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NEWSLETTER

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Eco-friendly Pest Management Strategies for Major Vegetable Crops

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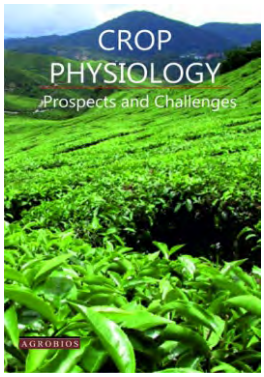

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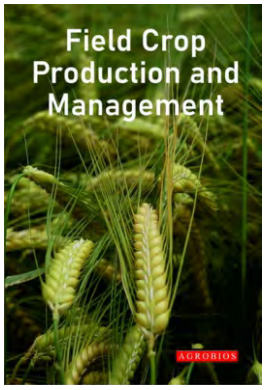

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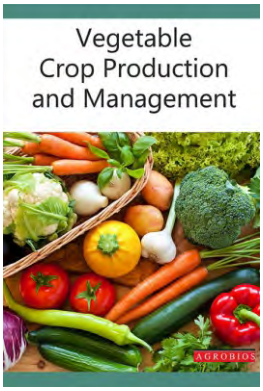

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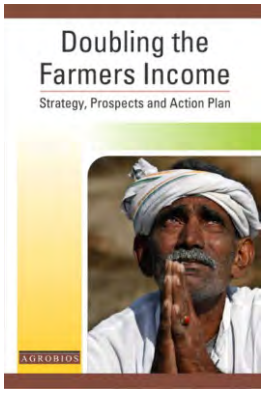

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1. Microgreens: A Superfood for Urban Lifestyle

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A "microgreen" is a general term used to describe an edible plant in its juvenile growth stage. It is important to note that a microgreen has been harvested (removed) from the plant's seed and root system prior to consumption, unlike a "sprout," which is consumed as the entire plant including seed and root system.

Depending on the plant species, a microgreen typically consists of the plant stem, cotyledons (initial leaves present in the seed) and the first "true leaves" of that plant. Based on the grower and customer's preference, microgreens may be harvested before or directly after the first true leaves have appeared. Around 5 to 7.5 cm (2 to 3 in.) in size, microgreens are sought after for various characteristics including, but not limited to, nutrition, flavour, colour, form and texture.

Why microgreens are called superfood?

Because the plant is harvested before all the food contained in the seed is used to fuel the growth of a mature plant, microgreens condense the nutritional value of their older siblings. They could contain anywhere from 4 top 40 times as much of a particular nutrient, according to a study conducted by researchers at the University of Maryland and the U.S. Department of Agriculture. And many of the plants grown as microgreens are already considered superfoods, so this makes their mini-versions super-superfoods. The researchers learned that overall microgreens tend to have higher concentrations of vitamins and carotenoids than the mature plants—many of which fall into the superfood category themselves. Because they are grown from so many types of plant seeds, what specifically they contain varies from plant to plant. Red cabbage microgreens had the greatest concentration of vitamin C—six times more than mature cabbage. It also had 40 times more vitamin E than the bigger plants. Red cabbage, garnet amaranth and green daikon radish microgreens had the highest concentrations of vitamin C, vitamin K and vitamin E. Cilantro was the winner when it came to the carotenoid's lutein and beta-carotene.

"In general, microgreens contained considerably higher levels of vitamins and carotenoids—about five times greater—than their mature plant counterparts, an indication that microgreens may be worth the trouble of delivering them fresh during their short lives," said the study.

What does that mean for you? It means more of what you eat your vegetables for. Lutein, for instance, has been found to have an impact on eye health, possibly helping to stave off conditions such as macular degeneration. Beta-carotene may help protect against some cancers. And all the carotenoids are antioxidants, which play a role in maintaining and improving overall health, boosting your immune system and delaying chronic diseases of aging. If it's good to eat your vegetables, it's even better to eat your microgreens.

FIGURE 1. Demand for products like microgreens has been increasing.

