume seaweed as a protein rich source. Seaweeds like *Ulva* sp., *Enteromorpha* sp., *Caulerpa* sp., *Codium* sp., *Monostroma* sp., *Sargassum* sp., *Hydroclathrus* sp., *Laminaria* sp., *Undaria* sp., *Macrocystis* sp., *Porphyra* sp., *Gracilaria* sp., *Eucheuma* sp., *Laurencia* sp. and *Acanthophora* sp. are used in the preparation of soup, salad and curry. Some of the seaweeds are also taken in dried form.

Antioxidant properties: Many studies have reported the antioxidant activities of seaweed species. Algae have protective enzymes like superoxide dismutase, peroxidase, glutathione reductase, catalase and antioxidative molecules like phlorotannins, ascorbic acid, tocopherols, carotenoids, phospholipids, chlorophyll related compounds, bromophenols, catechins, mycosporine-like amino acids, polysaccharides, etc responsible for

antioxidant activity. Due to good bioactive activity, present pharma industry is interested to develop seaweed based novel foods.

Antimicrobial properties: Seaweeds are good source of many bioactive compounds like $\omega 3$ fatty acids, polyphenols, flavonoids, glycosides, catechins and polysaccharides have been detected in brown, red and green algae and so, these products are used as nutraceuticals and in functional foods.

To control heart disease and stroke: Use of seaweed can help in Reduction of plasma cholesterol, which may reduce the risk of cardiovascular disease.

Seaweeds as anticancer agents: The dietary intake of seaweed has also been implicated as a potential protective agent in the aetiology of cancers by reduction of plasma cholesterol, binding of biliary steroids, antioxygenic activity, binding of toxic materials, induction of apoptosis, inhibition of cell adhesion, the addition of important trace minerals to the diet.

Antidiabetic activity: Aqueous extract of *Ulva fasciata* decrease in blood glucose and glycosylated haemoglobin level.

Other uses: Dietary supplementation of seaweeds helps in the treatment of goitre. Red seaweeds possess algal proteins called phycobiliproteins with antioxidant properties have beneficial effects on Alzheimer's and Parkinson's diseases as well as in the treatment of gastric ulcers and cancers.

As fertilizers: Dried and milled brown seaweeds like *Ascophyllum*, *Ecklonia* and *Fucus* are sold as soil additives and function as both fertilizer and soil con-

ditioner. Seaweeds have sufficient amount of nitrogen, potassium and insoluble carbohydrates, which are important for soil conditioning by improving soil texture, aeration and possess good moisture retention properties. Maerl is a fertilizer derived from red seaweeds and are used to neutralize acid soils, as a substitute for agricultural lime. Maerl is more expensive than lime but is alleged to be better because of the trace elements it contains.

For feeding: Today the availability of seaweed for animals and fishes has been increased with the production of seaweed meal.

Biomass for fuel: The seaweeds “giant kelp” is selected by the American gas association for the production of methane gas because of its high growth rate and ease of harvesting by mechanical means. And other seaweed species are also used for the methane production.

As Cosmetics: The “Extract of seaweed” is often found on the list of ingredients on cosmetic packages, particularly in face, hand and body creams or lotions. Usually, alginate or carrageenan are used in cosmetics.

Wastewater treatment: Seaweeds can be used to reduce the nitrogen and phosphorus content of effluents from sewage treatments.

Industrial uses: Seaweeds have many industrial uses. Brown algae yield a gummy substance called algin and red algae produce jelly like substances called agar and carrageenan. These substances are used as additives in food products and drugs to give them a smooth texture and help them retain moisture.

Seaweed sector as part of Blue Revolution

Initiative by GoI (2020): On the 86th foundation of ICAR-Our honourable prime minister stated that we need great research and promotion of seaweeds. Seaweeds have great potential for human health care and agriculture. Seaweeds are important raw materials and can play a significant role in improving crop productivity. The Pradhan Mantri Matsya Sampada Yojana (PMMSY) is one of the schemes to promote seaweed business. About Rs 640.00 crore investing by Government in seaweed sector. It will encourage about 8 lakh employment opportunities directly and indirectly in seaweed sector. It is a centrally Sponsored component (40% Subsidy for General Category and 60% for SC/ST/Women) involved in 1. Establishment of Seaweed culture Rafts, including inputs 2. Establishment of Seaweed culture with Monoline/Tubenet method, including inputs 3. Establishment of Seed Bank for Seaweeds.

Conclusion

Seaweeds are important marine plants termed as futuristically promising plants. The plants have multiple uses such as food, feed, medicine, fertilizer and are used for industrial production of agar and alginate. The seaweeds are source of important contents like proteins, lipids, minerals, polysaccharides, enzymes and vitamins. Present, bioactivity of secondary metabolites and other chemical constituents of seaweeds is of great interest. Many studies confirmed the use of seaweeds in prevention of various diseases like cancer and cardiovascular diseases.

Strategies for Doubling the Farmers Income

Arunkumar R, Vignesh K and M Sunil Surya

Abstract

Doubling farmers' income includes massive investments in agricultural research and irrigation development, fertilizers, agricultural market infrastructure that includes development of Agricultural Produce Market Committee (APMC) and agriculture value chains, supported by adequate and timely availability of bank credit, implementation of a number of schemes for revival of agricultural growth and farmers' welfare. Increase in yield or productivity of crops and other various enterprises are the most significant factor that can increase income. While, varietal improvement through biotechnology or conventional breeding is a long term method, bridging the yield gaps through following of recommended agronomic practices, planning profitable crop mix that can maximize aggregate income, and reducing crop losses through IPM are short/ medium term options that can bring in extra income. Since the area cannot expand much, either through expansion in net sown area or through expansion in cropping intensity, improving the productivity is the only way available to improve production. Lowering the costs without compromising on the output will increase the net income. It is possible to do so that there is a common tendency on the part of ranchers to apply over dosage of pesticides and fertilizers and expecting more yields.

Introduction

The doubling farmers' income involves massive investments in agricultural research and irrigation development, fertilizers, agricultural market infrastructure that includes development of Agricultural Produce Market Committee (APMC) and agriculture value chains, supported by adequate and timely availability of bank credit, implementation of a number of schemes for revival of agricul-

tural growth and farmers' welfare (Jadhav, 2017).

The well-being of farmers can be improved by bringing together the experiences and efforts of farmers, scientists, researchers, and students at different locations with similar eco-sociological system (Kumar 2013). The various ways strategies for doubling the farmers' income as enhancing production through increase in yield, focus mainly on dry land areas, enhancement of income through

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professionalism, risk management etc. This paper deals with the strategies for doubling the farmers' income.

Enhancing Production through yield Increase

Increase in yield or productivity of crops and other various enterprises are the most significant factor that can increase income. Since the area cannot expand much, either through expansion in net sown area or through expansion in cropping intensity, improving the productivity is the only way available to improve production. While, varietal improvement through biotechnology or conventional breeding is a long term method, bridging the yield gaps through following of recommended agronomic practices, planning profitable crop mix that can maximize aggregate income, and reducing crop losses through IPM are short/ medium term options that can bring in extra income.

Leveraging Water Resources for Enhancing Farm Incomes

Water resources are very scarce in relation to size of the population. By 2050, the worldwide agricultural sector requires to produce 60 per cent more, while developing nations need to produce 100 per cent more. This target can be met only by increasing water productivity. Micro irrigation (sprinklers and drips) was one of the technological ways which increases the water productivity.

Special Focus on Dry land Areas

Dry land areas are home to 43 per cent of our population. It receives rainfall between 150 mm and 1000 mm per annum. Water management intervent-

ions for dry land consists of adopting an efficient watershed management approach, reducing vulnerability through rainwater harvesting and storage, specifying and enforcing clearly defined water rights in watershed communities, recharging depleted groundwater and aquifers and strictly regulating groundwater extraction, enlisting government support for water saving options, pricing water and power to reflect their opportunity costs, enabling stronger collective action for community development in agricultural field and resource management and enhancing the technological and scientific support to watershed programmes.

Reducing Costs through Low Input Agriculture

Lowering the costs without compromising on the output will increase the net income. It is possible to do so that there is a common tendency on the part of ranchers to apply over dosage of pesticides and fertilizers and expecting more yields. Organic farming, sustainable agriculture, precision farming, low external input etc. are being promoted to reduce the chemical usage.

Focus on Small Holders' Problems

Small holder agriculture operates under problems related to the small scale operations. It struggles with inability to create economies of scope and scale, low bargaining power because of small marketable surplus, limited market access, scarcity of capital, lack of information and knowledge, market imperfections and, poor infrastructure and communication. While corporates view, small holder agriculture as an untapped resource for sourcing crop

produce and selling the inputs, transaction costs for industries dealing with small farmers tend to be particularly high because of uncertainties in dealing with farmers, physical distance because of underdeveloped infrastructure and required to deal with multiple suppliers, each offering small volumes. Same problems are reported by banks and financial service providers where their transaction costs shoot up due to small ticket loans demanded by several clients scattered across the globe. Further, the subsequent decline in state subsidies for production inputs such as electricity, water, fertilizer and seeds which created an economic environment of unknown competition for many small holders.

Conclusion

It is concluded that there are several strategies for doubling the farmers' income. Resistance to pests and diseases and by capturing the new market opportunities which helps the farmers to fulfils the doubling farmers' income. Diversification of activities which yields better remuneration (region specific) should be the ideal strategy and easy to increase the farmers income.

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Intercropping in Maize

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Introduction

Maize (*Zea mays* L.) is one of the most versatile emerging crop having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals, because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider adaptability to diversity of soil, climate, biodiversity and management practices. It contributes 36 % (782 million tonnes) to the global grain production. In India, maize is the third most important cereal crop after rice and wheat and mainly been cultivated during Rabi, Kharif and Spring season but in *Kharif* season it covers 80% of the total maize grown area. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc.

Classification of maize

Shurtevant (1884) classified maize into seven

groups on the basis of endosperm characters.

- ✓ Flint corn (*Zea mays indurata*)
- ✓ Dent corn (*Zea mays indentata*)
- ✓ Sweet corn (*Zea mays saccharata*)
- ✓ Flour maize (*Zea mays amylacea*)
- ✓ Pop corn (*Zea mays everta*)
- ✓ Pod or husk corn (*Zea mays tunicata*)
- ✓ Waxy maize (*Zea mays ceratina*)

1. **Flint corn (*Zea mays indurata*):** Its kernel is hard and smooth. It embodies a little soft starch and the whole of the crown is covered by hard or horny starch; consequently neither shrinking nor denting is observed.
2. **Dent corn (*Zea mays indentata*):** The kernel of the dent corn appears like a tooth. Its appearance is due to its wedge-shaped form coupled with a little dent at the top. The indentation may be smooth and deep which results on account of shrinking of the soft starch during the process of drying of mature kernels.
3. **Sweet corn (*Zea mays saccharata*):** The sweet corn kernel present a translucent and horny appearance before maturity, however, appear

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wrinkled at maturity. Its starch is glassy and sweetish. Sweet corn grain at the milky or milky-waxy ripeness stage are particularly valuable.