Microgreens have received a substantial amount of exposure over the last few years because of their potential profitability thanks to a relatively short production cycle, low input costs and small footprint (do not take large amounts of space or resources to

produce). However, this profitability is ultimately related to the ability to sell such a product, so care and attention should be paid to the market you plan to sell into. As with all crops, producing the crop is one endeavour, but selling it is another one altogether. Producers need to connect with target markets and clients early in business development to make sure they can sell their crops (Figure 1).

Common species used for Microgreens

S.I. No.	Fast growing vegetables (7 to 14 days)	Slow growing vegetables (15 to 25 days)	Slow growing herbs (15 to 30 days)
1	cabbage	amaranth	anise
2	corn	arugula	basil
3	cress	beet	cilantro
4	kale	carrot	dill
5	kohlrabi	Swiss chard	fennel
6	mustard	scallion	parsley
7	radish	--	saltwort
8	--	--	sorrel

Harvested microgreens should be kept at lower temperatures (at or below 4°C) as much as possible to reduce the risk of microbial growth while maintaining freshness. Packaging microgreens in shallow containers should be taken into account as these containers allow for rapid cooling and help minimize potential pathogen issues. Microgreens should also be stored in a manner that prevents product damage. Stacking too many clamshell packages or bags of product on top of each other could cause damage to the product at the bottom of the stacks, which raises the risk of faster deterioration of the final product.

While shelf life will vary from species to species and variety to variety, most microgreens will have a shelf life of approximately 5 to 10 days with proper handling and storage. The high level of care, attention and proper storage put into the product needs to be transferred into the distribution stages. Microgreens need to be transported in refrigerated spaces to reduce risk of contamination and microbial growth. Although it is up to the end consumer to follow basic food safety requirements, growers should advise customers on the recommended handling and storage of the product when opportunity allows.

Locally grown microgreens at home

Grown with love from ecological seeds and absolutely no pesticides. These locally grown, extremely tasty little greens are beneficial to your health at present day urban lifestyle, and to the planet. Enjoy!

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2. Green Fodder Production: A Prime Approach to Sustain the Livestock Production in India

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Agriculture is the backbone of Indian economy as it a source of employment and livelihood for nearly 70 per cent of the population in rural areas with a contribution of 15.96 per cent to National GDP. However, the agriculture systems in the country are mainly mixed farming systems with crops and livestock as major components. Farmers often integrate these components to realize maximum benefits with effective utilization of available resources. Thus, livestock production is considered as the backbone of Indian agriculture as it contributes 7 per cent to National GDP and 24.72 per cent to agricultural GDP alone.

At present, the increasing livestock population, reduced area under fodder crops, burning of available crop residues and higher cost of concentrate feeds are exerting immense pressure on livestock production in the country. As per the 20th livestock census conducted during 2019, Livestock population is around 535.78 million in the country with an increase of 4.6 per cent over Livestock Census-2012. On the other hand, at present only 8.6 m ha of cultivated area is devoted to fodder production in the country but as per the National commission on Agriculture, the recommended area under fodder production should be 10 per cent of arable land *i.e.*, approximately 16.5 m ha. On the other side, the feed cost alone accounts for 60 to 70 per cent of the cost of milk production due to higher cost and usage of concentrate feeds as generally in rural areas animals consume naturally grown grasses, weeds and shrubs in the agricultural lands which are of lower quality in terms of available nutrients and protein. Thus, the fodder availability is varying according to the seasons and affecting milk production throughout the year. All these hurdles associated with livestock are not allowing the farmers to fully exploit the potentiality of the livestock sector in the country. Thus, green fodder production will be a viable strategy to combat all these hurdles of the livestock sector. As green fodder will be a cheap source of nutrients and has the potential to increase milk production.

The cultivated forages are rich source of proteins (8-10 % in cereals and 18-22 % in legumes), minerals (Ca and P), vitamins (Carotene), carbohydrates, micronutrients and *in vitro* dry matter digestibility (IVDMD) between 55 to 75 per cent (Chaudhary *et al.*, 2012). But at present (2020), the predicted net deficit of green fodder, dry fodder, crude protein and total digestible nutrients is 64.21, 24.81, 26.52 and 23.70 per cent, respectively and the deficit will be 64.87, 24.92, 25.38 and 23.14 per cent, respectively

in the country by 2025 (Rathod and Dixit, 2019). Thus, at current situation, there is a need to increase the fodder productivity per unit area per unit time by adopting suitable strategies involving both annual as well as perennial cereal and legume fodder crops.

Strategies to increase fodder production/availability

- Adoption of Food-forage based cropping systems
- Intercropping of perennial fodder crops in orchards and plantation crops
- Cultivation of perennial cereal-legume fodder cropping systems
- Cultivation of perennial grasses on field bunds
- Introduction of short duration forage crops in rice fallows
- Cultivation of short duration forage crops in the gap periods of main crops
- Bringing marshy areas under fodder cultivation with suitable crops
- Cultivation of forages in waste lands
- Cultivation of fodder trees on farm bunds.
- Inclusion of different annual and perennial fodder crops in Agro-forestry and silvi-pastural system.
- Bringing problematic soil under cultivation with suitable fodder crops
- Adoption of high yielding varieties and hybrids of fodder crops
- Utilization of unconventional fodder crops

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3. Crop Weather Modelling: It's Application in Agricultural Research

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Introduction: Agriculture is the foremost requirement for the survival of mankind. Since, agriculture is a result of several interactions of biotic and abiotic factors. This complexity makes agricultural research cumbersome and complex. The modern concept of agricultural research lies in the idea of deriving crop models. Model is a simplified description of a method to provide estimations and forecasts. It is a computer program which can be repeatedly used for research work and predictions. Baier (1979) referred crop weather modelling as the techniques that can be used to determine the likely effects of weather on crops, its growth and production. There are three broad categories of models used in agricultural research. It includes:

a) **Mathematical model:** Physical relationship of natural phenomena are explained in terms of mathematical equations.
b) **Growth model:** These models simulate actual crop by forecasting the progress of its constituents.
c) **Crop weather model:** This predicts output in relation to the change in weather elements.

Pre-requisites of Crop Modelling:

Following are the common input data required for developing a crop simulation model:

- **Meteorological Data:** It contains high and low temperature, precipitation, relative humidity, solar radiation, wind speed etc.
- **Crop Data:** It includes Crop name, variety name, crop phenology, leaf area index etc.
- **Crop Management Data:** Sowing date, seed rate, fertilizer, manure, irrigation etc.
- **Pest Data:** Pest name and category of pest, nature of occurrence, pest outbreaks etc.
- **Other Data:** Data as per the specific relevance of a study is also collected as per the need.

Steps in Crop Modelling:

Developing crop modelling is similar to any problem-solving exercise. It starts with having a defined goal and then step by step working towards it. Steps in crop modelling can be explained as follows:

1. **Define Goals:** Depending upon the information base of altered disciplines the purpose of the work should be properly defined and presented very clearly before developing any crop simulation model.
2. **Describe method and its limitations:** In farming, agriculture farm is selected as a structure and its boundaries in terms of limitations must be taken into consideration for reliable result.
3. **Describe key variables in an arrangement:** It includes state variables, rate variables, driving and auxiliary variables and these should be properly defined to study the effect on these in study.

4. **Quantify relationship:** Using mathematical equations and functions, the relationship between the interest of study and several variables are quantified.
5. **Calibration:** Firstly, the model is track with any investigational data and calibrated consequently to reduce the mistake.
6. **Validation: After that, the** calibrated model is confirmed with new dataset to verify its simulation capability in altered situation to ensure the calibration has been performed properly and it can be used for the study.
7. **Sensitivity Analysis:** It is prepared to test whether the model is reacting to change in sensitive aspects or not. It is very important as error in this may lead to false interpretation of results.
8. **Simplification:** Initially Model is written in computer programming language and cannot be understood very easily without any expert guidance. So, they are prepared very simple and user friendly to allow the interpretation of result easy and in desired manner.
9. **Using model in decision care system:** After its calibration and validation, it is ready to use in decision support system for predicting or taking appropriate resolutions in crop controlling.