4. **Flour maize (*Zea mays amylacea*):** Its kernels almost entirely consist of soft starch. It is also known as soft corn. The endosperm is loose, starchy and has no horny portion.
5. **Popcorn (*Zea mays everta*):** The grain characters of pop corn are identical to that of the flint corn. Its grain contains an abundant amount of horny starch. When pop corn grains are heated, the endosperm cracks open due to the vapor pressure consequently releasing the loose floury mass.
6. **Pod or husk corn (*Zea mays tunicata*):** This group of maize has no known economic significance. Its grains are characteristically unlike other corn grains and are enclosed within a pod or husk. Its endosperm does not have any specific characteristics.
7. **Waxy maize (*Zea mays ceratina*):** The waxy corn caryopsis has two-layered endosperm. The outer layer is opaque and waxy and the inner layer is mealy.

Intercropping

Growing of two or more crops simultaneously on the same piece of land. There is a crop intensification in both time and space dimensions.

- ✓ Traditional agriculture has always included different forms of intercropping as practiced

through the centuries.

- ✓ Farmers grown a variety of crops, often intermingled in the same field, to sustain themselves and their families.
- ✓ Intercropping can also help to maintain the productivity of relatively fertile land.
- ✓ Intercropping is considered as the practical application of ecological principles such as diversity, crop interaction and other natural regulation mechanisms.



Types of Intercropping

1. Mixed intercropping

Growing two or more crops simultaneously with no distinct row arrangement.

2. Row intercropping

Growing two or more crops simultaneously where one or more crops are planted in rows.

3. Strip Inter-cropping

Two or more crops simultaneously grown in strips; wide enough to permit independent cultivation but narrow enough for crop interaction

4. Relay inter-cropping

Two or more crops simultaneously grown during the part of the life cycle of each. 2nd crop planted after the 1st crop has reached reproductive stage, before it is ready for harvest.

For successful intercropping, there are certain important requirements

- ✓ The time of peak nutrient demand of component crops should not overlap. *e.g.*, In maize + green gram intercropping system, the peak nutrient demand period for green gram is around 35 DAS while it is 50 days for maize.
- ✓ Competition for light should be minimum among the component crops.
- ✓ Complementary should exist between the component crops.
- ✓ The differences in maturity of component crops should be at least 30 days.

Advantages of Intercropping

- ✓ Better use of resources (light/nutrient/water)
- ✓ Suppression of weeds
- ✓ Yield stability & fetch income even if one crop fails due to unforeseen situations
- ✓ Higher equivalent yields (yield of base crop + intercrop), high cropping intensity
- ✓ Reduced pest & disease incidences
- ✓ Soil health & agro-eco system improved

Disadvantages of intercropping

- ✓ Yield decreases as the crops differ in their competitive abilities.
- ✓ Management of intercrops having different cultural practices seems to be difficult task.
- ✓ Improved implements cannot be used efficiently.
- ✓ Higher amount of fertilizer or irrigation water cannot be utilized properly as the component crops vary in their response of these resources.

- ✓ Harvesting is difficult.

Intercropping in Maize

- ✓ Maize is a most versatile crop for growing intercrops because of the wide row it needs, providing higher income to the farmers.
- ✓ Short duration variation of pulses (pea, rajmah and other beans), most vegetables and oilseed crop (soybean, linseed) can be successfully intercropped in maize.
- ✓ The yield of pure maize under intercropping system may be lower but the inter-crop yield is a bonus.
- ✓ Short statured varieties of maize perform better under intercropping.

Conclusion

It can be concluded that intercropping in maize with legumes like soybean, black gram, pigeonpea, green gram, groundnut, frenchbean, cowpea and vegetables like cowpea, potato, spinach and bush bean are agronomically viable and economically profitable than sole maize. It is also beneficial for to improve the soil fertility and to reduce weed infestation.

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Crop Residue Management

Barkha Kumari Verma, Dr. Vinod Kumar Yadav, Sanjeev Kumar and Gopal Khatik

Abstract

Soil is a critical component in plant growth and crop productivity. However, just a small portion of the soil may now be used for agriculture, and if we don't manage it effectively, it will be depleted. Soil organic carbon and soil matter have been identified as the most important indicators of soil quality and health. We detailed how crop residue management influences soil organic carbon (SOC), soil organic matter (SOM), soil aggregation; residue burning's effect, crop production in various cropping systems in this article. This article provides a thorough understanding of the negative effects of crop residue mismanagement in India, as well as other more promising management approaches such as the use of bioenergy, which, if widely adopted, could not only reduce crop residue management's environmental impacts, but also generate additional value for the agricultural sector globally.

Introduction

The rice-wheat system is India's most dominant farming method. The irrigated Rice-wheat system's high yields have resulted in massive amounts of agricultural leftovers. Rice straw burning is frequent in north-west India, resulting in nutrient losses and severe air pollution, which has a negative impact on human health, climate change, and global warming. To avoid straw burning, agricultural residue management innovations could help farmers achieve sustainable productivity, reduce nutrient and water inputs, and mitigate climate change risk. Crop leftovers contain considerable amounts of plant nutrients, and their proper use will improve nutrient management in the rice wheat system.

Other viable crop residue management options include incorporating a portion of surplus residue into soil, which improves soil health, increases nutrient use efficiency, and reduces air pollution, as well as mushroom cultivation, which converts inedible crop residues into valuable food, surface mulch, which conserves soil moisture, temperature, and controls weed emergence, and bio-fuel and compost production. Stubble burning of crop residues in India produces nearly 150 million tonnes of carbon dioxide (CO₂), more than 9 million tonnes of carbon monoxide (CO), a quarter-million tonnes of sulphur oxides, 1 million tonnes of particulate matter, and more than half a million tonnes of black carbon, according to recent studies.

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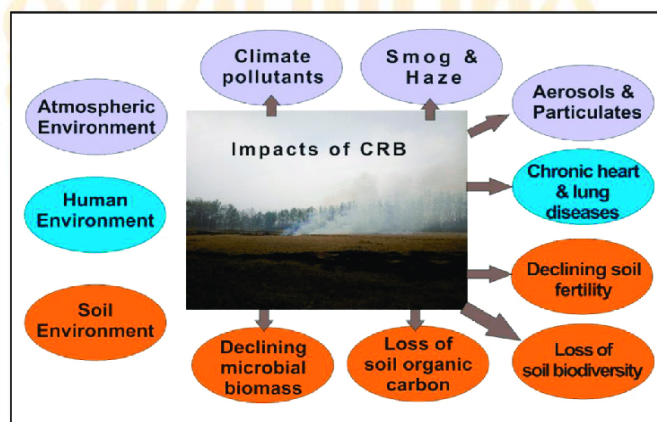
These directly contribute to environmental degradation, as well as the haze in New Delhi, India's capital, and the melting glaciers of the Himalayas. Although agricultural residue stubble burning is illegal under Section 188 of the Indian Penal Code (IPC) and the Air and Pollution Control Act (APCA) of 1981, there has been a dearth of enforcement of these laws across the country. Crop wastes can be used in a variety of ways instead of being burned, such as cow feed, compost with manure, rural roofing, bioenergy, packaging materials, wood, paper, and bioethanol, among others.

Crop Residue Management

Crop residue management is a well-known and widely acknowledged method of managing the physical, chemical, and biological functions of soil. Crop residues affect soil water movement, runoff, and infiltration by incorporating a significant number of nutrients in the soil for crop production. Successful crop residue management is an important aspect of the conservation agriculture (CA) system, and in-situ management is the only way to get the most out of CA. Soil management with agricultural leftovers encompasses a wide range of issues, including residue decomposition, soil erosion control, weed pest control, and various tillage conservation measures for maximising crop yields. Carbon-rich crop wastes are the primary food supply for soil microbes, kicking off the biological nutrient cycling cycle. The availability of NPK nutrients from crop residues to plants is largely determined by physical, chemical, and biological processes in the

soil. The degree of cycling and plant availability of nutrients from crop residues is determined by integrated management with fertilisation and the amount of crop residue left for incorporation in the crop field. Conservation of crop residues is a good way to handle crop residues. SOM levels can be maintained in agriculture to promote soil productivity and crop yield. Increased OM near the soil surface and improved nitrogen cycling and retention are two key benefits of surface-residue management. Crop residues from typical agricultural crops are valuable resources for improving soil, water, and air quality, as well as providing nutrients for future crops and hence agricultural production.

Environmental Effects from Wasteful Use of Crop Residues



Management of Crop Residues for Improving Input Use Efficiencies

Scientists and politicians face a significant difficulty in managing crop residues in such a way that they have a minimal negative impact on the environment and humans. Because these methods do not directly boost farm income, farmers are generally hesitant to adopt any remedial steps for prudent crop

residue management. In practise, agricultural residue management approaches such as conservation tillage, nutrient cycling, soil conservation techniques, zero-tillage and residue mulching, utilisation in animal feed, and vermicompost preparation are being implemented in various regions of the world.

- ✓ **Refining Soil Physical Properties:** It has been demonstrated that incorporating leguminous crop residues improves soil physical qualities such as water-holding capacity, soil permeability, and so on. By increasing the availability of nutrients for the root zone of the crops, including leguminous crop wastes boosts crop growth and yield.
- ✓ **Improving Soil Chemical Properties:** It's been proven that integrating leguminous crop wastes increases soil physical properties including water-holding capacity and permeability. Including leguminous crop wastes enhances crop growth and productivity by increasing the availability of nutrients for the root zone of the crops. Applying crop residues such as ryegrass and straw residues, as well as mixed litter, can considerably improve soil porosity and water-holding capacity, resulting in a more productive soil.
- ✓ **Improving Soil Microbial Activity:** The correct retention of crop residues has been shown to have a substantial impact on the management of soil microbial biomass. Samui *et al.* and Mondal *et al.* found that crop residue mulching boosted microbial activity in the top layer of soil, which

they attribute to changes in the plant–soil microclimate, increased water and nutrient availability, and soil temperature regulation.

- ✓ **Crop Residues Improve the Fertility and Productivity of Soil:** Soil fertility refers to a soil's natural ability to provide a sufficient amount of nutrients for plants, which can be assessed through a chemical study of the soil. However, crop yield can be used to estimate soil productivity, which is the combined consequence of soil fertility and management parameters in field circumstances. Soil fertility is closely tied to the physical, chemical, and biological qualities of the soil, which are all inherently linked to the amount of organic matter in the soil.
- ✓ **Crop Residue Management for Soil Organic Matter:** The labile pool of soil organic matter varies considerably as crop residues are incorporated into the soil. Continuous residue assimilation for three years has been shown to greatly enhance the light carbon component in the soil, which contributes significantly to total soil organic carbon. Variations in heavy-fraction carbon ($>1.6 \text{ g cm}^3$) are the cause of changes in total organic carbon in long-term practises, depending on residue management procedures.