Popular Crop Models: The concept of crop modelling has been gaining popularity and are being utilized in the agronomical as well as overall agricultural research. Several models were acquired by India which includes: DSSAT, ORYZA1, ORYZAW, WOFOST, DNDC etc. and some are developed by IARI, New Delhi, such as: WTGROWS, ORYZA1N, InfoCrop, InfoSoil etc.

InfoCrop is a multi-layered crop model which requires weather data, soil properties, genetic traits of variety, management factors and biotic stresses to give output in terms of economic yield, crop growth and duration, yield gaps, environmental impact and soil-nutrient-water dynamics. It is a dynamic model and have been used in several crops like: Rice, Wheat, Maize, Sorghum, Millets, Soybean, Chickpea, Pigeon pea, Potato, Cotton. (Aggarwal *et al.*, 2006).

Advantages of Crop Weather Modelling:

1. It helps in the identification of crop production constraints, which leads to better research and crop management recommendations.
2. It also reduces repetition of complex and time taking field research. It provides answers quicker and cheaper than traditional research systems.
3. It not only analyzes and predict the output but also helps in understanding of physical and biological causes for the same.
4. Since it is site-specific, it helps in regional land use planning more precisely.
5. Sometimes it can substitute multi-location field trials.
6. It can be accessed in a simplified manner.
7. It serves as a decision support system during recommending set of packages of practices or any special operation in the crop production.

Limitations & Challenges of Crop Weather Modelling:

1. Sometimes there are unrealistic and non-reliable projections of natural processes are made.
2. Model presentation is imperfect to provide accurate data.
3. Crop, soil and weather data is hardly accurate and most of the times they are taken from nearby sites.
4. Sampling errors contributes to inaccuracy of a crop weather model.
5. An ideal crop weather model has not been developed yet due to complexity of biological and physical systems.

Conclusion: As a study tool, crop weather model improvement and its applications can subsidize to recognize breaks in our understanding, hence allowing more effective and accurate research forecasting. Models generally built on sound functional and meteorological data are skilled of estimation of temporal and spatial variability specifically (Oteng-Darko, 2012). For efficient working of research, a calibrated and validated system should be used to utilized time and money Which ultimately helps in sustainable agriculture with proper technical support it can be a powerful tool in climate smart agriculture.

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4. Pokkali Rice Cultivation: A Unique Agricultural Practice

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Introduction

The coastal intertidal wetland is one of the key productive ecosystems on earth which support high biodiversity. Saline and acid-tolerant paddy cultivation in coastal wetlands are practiced in tropical countries. Such a standard integrated paddy-shrimp farming system is popular in India and is spoken by different names locally. Kaipad of North Kerala, Bheries/Bhasabhada of West Bengal, Gazani of Karnataka, Khazan of Goa and *Pokkali* of Central Kerala. The utilization of salt-tolerant and traditional tall rice varieties for cultivation and brackish water fish and prawn species for traditional culture practices in these coastal marshes offer a prospect for the popularization of this traditional farming system. This farming system must withstand the adverse effects of climatic changes which includes flooding or rise in seawater level owing to global warming, tidal current and moderate changes in temperature. Hence management of coastal wetlands for coastal protection and its continued use for livelihood support is an immediate concern. Promotion of climate resilience agriculture systems such as *Pokkali* gets relevance in this context. *Pokkali* rice ecosystem is a saline ecosystem. It's estimated that about one billion hectares of the world`s farms are damaged by salt ingress. *Pokkali* may be a unique kind of rice that's cultivated during a natural organic way within the waterlogged coastal regions of Eranakulam, Alappuzha, and Thrissur districts of Kerala. Only crop in this area is rice and that too cultivated only during monsoon season when heavy downpour diluted the salinity. The *Pokkali* fields are low lying marshes and swamps situated near the estuaries of streams and rivers near to sea. They are water-logged with a poor drainage system and are subject to tidal action throughout the year. The *Pokkali* variety has remained a favourite among many farmers and it attained global recognition also has an exclusive cultivation and distribution rights to Kerala growers. In view of the uniqueness of the system, *Pokkali* rice has been awarded the status of registered Geographical Indication (GI) by the Geographical Indications Registry Office, Chennai, Tamil Nadu in 2007. The registered *Pokkali* farmer group (Varappuzha-Kadamakudy Jaiva *Pokkali* ICS) received the Plant Genome Saviour Community award (2011-12) for protecting this valuable genotype through cultivation by the Protection of Plant Variety and Farmer's Right Authority of Government of India (Sreelatha and Shylaraj, 2017).