Crop Residue Management Decreases Soil Degradation

On average, regularly grown tropical crops such as rice, wheat, maize, and others contain 40% carbon, 0.8 per cent nitrogen, 0.1 per cent phosphorus, and 1.3 per cent potassium, and provide

food and habitat for beneficial soil bacteria. Furthermore, removing crop leftovers for cattle feed or other industrial purposes increases nutrient removal from croplands and affects soil, resulting in a variety of negative consequences ranging from soil erosion and degradation to deterioration of soil, air, and water quality. As a result, crop residues left over after harvest can successfully retain soil resources and maintain productivity.

- ✓ It has been reported that efficient residue utilisation reduces runoff, sediment transport or losses, and conserves water. It has been observed that using residue mulching can reduce soil loss by up to 43 times when compared to bare land. Mulching also aids in the reduction of runoff, N loss, and sediment in runoff water. It has also been observed that having a maximum ground cover with crop residue might reduce topsoil losses by 30%. Legumes are the most effective cover crop because they symbiotically supply atmospheric nitrogen and hence increase soil health.
- ✓ Soil moisture is a critical factor that influences nutrient availability, crop growth, and development. Because of its ability to maintain soil moisture, surface residue retention is highly useful for rainfed and dryland environments. By managing soil temperature, conserving soil moisture, and lowering soil evaporation, residue mulching is regarded an effective approach of manipulating the crop-growing environment for increasing crop production and enhancing produ-

ct quality.

- ✓ By limiting the entry of sunlight and keeping the heat, crop residue may effectively control soil temperature in the field. Crop residues are an efficient soil temperature moderator, as dense mulching with crop residues keeps the soil temperature in a comfortable range for plant growth throughout the cropping season. Surface crop residues reduce the temperature of the soil during the day to some amount. This action advantageous in dry tropical conditions, when the soil temperature becomes too high for plant growth.

Conclusion

Agricultural crop residues are carbon-rich biomass that remains in the field after the economic part of the crop has been harvested. Because of the expansion of agriculture, intensification of agriculture, and farm mechanization, the amount of crop leftovers produced is increasing year after year. Crop residue management is a common strategy in agricultural conservation. The SOC and nitrogen mineralization are both increased by this residue. The residue has a variety of consequences on the soil's physical, chemical, and biological qualities. Crop residue affects the factors directly related to soil humidity, temperature, and ventilation, as well as the degrees of interaction between soil minerals and organic matter, resulting to changes in physical and chemical soil qualities. As a result, agricultural residue management strategies should be chosen to improve crop yields while maintaining a healthy soil

environment. There is a need for research, education, outreach and policy interventions to restore SOC pool, improve quality of soils of agro ecosystems, increase productivity, and improve environmental quality.

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Use of Remote Sensing in Forest Cover Mapping

Ms. Meghna Sarma and Manoj Kumar

Introduction

Remote sensing is the “noncontact recording of ultraviolet, visible, infrared, and microwave regions of the electromagnetic spectrum by means of instruments such as cameras, scanners, lasers, linear arrays, and/or area arrays located on platform such as aircraft or spacecraft, and the analysis of acquired information by means of visual and digital image processing”.

Remote sensing has long been identified as an effective and efficient tool in forestry studies, such as forest inventory, forest health and nutrition, forest sustainability, forest growth, and forest ecology. Approximately 20% of the overall forest cover of India is located in the state of Madhya Pradesh. States like Maharashtra, Orissa, Andhra Pradesh, Uttar Pradesh, and Arunachal Pradesh also house a considerable volume of forests. Forests are ecological as well as socio-economic resource. These have to be managed judiciously not only for environmental protection and other services but also for various products and industrial raw materials. Considering the crucial role forests play in the country's ecological stability and economic development, the current National Forest Policy (1988) in India aims at maintaining a minimum of 33 percent of country's geographical area under forest

and tree cover. This requires periodic monitoring of the forest cover of the country for effective planning and sustainable development. Forest Survey of India (FSI), an organization under the Ministry of Environment & Forests (Government of India) has been mandated to monitor and map country's forest cover on a biennial basis. Consequently, FSI has been carrying out assessment of forest cover in the country using satellite based remote sensing data and has been publishing its findings in the State of Forest Report (SFR) every two years. Its first assessment of forest cover made in 1987 was published as SFR 1987 and the latest i.e., the eighth one as SFR 2001. With the improvement in satellite data resolution and adoption of digital image processing by FSI, it has been possible to assess forest cover patches as small as 1 ha.

The area under forest in India is about 75 million ha (Mha) constituting 23% of total Geographical area. This is very less against 33% forest cover according to Indian National Forest Policy. However, national level forest mapping carried out by Forest Survey of India (FSI) using 1985-87 satellite data shows 64.01 Mha of actual forest. This corresponds to 19.47% of India's total geographical area. The rapid depletion of forests made it essential to know the rate and trend of this

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degradation so that timely measures could be taken to prevent further loss of forest resources. Timely and accurate information for detecting changes over a period of time is required for forest ecosystems studies. This can be done through repetitive and cost effective technique of remote sensing. Accurate forest cover/vegetation map information are essential for formulating various management plans. Remote sensing technology can be effectively used for change detection and monitoring activities.

The most important forest information obtained from remotely sensed data can be broadly classified in the following categories:

- ✓ Detailed forest inventory data (e.g., within-stand attributes)
- ✓ Broad area monitoring of forest health and natural disturbances
- ✓ Assessment of forest structure in support of sustainable forest management
- ✓ By far the most widely used remote sensing data in forest studies are
- ✓ Optical satellite imagery, which utilizes the spectral information in visible and infrared portions (mainly ranging from 400 nm to 2500 nm) of the electromagnetic spectrum
- ✓ The three types of optical remote sensing data are multispectral imagery (e.g. Landsat TM [Thematic Mapper] image), panchromatic imagery (e.g. SPOT [Satellite Pour l'Observation de la Terre] 5 panchromatic image) and hyperspectral imagery (e.g. Hyperion image).

- ✓ In addition, Radar (Radio Detection and Ranging) and Lidar (Light Detection and Ranging) are becoming research hotspots in forestry studies.

Forest mapping

Forest cover typing can consist of reconnaissance mapping over a large area, while species inventories are highly detailed measurements of stand contents and characteristics (tree type, height, density). Using remote sensing data we can identify and delineate various forest types that would be difficult and time consuming using traditional ground surveys. Data is available at various scales and resolutions to satisfy local or regional demands. Requirements for reconnaissance mapping depend on the scale of study. For mapping differences in forest cover (canopy texture, leaf density,) are needed:

- ✓ Multi-spectral images, a very high resolution data is required to get detailed species identification
- ✓ Multi-temporal images datasets contribute phenology information of seasonal changes of different species
- ✓ Stereo photos help in the delineation and assessment of density, tree height and species
- ✓ Hyper-spectral imagery can be used to generate signatures of vegetation species and certain stresses (e.g. infestations) on trees. Hyper-spectral data offers a unique view of the forest cover, available only through remote sensing technology

- ✓ RADAR is more useful for applications in the humid tropics because its all weather imaging capability is valuable for monitoring forest
- ✓ LiDAR data allows the 3-dimensional structure of the forest. The multiple return systems are capable of detecting the elevation of land and objects on it. The LIDAR data help estimate a tree height, a crown area and number of trees per unit area.

Forest Cover Monitoring

The forest cover at the national level is being biennially monitored using remote sensing data and it is estimated that India has 19.47% of forest cover (1989-91) out of the total expected 33% of forest cover as per India's forest policy. So far Forest Survey of India (FSI) has brought out successfully four assessments on the status of forest cover in India (Table.) This information is more relevant in the context of assessing rate of degradation grossly at the state/district level in terms of closed and open forests. However, the extended use of this information for effective utilisation for the management purpose at the state level could be better achieved by supplementing the data each reserve forest boundaries thereby enlisting the districts having or degraded areas.

The forest cover has been classified on the basis of the tree canopy density into pre-defined classes, viz., Very Dense Forest (VDF), Moderately Dense Forest (MDF) and Open Forest (OF) and Scrub. (i) Dense forest, having canopy density of more than 40%, (ii) Open Forests with canopy

density between 10-40% and (iii) Scrub which are forest areas having less than 10% canopy density

Table-Status of Forest Cover in India (Based on Satellite Remote Sensing) (Area in million Hectares in bracket)

Forest Category	1972-75	1981-83	1985-87	1987-89	1989-91
Dense/ Closed	14.12 (46.45)	10.99 (36.14)	11.51 (37.84)	11.71 (38.50)	11.72 (38.55)
Open	7.38 (24.28)	8.41 (27.65)	7.83 (25.74)	7.60 (24.99)	7.61 (25.04)
Mangrove	0.10 (0.30)	0.12 (0.40)	0.13 (0.42)	0.13 (0.42)	0.13 (0.42)
Total%	21.60 (71.03)	19.52 (64.20)	19.47 (64.01)	19.44 (63.92)	19.47 (64.01)

Forest Cover Assessment

Till recently, FSI was using mostly visual interpretation of satellite data on 1:250,000 scale for assessment of forest cover. However, in its latest assessment i.e., 2001 assessment, it used digital interpretation of satellite data on 1:50,000 scale for mapping and monitoring forest cover. The present methodology uses Digital Image Processing software and involves the following steps:

1. Acquisition of satellite data: The digital data of IRS-1C and 1D LISS III is acquired from NRSA in CD. India is covered in about 340 scenes, of IRS 1C and 1D. One scene covers an area of about 20000 km², having an overlap of about 10% with adjoining scenes. While procuring the data, care is taken to ensure that it is cloud free (with not more than 10% cloud cover) and therefore data pertaining to the period from October-December is preferred.

2. Geometric Rectification of raw data: After downloading the data into computer, rectification is carried out in each image to provide Latitude and Longitude information into raw satellite scene using raster based geometric corrections.

Rectification carried out in geographic projection is re-projected in shape of polygonal projection and the scene is geo-coded with using SOI toposheets.

3. Mosaicing of rectified scenes: Different scenes, which are already rectified, may have to be merged together to get one combined FCC (False Colour Composite). FCC of sheet is extracted from mosaiced scene in a chosen area of interest. Image is displayed in three bands 3, 2, 1. Masking of non-forest areas is done separately to extract forest areas on the basis of ground knowledge, cover map of previous cycles and on the basis of information available through SOI toposheets in the area of interest.

4. Classification of forest cover using NDVI: Interactive method of display is used for assigning threshold values for each class (open, dense and scrub) on the basis of the ground knowledge to highlight forest/vegetated areas. Density class of forest cover and colour is accordingly allocated.

Constraints

Remote sensing data has certain inherent limitations that affect the accuracy of the forest cover mapping.

- ✓ Since the resolution of the LISS-III sensor data is 23.5 m, the land cover having a geometric dimensions on the ground less than the above are not discernible.
- ✓ Considerable ground details may sometimes be obscured due to clouds and shadows.
- ✓ Non-availability of appropriate season data sometimes leads to misinterpretation of the featu-

res owing to poor reflectance of data.