Rice Research Station, Vyttila

The Rice Research Station was started functioning during the year 1958 under the Department of Agriculture, Kerala, in a leased land in Kunnara near Vyttila. It had been shifted later the year 1963 to present site RRS, Vyttila. The Station's aim is to the development of *Pokkali* rice and rice-fish farming system within the *Pokkali* fields of Kerala. The station was appropriated by the Kerala Agricultural University (KAU) in 1974. The research station developed 11 high yielding acidic, saline tolerant and submergence tolerant rice varieties *viz*., VLT-1, 2, 3... and 11 for cultivation in *Pokkali* lands. To conserve this special genotype and unique system of cultivation, RRS Vyttila had taken keen interest to urge the geographical indication registry certification and a logo for *Pokkali* rice and its early added products in 2007. Aside from varietal development, the station had standardized the technology for prawn culture after rice which that they had evolved technology for the simultaneous culture of rice and fish (Shylaraj *et al*., 2013).

Pokkali Rice Cultivation: A Unique Agricultural Practice

1. *Pokkali* field preparation starts with the strengthening of bunds and sluices thereafter dewatering these fields by April.
2. During low tide, fields are drained out and sluices are closed.
3. Mounds having 1 m base and 0.5m height of 1000 mounds per acre are prepared and dried.
4. With the onset of monsoon, salinity on the top of the mounds is washed off and the soil becomes ready for sowing.
5. Special baskets plaited with coconut leaves and inside lined with banana or teak leaves are used as a special method of sprouting of seeds.
6. Sprouted seeds are sown on the top of mounds after raking and leveling, these mounds act as a *in situ* nursery and protect the seedling from flash floods.
7. When the seedlings reach a height of 40 to 45 cm (30- 35 days) mounds are cut into small pieces with a few seedlings which are uniformly spread in the field itself, this process is called as dismantling.
8. Harvesting done by cutting the panicles alone

from the crop and the leftover biomass is allowed to decay in the field which becomes the feeding ground for the juvenile prawns, fishes, and shrimps.

9. From November onwards prawn stocking starts naturally by trapping the juveniles by hurricane lamps during high tide at night.
10. Shutter planks of the wooden sluices are used for regulating the flow rate of tidal water into the fields during high tide (twice in a day).
11. Hurricane lamps are fixed on the outer mouth of the sluice during water intake at night, which attracts the shrimp seeds in large numbers into the field.
12. Sluice nets are fixed on the inner mouth region of the sluice to prevent the escape of shrimps and fishes from the field during low tide.
13. Shrimps are harvested with the sluice nets during the lunar phase starting from the second fortnight of December. This periodical harvest is carried out till March and the final harvest is done.

Two phases of *Pokkali* Agro-Ecosystem

Low saline phase (May/Jun - Sept/Oct) Single cropped rice / rice - cum – fish

High saline phase (Oct/Nov - Apr/May) Traditional prawn filtration

The sequence of *Pokkali* farming/ cultivation

Strengthening of outer bunds

Germinated seeds ready for sowing

Reasons behind quiescent seeds

Mat formation on the peripherals prevents the gas exchange.
Respiration of seeds releases CO2 inside the basket.
O2 level decreases and the seeds remain quiescent in CO2 atmosphere.
Resoaking displaces CO2 and allows entry of O2 and growth restarts.

Reasons behind quiescent seeds

Mat formation on the peripherals prevents the gas exchange.
Respiration of seeds releases CO_2 inside the basket.
O_2 level decreases and the seeds remain quiescent in CO_2 atmosphere.
Resoaking displaces CO_2 and allows entry of O_2 and growth restarts.