- ✓ Occurrence of weeds like lantana in forest areas and crops like sugarcane, etc. adjacent to forest area causes mixing of the spectral signatures and forest cover delineation difficult.
- ✓ Young plantations and tree species with lesser chlorophyll or poor foliage are many times not discernable on satellite images due to poor leaf area index and transmittance.
- ✓ Where heterogeneity in tree species composition is high, generalized classification may affect the accuracy level.

Future directions of remote sensing in forestry

A key development in remote sensing has been the increased availability of high-spatial- and high-spectral-resolution remotely sensed data from a wide range of sensors and platforms including photographic and digital cameras, video capture, and airborne and spaceborne multispectral sensors. Hyperspectral imagery promises to provide improved discrimination of forest cover and physiological attributes. Radar applications are being developed that penetrate the forest canopy to reveal characteristics of the forest floor. New technologies such as LIDAR can provide estimates of forest biomass, height, and the vertical distribution of forest structure with unprecedented accuracy. The use of advanced digital analysis methods and selective use of complementary data have provided more detailed information about forest structure, function, and ecosystem processes than ever before. Operational capabilities continue to improve forest attribute

mapping with a precision commensurate with forest management scales. This, in turn, will contribute to efforts aimed at assessing the sustainability of our forests through better forest practices and improved decision-making in forest management.

Conclusion

- ✓ Satellite remote sensing is valuable technique for mapping of forests and potential afforestation sites occurring over large area, rapidly and economically.
- ✓ Up-to-date information on location and spatial extent of forests and wastelands is an essential prerequisite for management of forest and wastelands.
- ✓ Due to low forest cover, a massive self-sustaining, self-propagating, autonomous people's afforestation movement should be launched without delay.
- ✓ The economic condition of the rural poor people needs improvement so that their dependence on small bits of unproductive agricultural lands and forestlands is reduced which will be only by establishing small-scale industries in rural areas, provision for alternative fuel-efficient hearths and conscious efforts to educate the villager on the environment.

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Role of Agricultural Scientist in the Transformation of Agriculture

Mr. Santosh Pathak and Dr. Pradip D. Narale

The Indian agriculture sector involves a bulk of the population of India. Agriculture is the building block of our country India. It does not only engage the majority of the population in agriculture and allied activities to sustain their livelihood but also acts as a major contributor to GDP. It contributes more than 16% in the total GDP of India.

Since the time of agricultural revolution India has been an agriculture-based country. Agriculture in India has always been traditional. Farmers in the country have been relying on traditional methods of farming since ages. Changing weather patterns, untimely rain, prolonged drought, Population growth and shrinking agricultural land have put the agricultural sector under stress. This is leading to a threat to food security in our country. It is also a threat to the source of income generation of farmers and other people associated with this sector. In order to mitigate these challenges, we need agricultural reforms. We need to come up with innovations which have potential to change the face of agriculture in the coming future. For this innovation to come we need a lot of research and data collection. India has a wide range of soil types; it has a varying rainfall pattern and terrain. This makes the task of data collection for the progression of research work

ists. Agricultural Scientists are those who critically analyze the methods of farming and methods related to food production in order to increase safety and achieve optimum crop yield.

Agricultural scientists play a pivotal role in the income generation of a country like India where more than 60 percent of the population is directly or indirectly dependent on agriculture. Agriculture has the largest share in GDP of our country. Economy of our country is directly linked to the agricultural produce. Agriculture is a practice which is completely linked with the environment. It involves deep research and techniques that our agriculture scientists do to improvise agriculture productivity in terms of quality and quantity.

Agricultural Scientists as a key player

Agriculture scientists have a huge role to play in developing effective scientific strategies for cheap and easy farming techniques and animal husbandry, and educating the farmers. Agriculture scientists around the world and in our country are working in developing crops for higher yield, pest and harsh environment resistance and for judicious consumption of food. Agricultural Scientists have a better understanding of the socioeconomic and political factors that enhance the productivity and

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poverty-reducing impacts of new technologies and management practices.



Green Revolution and Agricultural Scientists

The Green revolution in India is a living example of how the knowledge of an agricultural scientist can revolutionize the production of wheat in a country like India. In the year 1965, the government of India launched the Green Revolution with the help of a geneticist, now known as the father of the green revolution (India) M.S. Swaminathan. The movement of the green revolution was a great success and changed the country's status from a food-deficient economy to one of the world's leading agricultural nations. It started in 1967 and lasted till 1978. His suggestions make the agriculture world stronger and vanquish the problem of hunger and poverty.



Changing Irrigation Methods

With the advent of micro irrigation and with the aid of precision farming, farmers in India are now

relying on sensory based data for their irrigation scheduling. Micro irrigation has demonstrated an increase in water use efficiency up to 80% to 90%, which increases the productivity and yields of crops, reduces soil erosion and reduces groundwater pollution. This eventually will help in increasing the income of farmers. This has become possible only after the efforts of agricultural scientists around the country. Micro irrigation has a potential of increasing farmers income by 50%.

Agricultural Scientists are helping in collecting data on weather and soil of the region and processing them to develop AI (Artificial Intelligence) based agriculture. Collected data when processed, helps in developing mechanisms for precision farming which is going to be the future of farming. It has a potential of enhancing the income status of farmers and at the same time it can also reduce the drudgery of farmers.

Crop-Field Relation

Soil scientists working in agricultural research organizations, universities and other institutions have collected soil samples from around the country and they have suggested which soil type is more favorable for a particular crop. This will not only make the region a hotspot of that particular crop but also it will create a sophisticated market network to meet the demand and supply chain. This will eventually aid the income of farmers and economic growth of the country as a whole. A lot of research and Development work has been done in the field of drone-based agriculture which is also a part of AI

(Artificial Intelligence) based farming. Application of drones especially in hilly areas will help the farmers in keeping a surveillance of their crop staying at one place. It will reduce their time and it will help in saving their energy by not moving on high and steep slopes.

Steps towards Sustainability

The Agricultural Scientist community is devoted to pave the way for sustainable and climate resilient agriculture for our country. When the government aims to cut down the carbon emission by 2030 agricultural scientists are looking for a way to reduce emission from agricultural practices. They are looking for a solution which will not only cut the emission but also add to the economy of farmers. One such innovation is bio-oil, biochar, bio gas production using agricultural residue. Research by the scientists has revealed that the crop residue has a huge carbon content which can be utilized for bio-oil, biochar and bio gas production.

When the government is focusing on natural farming a lot of data, research and development is required to know the nitrogen, phosphate, carbon content of different soil. Only knowing the content is not enough, there is a requirement of selection of a particular type of crop for the particular selected region. Agricultural scientists have to come up with a solution that promotes natural farming by not interfering with the culture and tradition of the people associated with the region. Various research institutions are currently conducting the research to assess results of natural farming. Some research is

based on field experiments, while others are based on surveys with practicing farmers. Most research works are still in progress. Indian Council of Agricultural Research (ICAR) has also set up a committee to validate. Zero budget natural farming especial results.

Effect of Agricultural Research

The effect of agricultural research on income generation comes through its effects on agricultural productivity. Research produces new technologies and management practices that increase productivity and income of the farmer. Data collection and their processing takes time, Data on agricultural practices and land use are not accurately known. People believe that research is some kind of a magic wand which gives desired results when it is waved over the problem. Research is science-based and one cannot expect anything and everything from research. If expectations are controlled, or at least, they are made more realistic then agricultural research done by Agricultural Scientists can bring a better future for farmers and the nation.

Conclusion

Agricultural Scientists are transforming the agriculture in our country. Research and development in the field of agriculture is rapidly changing the way of farming. It has given farmers the scope of income generation through more than one agricultural practice. As globalization has taken place, India is becoming a hotspot market of agricultural as well as horticultural produce. Institutions such as ICAR in collaboration with other

institutions are working on research and development. These research and development done by agricultural scientists are changing the income generation of farmers. India is becoming the largest exporter of many cereals as well as horticulture crops due to the efforts of Agricultural Scientists who are continuously putting effort to bring new innovations that have potential to enhance the income status of Indian farmers. It is Agriculture that gives India a unique position on the globe. Jai Jawan, Jai Kisan.



Turmeric: Importance and Its Uses

Shaifali Tanwar and Vikas Rao

Introduction

Turmeric is a plant that has a very long history of medicinal use, dating back nearly 4000 years. In Southeast Asia, turmeric is used not only as a principal spice but also as a component in religious ceremonies. Because of its brilliant yellow colour, turmeric is also known as “Indian saffron.” In North India, turmeric is commonly called “haldi,” a word derived from the Sanskrit.

General Information

- ✓ The turmeric plant needs temperatures between 20°C and 30°C and a considerable amount of annual rainfall.
- ✓ Individual plants grow to a height of 1 m, and have long, oblong leaves. Plants are gathered annually for their rhizomes.
- ✓ The rhizome, from which the turmeric is derived, is tuberous, with a rough and segmented skin.
- ✓ The rhizomes mature beneath the foliage in the ground. They are yellowish brown with a dull orange interior.
- ✓ The main rhizome is pointed or tapered at the distal end and measures 2.5-7.0 cm (1-3 inches) in length and 2.5 cm (1 inch) in diameter, with smaller tubers branching off.
- ✓ India produces nearly all of the world's turmeric crop and consumes 80% of it. With its inherent qualities and high content of the important bioactive compound curcumin, Indian turmeric is considered to be the best in the world.
- ✓ Erode, a city in the South Indian state of Tamil Nadu, is the world's largest producer of and the most important trading centre for turmeric. It is also known as “Yellow City,” “Turmeric City,” or “Textile City.” Sangli, a city of Maharashtra, is second only to Erode in size and importance as a production and trading site for turmeric.
- ✓ Before turmeric can be used, the turmeric rhizomes must be processed.
- ✓ Rhizomes are boiled or steamed to remove the raw odor, gelatinize the starch, and produce a more uniformly coloured product.
- ✓ In the traditional Indian process, rhizomes were placed in pans or earthenware filled with water and then covered with leaves and a layer of cow dung.
- ✓ For hygienic reasons, this method has been discouraged. In present-day processing, rhizomes are placed in shallow pans in large iron vats containing 0.05-0.1% alkaline water (e.g., solution of sodium bicarbonate).
- ✓ The rhizomes are then boiled for between 40-45

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minutes (in India) or 6 hours (in Hazare, Pakistan), depending on the variety.

- ✓ The rhizomes are removed from the water and dried in the sun immediately to prevent overcooking.
- ✓ The final moisture content should be between 8% and 10% (wet basis). When finger tapping of the rhizome produces a metallic sound, it is sufficiently dry. The dried rhizomes are polished to remove the rough surface. Sometimes, lead chromate is used to produce a better finish, but for obvious reasons this practice should be actively discouraged. The powder maintains its colouring properties indefinitely, although the flavour may diminish over time. Protecting the turmeric powder from sunlight retards the rate of deterioration.

Composition of Turmeric

- ✓ The main component of the root is a volatile oil, containing turmerone, and there are other colouring agents called curcuminoids in turmeric.
- ✓ In a standard form, turmeric contains moisture (>9%), curcumin (5-6.6%), extraneous matter (<0.5% by weight), mould (<3%), and volatile oils (<3.5%).
- ✓ Volatile oils include d- α -phellandrene, d-sabinene, cinol, borneol, zingiberene, and sesquiterpenes

Importance

Turmeric has been put to use as a foodstuff, cosmetic, and medicine.

1. Food Stuff

- ✓ Turmeric is traditionally used to give boiled white rice a golden color.
- ✓ Turmeric is also used in manufactured food products such as canned beverages, dairy products, baked products, ice cream, yellow cakes, yogurt, orange juice, biscuits, popcorn, sweets, cake icings, cereals, sauces, and gelatins.
- ✓ It is a significant ingredient in most commercial curry powders.
- ✓ Turmeric has numerous uses in Asian cuisine.
- ✓ It is used in savoury and sweet dishes, and is widely used in Eastern specialties such as fresh turmeric pickle.

2. Meditational Use

- ✓ Strengthening the overall energy of the body, relieving gas, dispelling worms, improving digestion, regulating menstruation, dissolving gallstones, and relieving arthritis.
- ✓ Used as an antiseptic for cuts, burns, and bruises, and as an antibacterial agent.
- ✓ It is used as an anti-inflammatory agent, and as a remedy for gastrointestinal discomfort associated with irritable bowel syndrome and other digestive disorders
- ✓ Indians use turmeric, in addition to its Ayurvedic applications, to purify blood and remedy skin conditions.
- ✓ Turmeric paste is used by women in some parts of India to remove superfluous hair.
- ✓ Turmeric is currently used in the formulation of several sunscreens.

- ✓ Several multinational companies are involved in making face creams based on turmeric.
 - ✓ Turmeric is a well-documented treatment for various respiratory conditions (e.g., asthma, bronchial hyperactivity, and allergy), as well as for liver disorders, anorexia, rheumatism, diabetic wounds, runny nose, cough, and sinusitis.
 - ✓ In traditional Chinese medicine, it is used to treat diseases associated with abdominal pain. From ancient times, as prescribed by Ayurveda, turmeric has been used to treat sprains and swelling). In both Ayurvedic and traditional Chinese medicine, turmeric is considered a bitter digestive and a carminative.
- 3. Vitro use of Turmeric**
- ✓ Modern in vitro studies reveal that turmeric is a potent antioxidant, anti-inflammatory, anti mutagenic, anti microbial, and anti cancer agent.
 - ✓ Sufficient levels of turmeric may be consumed from curries in vivo to ensure adequate antioxidant protection.
 - ✓ As an antioxidant, turmeric extracts can scavenge free radicals, increase antioxidant enzymes, and inhibit lipid per oxidation.
 - ✓ A mutagenicity study showed that turmeric inhibits the mutagenicity produced by direct-acting mutagens such as N-methyl N'-nitro-N-nitrosoguanidine and sodium azide. Turmeric extracts were found to inhibit microsomal activation-dependent mutagenicity of 2-acetamidofluore.
 - ✓ The curcumin in turmeric has proven strong anti-inflammatory properties that blocks the action of inflammatory molecules in the body.
 - ✓ Positive results are shown on the people suffering from conditions like rheumatoid, arthritis and inflammatory bowel diseases.
- Conclusion**
- ✓ The most widely used part of turmeric is its root, comprising loads of phytochemicals, vitamins, and minerals, quite beneficial for the cure of various human diseases.
 - ✓ It has various other medicinal use as it possess antioxidant, anti-inflammatory and anti-mutagenic property.
 - ✓ Hence, it seems that turmeric is a safe medicinal herb.

Insect Pollination in Fruit Crops: Productivity and Quality

Mukesh Shivran, Uttam Shivran, Narendra Singh and Arjun Lal Ola

Transfer of pollens from anther to receptive stigma is known as pollination. Flowers are fully dependent on vector to move pollen. Insects, water, wind, birds, bats, and animals that visit flowers could all be vectors. Pollinators are important ecosystem services providers for both cultivated and wild plant populations (Klein *et al.*, 2007). Pollinizers and pollinators play an important role in fruit crop pollination in order to maintain crop diversity and production systems. Most of the fruit crops such as apple, pear, peach, plum, apricot, strawberry, blueberries, blackberries, cherries, cranberries, raspberries, mango, aonla, ber, pomegranate, jamun, fig, citrus, banana, etc. require insect pollinators for efficient pollination to obtain the high yield and quality fruit production. Having enough pollinator's during bloom is essential to produce a sustainable crop in fruit crops. Improved pollination can reduce the time between flowering and fruit set, reducing disease, insect, adverse weather, and pesticide exposure while conserving water. Efficient pollination enhances the fruit size at yield, produces a more symmetrical fruit shape and hastens maturity (Pashte and Kulkarni, 2015).

Honey bees are the primary pollinators for the majority of the world's angiosperms, pollinating approximately 66 percent of the 1500 crop species and accounting for 15-30 percent of global food supply. For the pollinators who visit them, the flower type, colour, shape, nectar, odour, and structure are all critical (Halder *et al.*, 2019). Insects are responsible for more than 80% of all pollination activities. Honeybees are essential for crop pollination all around the world.

The importance of pollinator and pollinizer species richness or diversity in their natural environment, as well as their involvement in crop improvement, must be understood. Honeybee pollination, understanding of pollinizers, pollinator management, and artificial pollination are key horticultural inventions that increase yield and quality in fruit crops, which are heavily cross-pollinated, and boost the beekeeping business to generate high-quality honey. Through varietal compatibility, synchronised blooming, and ideal environmental conditions, it involves effective pollinator and pollinizer integration. A pollinator is a biotic agent that transports pollen from the anther to

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the stigma of a flower, allowing fruits or seeds to develop through fertilization. Bees, flies, bats, moths, and birds are examples of pollinators. A well-pollinated flower will have more seeds and a higher germination rate, resulting in larger and better-shaped fruit. The role of many insect pollinators in important fruit crops is mentioned below.

Mango: Mango is highly heterozygous and cross-pollination fruit crop and need for pollinating insects to transfer the pollen from anthers to stigma for gain good fruit quality and yield. Bee pollination significantly enhance the per cent fruit set in mango. Major pollinators are house fly, honey bee, *Rhynchaenus mangiferae*, *Lucilia* sp and *Sarcophaga* sp etc.

Citrus: Distinct citrus species have different pollination requirements, while pollinators have different preferences for different citrus species (Roubik, 1995). Some citrus and sweet orange types are partially or entirely self-incompatible, requiring insect pollinators for pollination (Sanford, 1992). Honeybee pollination may improve fruit set, fruit size, fruit shape and seed number depending on the variety and conditions at the site.

Guava: Guava is a tropical fruit that thrives in warm climates. Honey bees were the most effective pollinators, resulting in increased fruit set and higher fruit quality. Honeybees were responsible for 20% to 40% of pollination. Fruit length and girth were also significantly improved in the bee pollination treatment compared to the control group.

Apple: In apple required 11-33 % polliniser for enhancing the productivity and improving the quality of apple fruits, pollination services through bees is of significant value. The vast majority of apple types are unsuitable for each other. The best strategy to ensure a successful harvest is to allow enough cross-pollination of two or more apple varieties.

Fig: The wasps is required for pollination in figs referred to as caprifigation. Because most commercially significant figs require fertilisation to ripen, the female fig wasp's involvement in pollinating some edible figs.

Banana: In banana honeybees is the most common visitors to banana inflorescences followed by wasps.

Pomegranate: Bee pollination increase the fruit setting per cent and weight of pomegranate fruit is compared with self-pollination. In crosspollination, fruit set can higher to around 68 per cent and additionally there is an increase in fruit quality like fruit size, number of seeds per fruit and yield. Major pollinators are namely *Apis* spp., *Camponotus* spp.

Ber: In ber for fruit setting requires cross-pollination by insects attracted by the aroma and nectar. It is transmitted from blossom to flower by honeybees, not by the wind. Insects appear to play a vital role in pollination. House flies (*Musca domestica*) and honey bees have been observed to play a major role in pollination.

Conclusion

Pollination and pollinisers can enhance the qualitative and quantitative traits of fruit crops and

it depending on the cultivar and conditions at the site. Pollinator and pollinizer species richness or diversity in their natural environment, as well as their involvement in crop improvement (high yield and good quality).

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Jeevamrutham: An Effective Activator of Soil Microorganism

Uttam Shivran, Mukesh Shivran, Arjun Lal Ola and Sneha Rathore

Jeevamrutham is an organic fertilizer and a great replacement of chemical fertilizers. It is a very good source of biomass, natural carbon, nitrogen, phosphorous, calcium and other nutrients which are essential for plant growth and development. The microorganisms which are present in the soil are responsible for increasing the fertility of the soil and the productivity of the crops. In order to increase the microorganisms in the soil jeevamrutham is used. Jeevamruth enhances microbial activity in soil and helps in improvement of soil fertility.

Introduction

Jeevamrutham is moderate green in colour with mild foul odour and with progression in storage period it attains darker in colour with strong foul odour. Jeevamrutham is made of two words – jeeva and amrutham. Both are derived from Sanskrit. The word “Jeeva” means a living being and amrutham means the elixir (medicine) up to extending life. According to agricultural view, jeevamrutham is for crop life. It is the best culture to increase the count of microorganisms. Jeevamruth, is a microbial culture, mainly prepared from cow dung and cow urine

generally used in organic farming to meet the nutritional requirement of crops. The freshly prepared jeevamrutham was acidic in nature with a pH of 5.63. The EC (Electrical Conductivity) of jeevamrutham was 0.23 dS m⁻¹ and the calcium content (66.4 ppm) was recorded in fresh preparation.

According to agriculture view to fresh preparation.

Types of Jeevamrutham

- ✓ The liquid state of jeevamrutham
- ✓ The semi-solid state of jeevamrutham
- ✓ Dry jeevamrutham (Ghana jeevamrutham)

Method and application of liquid jeevamrutham

Requirements for liquid jeevamrutham: Water, cow dung, cow urine, jaggery, flour of any pulse and a handful of fertile from the same land.

Preparation

The dung and urine of cow, hybrid cow, were prepared by using 1 kg dung, 1 litre urine, 200 g jaggery, 200 g flour and 100 g soil from the same field mix them in a big tank properly and keep the tank in shade and cover it with jute bag and it should

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be breathable and leave it. The mixtures were kept for incubation under shade for 5 days and stirred vigorously for 10-15 minutes three times a day with a wooden stick. The average minimum and maximum temperatures during the study period were 13.4 and 31.1°C, respectively. The final volumes of the mixtures were made to 20 litres with water in plastic containers.

Application: If jeevamrutham is given by Irrigation like a drip, canal water, sprinkler utilize complete 200 liters. When you are considering the spray, you can dilute the mixture.

First spray: One month after seed sowing or transplanting of seedling. Take 100-liter water to add 5 liters of filtered jeevamrutham.

Second spray: 21 days after the first spray. Here 150 liters of water plus 10 liters of filtered jeevamrutham.