Drying fields

Weathering

Sowing on mounds starts when salts are washed off.
Mound tops weeded, raked and leveled

Ridges vs Mounds
Equally good in plant stand establishment.
Ridges of 20 - 25 cm top width, the height of 30 cm taken at 60 cm apart
Ridges preferred for early sowing.
Advantages
Exploring the feasibility of mechanization.
Labor-saving technique.

Seeds packed in special baskets - plaited with coconut leaves - lined with banana/teak leaves.

Sowing on mounds
Starts when salts are washed off.
Mound tops weeded, raked and leveled.
Re - soaking of seed baskets for 4 hrs.
Sprouted seeds sown on mound tops.
Clay plastering to prevent washing away of seeds.
Acts as in -situ nursery - Unique to *Pokkali*

Why nursery on mounds?
Helps in rainwater infiltration
Facilitates washing away of salts.
Aids in reducing toxicity.
Protects the seedlings from flash floods.
The cheapest method of soil reclamation.

Clay plastering to prevent washing away of seeds.

Dismantling of seedlings -Unique to *Pokkali*.

Seeds start germinating

Uniformly spreading seedlings

Mound surface acts as an in-situ nursery – Unique to *Pokkali*

Rice cum fish culture
Open 1 m deep and wider peripheral and diagonal channels
Stock male Tilapia nos. one week after dismantling
Fish yield 450 kg/ha
Carps, milkfish, pearl spot and mullet incompatible under this stress condition

Seedlings get established

Active tillering stage

Maturity stage

Fertilizers
The luxuriant growth of microbes
Inherent high fertility
Decaying of leftover straw and stubbles
Decomposition of aquatic flora during high saline phase
Complimentary effect of prawn filtration
Low fertilizer responsive varieties

Panicles alone are harvested and transported by Boats

A sequence fields open for prawn to rice crop filtration

Varietal characters

Tolerance to acidity, flood, salinity
Early seedling vigor and seed dormancy
Height not less than 125 cm
Duration not exceeding 125 days

Harvest of prawn
Starts after 45 days
Only at 3 days prior and after full and new moon period
let in water at maximum level
Fixing conical net in a sluice
Keep the lamp at the exterior of sluice
At peak low tide, open the sluice for forced drainage, Prawn trapped and removed

CONCLUSIONS

- Rice as a monoculture system is not sustainable; integration of rice cum fish-prawn culture is ecologically viable.
- *Pokkali* systems can significantly reduce high energy inputs and the cost of production.
- *Pokkali* farming system approach is capable of reducing carbon emission and sequestering of carbon in soils and plants.
- Prawns in *Pokkali* fields subsist on organic matter from decayed stubble, drying water weeds, *etc.*, and in turn, the fields are enriched in manure and the excreta of organic wastes from fish and prawns.

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5. The Revival Of Quinoa: A Crop For Health

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Introduction

In the era of burgeoning world population across the world, modern and unfamiliar food crop that has been heretofore abandoned is attaining recognition. The exclusion of such type of lesser known food crops has not been due to their inferior characteristics but because of the dearth of appropriate and well organized research and being often disregarded as "poor people's plants". Food security and good health has become major important issues in all of the countries more specifically in the developing countries in the present world. Due to continuing alterations in our ecosystem services and rapid climatic change, a huge burden is imposed on reliable food production to facilitate healthful condition to the world's ever increasing population. In the current situation, 1 in 8 individuals already suffers from chronic undernourishment or malnutrition including many are subjected to diabetes, cardiovascular diseases, cancer, obesity and other metabolic disorders that have also reached global epidemic proportions by that time. In this context, it is very much essential to take into account few alimentary traditions and the social value of food practices that have been lost with time. Functional foods are quite comparable to conventional foods alongside providing certain health benefits beyond basic nutritional functions. Quinoa is one such food gaining popularity nowadays. Being high in various important nutrients, it is considered as world's one of the most popular healthy foods. The Food and Agricultural Organization of the United Nations (FAO) officially declared the year 2013 as "The International Year of The Quinoa". FAO declared quinoa as a food with high nutritive value, vast biodiversity and as a food which can have an important role to play in the achievement of food security worldwide.

What is Quinoa?