Third spray: 21 days after the second spray, take the third spray. 200 liters of water plus 20 liters of filtered jeevamrutham.

Fourth spray: When fruits are beginning to show up. 200 liters of water plus 6 liters sour buttermilk can be sprayed for one acre. In summer, spray to be done in early morning or evening.

In winter any time of the day can be sprayed. It can also be applied by hands whenever there is a water scarcity problem or no sprayer available, still we can use jeevamrutham. The first month after seed sowing or transplanting seedlings add one cup (50 ml) jeevamrutham in between two main vegetable plants on the surface of the soil. Repeat this once or

twice or even thrice a month. Repeat the same for every month for four months till the harvest is completed.

Method and preparation of semi-solid state jeevamrutham

Requirements for semi solid jeevamrutham- 100 kg desi cow dung, 5 litre urine, 1 kg jaggery, 1 kg pulse, one handful of soil from the same land.

Preparation: Mix all of them with a small amount of water. Make the small balls out of the mixture. Keep these balls in full sunlight to dry them. Now, these dried balls can be kept near the mouth of a dripper or near the sprinkler. When the waterfalls on the semi-solid jeevamrutham, the microbes get activated again.

Method and application of dry jeevamrutham (Ghana jeevamrutham)

Spread 200 kg of cow dung on ground uniformly in the form of layer and add 20 liters of liquid jeevamrutham on it and mix it. Now, make a heap of treated cow dung and cover it using jute bag for 48 hours allow it for fermentation then spread on the floor, dry in the sunlight. After drying is completed, store it in jute bags in the room. Air should be flowing. You can store Ghana jeevamrutham for 6 months.

Application: At the sowing period, use the 200 kg ghana jeevamrutham per acre. For example, two hands of ghana jeevamrutham with each seed. Again, during the flowering period of the crop, add 50 kg of ghana jeevamrutham in between two crop lines on the soil per acre. Amazing yield will be produced.

Advantages

It helps the soil to activate their available nutrients, microorganisms to make them available for the crop sown in that particular area. It increases the count of earthworms in soil which is beneficial for soil fertility. jeevamrutham is one of those organic fertilizer which have large number of nutrients like nitrogen, phosphorus, calcium, and other micro-nutrients. This will ensure higher yield by enhancing the availability of nutrients through faster decomposition of bulky organic manures by boosting the microbial activity in the soil. Many of these formulations are rich in beneficial micro flora and can act as efficient plant growth promoters.

Precaution

Do not use chemical fertilizers, pesticides or weedicides for 20 days before and after application of jeevamrutham.

Conclusion

Jeevamrutham helps to maintain the soil health and fertility. It provides varieties of benefits to user like less cost, easily adoptable to poor farmers, increase the crop productivity, environmental safety, and successful crop production. Generally, only the fresh preparations of liquid organic formulations are used by the farmers as they do not have information about the shelf life of liquid organic formulations. We can store jeevamrutham for many days or for weeks too. Stored material also has their own advantages like increase in nitrogen, micronutrients, EC, etc. To get good yield, healthy quality of crop, we must have to adopt this organic fertilizer applic-

ation.

Biotechnological Strategies to Ameliorate Heavy Metal Toxicity in Rice

Ankit Kumar Keshari, Sarita Kumari, Ashutosh Singh and Sumeet Kumar Singh

Heavy metal pollution increasing drastically that impacts various life forms including plant, animals and causing serious health risks to human health (Tong *et al.*, 2023). Various anthropogenic activities such as rapid industrialization, mining, irrigation and use of inorganic fertilizers contribute towards major sources of soil contamination through heavy metal toxicity (Malinowska *et al.*, 2020). Naturally, metals with a density and atomic weight higher than 5g/cm³ are considered as heavy metals which are further classified as essential and non-essential based on their necessities for normal functioning of life (Shen *et al.*, 2023). Heavy metals like As, Cd, Pb, Hg, Tl and Cr has no functional role in crop plants and are categories under non-essential heavy metals, hence excessive accumulation of these metals can cause detrimental effect on plant growth and development (Sodhi *et al.*, 2022). These metals can easily accumulate in human body through consumption of plant products that are grown in the contaminated soil and cause severe health risk. Additionally, HMT is responsible for sever acute and chronic diseases including kidney dysfunction, immunological & cardiovascular diseases, abnormal embryonic development, infertility, bone problems

and even cancer (Giri *et al.*, 2020). It has been estimated that 90 % of the heavy metal toxicity accumulate in human body that comes through the intake of dietary food and rice is the primary source of food for more than 3.5 billion people around the world and 2.4 billion especially in Asiatic region (Martorell *et al.*, 2011). Therefore, it is imperative to understand the mechanism of heavy metal bioaccumulation in plants. So, that we can adopt efficient management strategies to ameliorate harmful effect of HM toxicity in rice plant.

Mechanism of heavy metal accumulation in rice

plant: Use of HM-rich fertilizers, pesticides, irrigation, sludge waste prompt to accumulation of heavy metals in soil through leaching process that contaminate both groundwater as well as surface water (Ayejoto *et al.*, 2022). In rice crop, heavy metals such as Arsenic, Cadmium and Lead along with some other essential metals like Fe, Cu and Zn are absorbed from the contaminated soil and transported to various plant parts under different soil moisture levels (Fig. 1) (Slamet-Loedin *et al.*, 2015). Arsenic and Cadmium accumulation in rice grain is a major concern that causes severe health issues in human body (Yu *et al.*, 2016).

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There is ionic interaction between metal containing positive ions present in contaminated water with the binding sites on the cell wall of plants possessing negatively charged ions. It creates a gradient change in the cell membrane of plant, promoting metal to enter the cell.

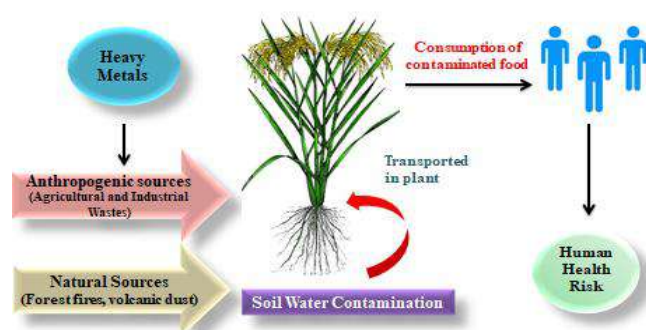


Fig. 1: Transportation of heavy metals from various sources to the human body via rice plant

Effect of Heavy Metal Toxicity (HMT) in Rice Plant:

Accumulation of heavy metals in rice plants can have harmful effect that impact on plant growth, development and quality of grains produced. The intensity of negative impact depends upon the various types of heavy metal, its availability in contaminated soil and specific biochemical processes. Presence of these heavy metals adversely affect the transportation and accumulation of other metals which are essential for normal functioning of plant metabolism, which eventually responsible for change is various morphological and anatomical parameters in plant such as variation in leaf area, shoot length, diameter and length of root, reduction of parenchyma cells, mesophyll cells and reduction in xylem vessels in plant (Seneviratne *et al.*, 2017 and Batool *et al.*, 2015). Arsenic, lead, cadmium, and mercury are common heavy metals that pose a threat

to rice plants (Table 1). It has been found that Arsenic, one of the most hazardous metalloids to cause stress in the seedlings of rice by shortening root and shoot length, thus resulting in stunted growth and reduced yield (Abedin *et al.*, 2002). Excess exposure of arsenic to rice seedlings significantly reduces plant biomass and germination percentage (Shri *et al.*, 2009). Accumulation of Cadmium reduces absorption and translocation of essential minerals like Zn, Fe, Cu and Mn, that induce low potassium (K) and Fe content in rice seedling, ultimately initiate loss of chlorophyll (Parmar *et al.*, 2013 and Liu *et al.*, 2012). Excessive Cd content induces anatomical changes in leaf structure by reducing size of vascular bundles, chlorosis in mesophyll cells (Tripathi *et al.*, 2012b). Another destructive toxic element, mercury (Hg) accumulation causes a significant reduction in root-shoot biomass in rice plant, further disrupting nutrient uptake and affect plant metabolism, leading to reduced growth (Wang *et al.*, 2014). When Lead (Pb) gets accumulate in rice crop it reduces dry biomass and it cause more damage in guard cell's shape in leaf stomata, moreover gradually it leads to decrease in in chlorophyll content in rice (Srivastava *et al.*, 2014).

Biotechnological approaches to ameliorate HMT in rice plant: Numerous agricultural management practices have been devised to reduce the heavy metal toxicity in rice cultivation. However, only a handful of these technologies are practical and often suffer from time-consuming processes and imprecise

Table 1: Effect of heavy metal toxicity in rice plant

Heavy Metals	Morphological Effects	Physiological Effects	Anatomical Effects	Biochemical Effects
Cd	Reduce root- shoot elongation, root frequency and growth. Caused chlorosis and leaf curling	Inhibit germination of seed. Reduction in chlorophyll content Cause Fe deficiency.	Modify leaf structures, decrease in size of vascular bundles, increase width of roots	Enzymatic and metabolic alterations and generate oxidative stress
As	Reduce root- shoot length and biomass	Inhibit Seed germination	-	-
Hg	Decreases root-shoot biomass	-	Development of apoplastic barrier occurs	-
Pb	Reduce dry biomass	Decrease chlorophyll content	-	-
Al	Reduce root-shoot growth Causes chlorosis and dwarfing of leaves	Decrease total chlorophyll and carotenoid content	Reduce the size of vascular bundles, length of leaf, phloem parenchyma cells	Reduce total protein content in root and shoot
Cu	Reduce root- shoot length and biomass	Decrease chlorophyll content. Reduces seed germination.	-	Reduce total protein content in root and shoot
Cr	Reduce root- shoot length and biomass	Decreases macro and micro nutrients availability in root and shoot. Decreases seed germination percentage	Damages mesophyll cells, xylem, phloem and increases root hair frequency.	Reduce protein content in root and shoot
Zn	Decreases root length. Make root hairless, stunted, curled and brittle with small lateral branches.	Decrease chlorophyll content. Causes mineral deficiency. Reduces uptake and translocation of essential minerals.	-	Decrease SOD and CAT content
Mn	Decreases root-shoot biomass. Make root hairless, stunted	Decreases root length. Make root hairless, stunted, curled and brittle with small lateral branches.	-	-
Ni	Cause leaf wilting and necrosis. Rolling up of leaves and necrotic zones at leaf margins. Stunted growth, brownish roots.	Decreases respiration processing root. Reduces water content in plant	-	-

results, accompanied by certain limitations. Use of molecular genetic tools can be an innovative approach to minimize HMT in rice plant, which involves identification of genetic loci responsible for various heavy metal accumulation and subsequently utilizing genome editing techniques to knock out and precisely editing of genes. This method presents a novel means of addressing several issues stemming from heavy metal toxicity in rice plants. Several key steps have been identified at molecular level for

better understanding and enhancing the phyto-remediation abilities of crop plants (Yang *et al.*, 2005). It has been demonstrated that several genes are responsible for uptake and translocation of heavy metals in crop plants. Manipulating the genetic structure these genes through efficient molecular tools may strive to create plants with low heavy metal toxicity. Specifically, HM tolerance has been successfully increased by overexpressing several genes coding for antioxidant enzymes, including

GST. Further, genes encoding various metal chelators, metal transporters and transcription factors have been overexpressed, that significantly boosting tolerance mechanism to heavy metals in rice plant (Singh *et al.*, 2016). Stress resistance to Cd, Zn and Mn can be enhanced by overexpressing of TaCNR2 gene in rice (Qiao *et al.*, 2019). Gene OsHMA2 found in root that responsible for transporting Zn/Cd from root to shoot in rice plant (Takahashi *et al.*, 2012). Several QTLs/ candidate genes that influence HM accumulation and toxicity tolerance in rice have been identified by various QTL mapping and genome wide association studies (GWAS) (Zhang *et al.*, 2020). Additionally, various genome editing tools such as ZFNs (Zinc Finger Nucleases), TALEN (Transcription Activator-Like Effector Nucleases) and CRISPR/Cas9 are being used to modify the genomic DNA of plants to improve the quality and productivity of the crop plants. However, CRISPR/Cas9 has been predominantly used in rice crop to ameliorate heavy metal toxicity.

CRISPR/Cas9 genome editing tool for HMT tolerance in rice: Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR/Cas9) a novel genome editing technique has demonstrated tremendous promise for agricultural improvement. CRISPR, collaborating with the Cas9 nuclease, allows for precise and site-specific manipulation in the plant genome, intending to create desirable traits responsible for heavy metal tolerance, and overcoming the limitations of conventional breeding methods (Noman *et al.*, 2016).

It is based on the natural defense mechanism found in bacteria and archaea, which enables the recognition and targeting of specific DNA sequences. The mechanism of the CRISPR-Cas system involves two key components: the Cas9 nuclease and guide RNAs (gRNAs). CRISPR works in collaboration with the Cas9 nuclease, an enzyme that functions as a pair of molecular scissors, capable of cleaving the DNA at exact sites directed by short RNA molecules known as guide RNAs. The g RNA comprises of two small RNA molecules *i.e.*, CRISPR RNA (crRNA which is complementary to the target DNA) and another is trans activating crRNA (tracrRNA) that bind with Cas9 endonuclease. To recognize the target site by Cas9, it must be flanked by a short protospacer- adjacent motif (PAM). Cas9 derived from *Streptococcus pyogenes* is commonly used Crispr enzymes for genome editing (Deltcheva *et al.*, 2011). Researchers can direct the Cas9 nuclease to cut the DNA at the desired location by designing specific guide RNAs complementary to the target DNA sequence. Subsequent DNA repair mechanisms within the plant cells can introduce precise modifications or changes in the genetic sequence (Jinek *et al.*, 2012). The OsNRAMP1 gene that regulates the uptake of several heavy metals such as Cd, Fe, As and Mn in various crops has been modified by genetic approach, which also significantly reduced the accumulation of Cd and As in rice grain (Chang *et al.*, 2020). Additionally, tolerance to Cadmium toxicity was successfully developed in rice by using CRISPR/Cas9 technology

(Fu *et al.*, 2019). Gene and their role in Cd toxicity tolerance in rice are mentioned in Table 2.

Table 2: Genes modified by CRISPR/Cas9 for HMT tolerance in rice

Targeted Genes	Role in tolerance to HM toxicity	References
<i>OsLsi</i>	Less As uptake	Hillary <i>et al.</i> , 2022
<i>OsABCG36</i>	Tolerance to Cadmium toxicity	Fu <i>et al.</i> , 2019
<i>OsHAK1</i>	Less Cesium accumulation in root	Nieves <i>et al.</i> , 2017
<i>OsNRAMP1</i>	Low As and Cd content in rice grain	Chang <i>et al.</i> , 2020
<i>OsNRAMP5</i>	Less Cd in grains	Songmei <i>et al.</i> , 2019
<i>OsLCT1</i>	Less Cd uptake	Songmei <i>et al.</i> , 2019
<i>OsLCT2</i>	Less Cd accumulation in grains	Tang <i>et al.</i> , 2022

Conclusion and Future Prospects

Rice is the major food crop that is being affected with heavy metal pollution in the soil. Since it is majorly consumed by Asian people thus, their health is in perilous state. In order to tackle the issues caused by various natural and anthropogenic sources, molecular approaches have shown a great promise to mitigate heavy metal toxicity in rice plant. Over the past decade, the evolution of techniques CRISPR/Cas enhances the opportunity to edit target gene (Kumari *et al.*, 2021). Continuous efforts have been explored to enhance the tolerance mechanisms in rice against heavy metal stress. Till date, moderate level of tolerance mechanism has been shown against HM tolerance, which is insufficient to completely prevent future food security and human health. However, inducing natural tolerance mechanism in plant is more economical and sustainable approach. Therefore, it is necessary to identify potential genes responsible for developing rice varieties that are

resistant to heavy metal toxicity. Recently several genome editing tools have been used to create novel rice varieties that are more resistant to heavy metal toxicity. The ultimate goal is to contribute to the creation of rice varieties with reduced HM levels, thereby improving food safety, safeguarding human health, and promoting sustainable agriculture in regions affected by heavy metal contamination.

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Role of Biotechnology in Yield Improvement of Sugarcane

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Sugarcane is an essential crop for the food and energy. Eighty percentage of the sucrose produced globally comes from this genus of grass (*Saccharum*), with sugar beets providing the remaining. To extract the sucrose juice, sugar mills crush over two billion metric tons of sugarcane stalks annually. Nevertheless, this crop is more than just its delicious juice. Although some promising cultivars have been created thus far, they are subject to severe biotic and abiotic stresses. Similar attempts have been made to enhance the recovery of sugar. Since using cutting-edge technologies is the only way to increase agricultural productivity and quality. Genetic engineering and plant tissue culture have enormous potential to address this crop's issues (Sundar, 2015). Metabolic pathways have been engineered to increase the amount of sugar, production of biopolymers and bioplastics (Vickers, 2005). As a result, biotechnology treatments hold considerable promise for advancing sugarcane as a future energy crop as well as a manufacturing facility for industrial and medicinal components. In order to concentrate on important research topics that can draw researchers to the enhancement of this crop, these interventions have been discussed here.

Traditional approaches: The introduction of a new variety is always a hope in the pursuit of productivity gains and does not require significant adjustments to the production system. It takes at least ten years to produce results when selecting the best genotypes within a population that is created by crossing two superior lines. For every 250 thousand seedlings assessed in the initial phase of the breeding program, one variety can often be obtained (Cheavegatti-Gianotto 2011). However, because sugarcane's pedigrees share many common ancestors, breeding programs still need to expand the crop's genetic base. In order to overcome the drawbacks of traditional breeding, biotechnology might be essential. Both basic and commercial research, such as the maintenance of elite germplasm, the creation of agronomically superior soma clones, the micropropagation of elite clones, the production of healthy planting material, and the screening for abiotic/biotic stress tolerance, have been greatly impacted by in vitro techniques.

Somatic embryogenesis: The two stages of somatic embryogenesis are induction and expression. Differentiated somatic cells acquire embryogenic competence during the induction phase, while embr-

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yogenic cells differentiate into somatic embryos during the expression phase. It was determined that embryogenic cells did not require any exogenous stimuli, such as growth hormones or vitamins, during the induction state. Instead, competent cells need relatively small amounts of external stimulation during the transitional period. Different factors have been found to play key role in the acquisition of embryogenic competence. Exogenous growth regulators promote embryogenic competence by affecting cell polarity, pH gradients and by modifying ionic balance all around the cells. Intracellular pH is very crucial for embryogenic competence acquisition. Another critical aspect is the physical isolation of a cell from others. Embryogenic competence acquisition by somatic cells is regulated by the expression of certain genes, which involve either upregulation or downregulation of certain functional genes. Furthermore, changes in metabolism, morphology, and physiology are crucial for developing embryogenic competence. According to Lakshmanan (2006), somatic embryogenesis is a significant advancement in sugarcane biotechnology. This technique was initially created as an alternative to meristem culture and regeneration, but it is now also a crucial part of genetic engineering. It has been effectively used to preserve mutants and altered material until they are approved or established in the wild. Through somatic embryogenesis, several high-yielding, early-maturing, high-sucrose, smut-resistant cultivars with good ratooning capacity have also been created.

Somaclonal variations: Somaclonal variation has been used to increase yield, drought tolerance, disease resistance, sugar recovery, and cane quality. Physical (ion beams, gamma rays) and chemical (sodium azide, sodium nitrite, and ethyl methane sulfonate (EMS)) mutagens have been used to increase the incidence of genetic diversity and to obtain beneficial alterations in the target plant genome. It has been effective to isolate mutants with desirable characteristics by applying selection pressure at the cellular level. Many researchers have isolated embryogenic cells and plants resistant to red rot through mutagenesis. In a similar vein, plants that are resistant to drought and salinity have been selected using polyethylene glycol, mannitol, and sodium chloride for abiotic stress tolerance (Suprasanna, 2008). However, since the majority of the polymorphisms returned to the original phenotype in the first ratoon crop, comprehensive field trials demonstrated that tissue culture-derived phenotypic changes were frequently transient (Irvine, 1991). In any case, ideas about soma clonal differences and their transmission to the following generation vary. According to the majority of studies, these differences are dependent on the genetic composition and experimental setup used for plant screening and selection.

Micropropagation: Plant health and vigor are impacted by the systemic accumulation of infections, including bacterial, fungal, and viral illnesses. One of the main obstacles to providing disease-free elite germplasm in sugarcane is the lack of an effective *in*

vitro mass multiplication technology (Kaur, 2016). The breeding cycle for sugarcane is lengthy, taking 10 to 15 years to finish the selection process. One significant obstacle to the improvement of the sugarcane crop is the lack of disease-free planting material. Although sugarcane typically reproduces vegetatively, some climatic conditions can also result in seed propagation. Commercially, sugarcane is being propagated using nodal cuttings. Meristematic or non-meristematic tissues are used as explants in this multiplication technique. Apical and axillary meristems, as well as immature leaf tissues, have been used to directly regenerate sugarcane plants (Geijskes, 2003). White leaf disease, ratoon stunting disease, sugarcane mosaic virus, and chlorotic streak disease have all been effectively eradicated through meristem culture. Meristem culture and heat treatment are highly efficient in eliminating downy mildew, SCMV, and Fiji disease pathogens (Wagih, 1995). It is frequently used to eradicate diseases of unknown etiology and is a successful way to remove the majority of bacterial and fungal disorders. Nowadays, sugarcane is regularly traded internationally using disease-free planting material derived from apices culture. In the USA and Brazil, *in vitro* culture methods are employed to generate commercially viable plant material.