Quinoa (pronounced as 'keen-wah') (Chenopodium quinoa), a herbaceous annual flowering plant, belongs to the amaranth family and is grown primarily for its edible seeds that come in different colours including black, red, yellow and white which are quite rich in protein, fibre, vitamins and minerals than many grains. It is not a grass but a Pseudocereal and is botanically related to spinach and amaranth (Amaranthus spp.) and indigenous to the Andean region of South America, specifically Bolivia, Ecuador, Chile, and Peru (Matiacevich et al., 2006). It is known as 'the mother of all grains' to the Incas and was first cultivated over 5000 years ago and is considered as a gift from God.

Proven health benefits of quinoa

1. Very nutritious: Quinoa is one of the world's most popular healthy foods which contains high protein, fibre, magnesium, manganese, vitamin B (mainly B1, B2 and B6 and small amounts of B3 or niacin) and E, folate, zinc, copper, iron, potassium, calcium, phosphorus, and nine essential amino acids as well as several beneficial antioxidants and omega-3 fatty acids. This imparts a total of 222 calories, with 39 grams of carbohydrate and 4 grams of fat.
2. Contains plant compounds 'Quercetin' and 'Kaempferol': Quinoa contains higher amount of plant antioxidants called flavonoids particularly Quercetin and Kaempferol which offer numerous health benefits including anti-inflammatory, anti-viral, anti-cancer and anti-depressant effects in animals.
3. Gluten free and perfect for people with gluten intolerance: Instead of typical gluten free ingredients such as refined tapioca, potato, corn, rice and wheat flour etc., using quinoa can drastically enhance nutrient and antioxidant value of diet due to its gluten free nature.
4. Low Glycaemic Index: It has a glycaemic index of 53, which is considered low and good for blood sugar control.
5. Beneficial effects on metabolic health: Quinoa can improve metabolic health due to its high beneficial nutrient content by reducing blood sugar, insulin and triglyceride levels.
6. Very high in antioxidants: The high antioxidant content in quinoa neutralizes free radicals, helps to boost body's defence system against infection and inflammation and also fights against aging and many diseases.
7. Help to lose weight: The high protein content in quinoa can promote weight loss, either by boosting metabolism or reducing appetite, besides, the large amount of fibre and low

glycaemic index may increase feelings of fullness, leading to reduced calorie intake.

8. Easy to incorporate into diet: Many healthy and diverse recipes of quinoa are available including breakfast, lunch and dinner which can be ready to eat in as little as 15–20 minutes and it is also tasty and goes well with many foods.

Nutritional disadvantages

Saponins and Phytic acid are two major deleterious factors in quinoa. Moreover, it contains some other harmful constituents such as Trypsin inhibitor and Polyphenols (tannins) in small amounts (0.53 g/100 g in the whole quinoa seeds) (Valencia-Chamorro, 2003). Saponins are glycosides that impart a bitter taste and leads to the reduction of plasma cholesterol and bile salt concentration in diet. Nevertheless, saponins can form insoluble complexes with minerals like zinc and iron making them unavailable for absorption in the gut. Besides, higher intake of oxalate influences mineral and trace element absorption in human body and also results in secondary hyperoxaluria which is a major risk factor for calcium oxalate stone formation due to the ability to form insoluble complexes with divalent cations in the gastrointestinal tract.

Future perspectives

Now-a-days, Quinoa has been appreciated for its nutritional excellence throughout the globe although it has been acknowledged since ancient times in the Inca Empire. The significance of this crop has been emphasised not only in the context of developing countries but also in developed world. It can play a remarkable role in up scaling economies, giving a new export market and in national subsistence in distant future. Notwithstanding, quinoa as the 'mother grain' can be considered as a strategic crop to supplement the diet chart in rural or marginal areas where energy and protein malnutrition jeopardizes most of the population of developing countries. In this regard, further agronomic research involving selection of sweet genotypes with very low Saponin content in the seeds, plant density, potential cultivation, phenology, morphology, adaptability of different cultivars to new niches, physiological maturity, weeds control and finally yield should be promoted and also the mechanized agriculture should be given consideration to facilitate mechanical harvesting of grains, reducing postharvest losses. However, quinoa may be encouraged as an extremely healthy food, a super grain of the future and a food of the twenty first century.