Conclusion

Biotechnological intervention provides an efficient tool as tissue culture approaches. Micro propagation is used for large production of true-to-type mother plant to maintain the sugarcane hetero-

zygosity. Some clonal variations are another aspect for the induction of novel trait in the *in vitro* growing sugarcane plant. Disease free plant material is another major output for the tissue culture generated plants. Genetic engineering-based modification of metabolic pathway provides may enhance the qualitative and quantitative feature of sugarcane.

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Role of Indigenous Technical Knowledge in Breaking Dormancy and Inducing Germination in Pre-sowing Treatment

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Abstract

Indigenous Technical Knowledge (ITK) has been utilized by various traditional agricultural communities to overcome various challenges in crop production, since very long time. One such challenge is breaking dormancy of seed and inducing its germination during pre-sowing treatment. This comprehensive article delves into the multifaceted role of ITK in this crucial aspect of agriculture. By examining underlying principles, historical practices, practical applications, challenges, advantages and future prospects, we aim to provide a holistic understanding of ITK's role in breaking dormancy and inducing germination of seeds.

Introduction

The knowledge, skills and practices developed by indigenous communities over centuries to address various agricultural challenges can be called as indigenous technical knowledge or ITK. In agricultural practices breaking dormancy of seeds and inducing its germination are essential steps to ensure optimal crop establishment and yield. To accomplish these tasks effectively, traditional agricultural communities have developed ingenious technique based on Indigenous technical knowledge (ITK). This article explores the rich tapestry of ITK in breaking dormancy of seeds and inducing its germination, shedding light on its historical roots, underlying principles, diverse applications, advantages, challenges, and future scope of this.

Historical Perspectives: The application of ITK in breaking dormancy of seeds and inducing its germination traces back to ancient agricultural practices of indigenous communities worldwide. These traditional practices evolved over generations to generation via careful observation, experimentation and adaptation to local environmental conditions resulting in a rich repository of knowledge that continues to be relevant today. From seed scarification to smoke treatments, these traditional methods were finely tuned to the unique requirements of various crops and ecosystems. The historical context provides invaluable insights into the resilience and adaptability of these indigenous agricultural systems.

Principles of Indigenous Seed Treatment

Practices: Indigenous seed treatment practices are

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guided by the principles that are attached or deeply rooted in the ecological and cultural context of the communities that developed them. These principles include:

Observation and Adaptation: Indigenous communities or farmers have a deep understanding of their local environment and ecosystems, allowing them to observe and adapt their seed treatment practices to suit prevailing conditions, for better germination of seed.

Utilization of locally available resources: It minimizes dependence on external inputs, fostering sustainability and self-reliance of farmers.

A holistic approach: it is a holistic approach integrating cultural, spiritual, and ecological dimensions, emphasize the interconnectedness of all the elements within the agroecosystem.

Respect for Traditional Knowledge: Indigenous seed treatment practices are grounded in centuries-old wisdom passed down from generation to generation. This traditional knowledge encloses a diverse array of techniques for seed selection, storage, and treatment, honed through observation, experimentation, and adaptation over long time. Central role in preserving and transmitting this knowledge is played by elders within indigenous communities that ensure its continuity and relevance in a rapidly changing world.

Advantages of ITK: The advantages of indigenous technical knowledge in breaking dormancy and inducing germination are diverse. Firstly, by utilizing locally available materials, it offers low cost

solution, reducing the farmer's financial burden. Secondly; indigenous technical knowledge promotes environmental sustainability by minimizing the use of synthetic chemicals like fertilizers and fostering ecosystem resilience. Thirdly, it preserves cultural heritage and promotes community resilience by valuing traditional knowledge and practices. Lastly, ITK enhances crop adaptability and resilience to climate variability, ensuring food security in the face of environmental challenges.

Challenges and Limitations: Though ITK has numerous advantages, but it also faces several challenges and limitations in contemporary agricultural system. Due to globalization and modernization erosion of traditional knowledge occurs which poses a significant threat to the preservation and transmission of ITK. Due to lack of scientific validation & documentation, wider adoption of indigenous seed treatment practices in mainstream agriculture operations is hindered. Limited access to resources and marginalization of indigenous communities exacerbate disparities in agricultural development and innovation. Moreover, the lack of recognition and respect for indigenous knowledge systems perpetuates a cycle of cultural marginalization and exploitation.

Future Directions and Opportunities: Despite these challenges, there are many promising opportunities also for revitalizing and promoting ITK in breaking dormancy of seeds and inducing its germination. Collaborative efforts between indigenous communities, researchers, policymakers, and

NGOs can help to facilitate the documentation, validation, and dissemination of traditional seed's treatment practices. By integrating ITK with the help of modern agricultural technologies and practices can increase or enhance its efficacy and scalability, fostering sustainable agricultural development. Empowering indigenous communities through capacity building, land rights recognition, and policy support can ensure their active participation in shaping the future of agricultural operations.

Conclusion

Indigenous Technical Knowledge (ITK) plays an essential role in breaking dormancy and inducing germination of seeds in pre-sowing treatment. Rooted in centuries of traditional knowledge and practices, ITK offers sustainable, culturally relevant solutions to agriculture related challenges. By preserving indigenous knowledge systems and its application on field, we can harness the full potential of ITK in enhancing and promote food security, environmental sustainability, and cultural resilience in agriculture. Embracing ITK as a cornerstone of agricultural innovation is not only a tribute to the ingenuity of indigenous farmers but also a pathway to a more inclusive, equitable, and resilient agricultural future.

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Genome Editing Tools for Rice Improvement

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Introduction

Rice is one of the most important cereal crops in Asian countries. Being the staple grain for many of the countries and possess challenge due to a rice shortage for the steadily growing population. Despite if the efforts made by plant breeders and popularizing high yielding hybrid varieties, the production of rice has been increasingly constrained by swift climate change. Consequently, it is essential for breeders to adopt advanced breeding methods that enhance rice production while also ensuring greater environmental sustainability. Existing hybrid rice development and maintenance are often challenging due to the inconsistent care of their offspring and frequent effects from genetic segregation. These programs are often time consuming too. In such cases the CRISPR-Cas9 offers a rapid and transgene-free approach for developing new superior plant varieties to alleviate food insecurity (Jinek *et al.*, 2012). This technology has enabled scientists to maintain parental heterozygosity clonally via seeds.

CRISPR-Cas9 technologies in Rice

Several genes viz. ROC5, SPP, and YSA etc. in rice have been successfully targeted by CRISPR-Cas9 systems, producing plants that exhibit an albino

phenotype. This implies that the technology is applicable for precise genome editing in rice (Feng *et al.*, 2013). Genome editing methods with efficiency reaching 100% are required to aim for the same locus across various locations or multiple sites within distinct genes (Xie *et al.*, 2015). Besides generating herbicide resistance in rice, this method can also be employed for precise genome editing to improve additional rice traits (Butt *et al.*, 2017)

Expanding the target sites for editing: Cas9-VQR (D1135V/R1335Q/T1337R) and *Staphylococcus aureus* Cas9 (SaCas9) are among the numerous Cas9 orthologs developed with altered PAM specificities (Hu *et al.*, 2016). The function of the CRISPR-SaCas9 toolkit was investigated in rice after it was recently enhanced by incorporating three significant mutations. Achieving a mutagenesis effectiveness of up to 77%, the newly improved technique performed genome editing (Qin *et al.*, 2019). Using NAG as the PAM to modify the rice genes RAD51A and DMC1 resulted in a mutation frequency reaching 85% (Meng *et al.*, 2018). Additional Cas9 variants, including Cas9 that can recognize relaxed NG PAMs (Cas9-NG) and expanded PAM SpCas9 (xCas9), have also been investigated in rice (Zhong *et al.*,

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2019). These enzymes can recognize NG and GAA along with other PAMs. Although successfully used in rice genome editing, the efficiency of the Cas9 system was relatively low. Besides NG and GAT, GAA, and CAA, Cas9-NG is capable of recognizing several non-canonical PAM sites, such as NAC, NTG, NTT, and NCG (Ren *et al.*, 2019).

Base Editing: Originally, base editing was employed for the rice gene OsCDC48. To enhance rice's tolerance to herbicides, base editing for C-to-T replacement was performed in OsALS (Shimatani *et al.*, 2017). In the same way, OsSPL14 was aimed at by merging SpCas9 nickase with the rice tRNA adenosine deaminase for A•T to G•C conversions. The fusion of human APOBEC3A and Cas9 nickase resulted in enhanced base editing efficiency for rice, increasing editing effectiveness and expanding the size of the edited sites (Zong *et al.*, 2018).

Gene Knock-in via improving HDR-mediated:

Multiple efforts have been made to improve rice genome editing through homology-directed repair (HDR), with many of these concentrating on the repair template. In rice, a gene knock-in frequency of 19.4% was achieved utilizing a donor template delivery system derived from the Gemini virus (Wang *et al.*, 2017). Another effort was the combination of Cas9 with *Agrobacterium* VirD2. To develop herbicide-resistant rice plants, the OsALS allele was accurately altered utilizing the newly established Cas9-VirD2 system (Ali *et al.*, 2020).

Gene Knock-in via Prime Editing: In contrast to HDR-based editing, prime editing offers various

forms of precise editing in mammalian cells with remarkable efficiency. This method contains two components: (1) a primary editing guide RNA (pegRNA) that recognizes the genomic target region and represents the intended modification, and (2) RNA-programmable nickase (Cas9-H840A) associated with reverse transcriptase (RT). Unlike the HDR method, prime editing embeds the required changes directly into the pegRNA sequence, eliminating the requirement for a donor repair template. The desired modifications are integrated into the genome by the RT utilizing the pegRNA as a template (Lin *et al.*, 2020). Creating an efficient primary editing system in rice has been the focus of numerous recent efforts. They successfully targeted nucleotide substitution of the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) gene at a rate of 2.22% (Li *et al.*, 2020) and the rice endogenous acetolactate synthase (ALS) gene at frequencies reaching 26% and 14.3% (Lin *et al.*, 2020). Despite being a recent technology, a limited number of studies suggest it can accurately alter plants; nevertheless, additional optimization of components and environmental factors is necessary.

CRISPR-Cas 9 variants: Cas12a, a type 2 CRISPR effector, is part of the genome editing tool CRISPR-Cas12a previously known as CRISPR-Cpf1. In contrast to Cas9, Cas12a is an endonuclease guided by a single RNA that enhances powerful DNA interference. Cas12a can recognize T-rich PAMs without the need for TracrRNA (Alok *et al.*, 2020). Moreover, OsPDS and OsSBEIIb, responsible for encoding a phytoene desaturase and starch branching

enzyme respectively, were employed to demonstrate the editing capabilities of CRISPR-Cas12a and the use of multiplexing in rice. It confirms the potential of CRISPR-Cas12a for genome editing in enhancing rice (Miao *et al.*, 2018). The OsEPFL9 gene, responsible for stomatal density in leaves, was recently knocked out to evaluate the efficiency of the Cas12a system in rice. Under stress, the OsEPFL9 knockout rice lines showed a significant reduction in stomatal number and an enhancement in water use efficiency (Yin *et al.*, 2019).

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