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6. Application of Drones for Sustainable Agriculture

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Introduction:

Climate change and environmental pollution are the major global issues of the current era and severely impacting agricultural productivity. Sustainable agriculture is one of the solutions to combat environmental pollution and reduction of greenhouse gas emissions, thereby offsetting the effect of climate change. In present agriculture systems, farmers usually apply fertilizers, pesticide, and other agrochemicals in heavy amounts indiscriminately. The higher dose of fertilizers is not utilized by crops appropriately, and thus unutilized fertilizers act as a source of pollution in the environment producing greenhouse gases. Therefore, there is a necessity for clean and green technologies to carryout agronomic practices in a sustainable manner.

DRONE (Dynamic Remotely Operated Navigation Equipment), also known as unmanned aerial vehicle, is a device which can fly either with the help of autopilot or can be operated manually with radio signals using the remote control. With the availability of so many sensors, drones can detect the things which are beyond the visible range of human sight. Therefore, real-time, more precise, reliable, and unbiased information can be derived from drones in greater detail and fewer errors.

- Fixed wing drones are ideal for aerial assessments, capturing high – resolution aerial photographs, mapping and land surveying.
- Multirotor drones are best for surveillance, and detection of crop pests, diseases and weeds.

Information collected by drones are superior than satellite data in many facets as drones can avoid the hindrance affected by clouds, thus, can avoid omitted data while taking images which is a common problem in obtaining data by satellites particularly during rainy season.

Applications of Drones in Agriculture:

1. **Soil and field scrutiny:** Drones can be used to mount sensors which are able to analyse the soil

environments, landscape conditions, moisture content, nutrients content and fertility levels of the soil which can be further used for planning the pattern of sowing of different crops, irrigation scheduling as well as for managing fertilizers application considering spatial variability of the crop growth and field conditions.

2. **Crop monitoring:** Drones can be used for nursing the conditions of crops all over the crop period so that the need-based and appropriate action can be taken. This technology will eliminate the need to visually inspecting the crops by the farmers. They can observe the agricultural crops or horticultural crops present in remote areas like hilly regions. The data acquired by drones during crop monitoring could be used to compute vegetation indices, which can be integrated with weather forecast data and soil fertility data. This could be used to precisely estimate the time of harvesting and yield of the crops.
3. **Crop spraying:** Drones can be used to spray chemicals like fertilizers, pesticides, etc. based on the spatial variability of the crops and field. The amount of chemicals to be sprayed can be adjusted depending upon the crop conditions, or the degree of severity of the insect-pest attack. In this manner, drones flag the path to precision farming. This ultimately increases the efficiency of the chemicals applied, thereby reducing their adverse impacts on the environment by decreasing the soil and water pollution. Thus, it can lead towards sustainable agriculture.
4. **Crop health assessment:** By using different kinds of sensors pertaining to visible, NIR and thermal infrared rays, different multispectral indices can be computed based on the reflection pattern at different wavelengths. These indices can be used to assess the conditions of crops like water stress, insect-pest attack, diseases, etc. The sensors present over the drones can see the incidence of diseases or deficiency even before the appearance of visible symptoms. Thus, they serve as a tool for early detection of the diseases.

Conclusion:

Drones have great potential to transform Indian agriculture. With the advancement of technology in the future, the production of drones is expected to become economical. The modern youth are not attracted towards farming but with the implication of drones may fascinate and encourage the youth towards agriculture. The next agricultural revolution would be data-oriented, and drones can play a major role in it. Appropriate usage of data may increase agricultural productivity without any adverse effect on the environment, along with improving the livelihoods of farmers. Therefore, drones may become part and parcel of agriculture in the future by helping farmers in managing their fields and resources in a better and sustainable way.

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7. Seawater Rice: A Magic Rice

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Introduction:

Rice is a principal food crop with highest contribution to global food requirement, feeding more than 50% of humanity as 80% of their diet. Globally around 950 m.ha are salt affected which is 20% of total cultivated area, that include both sodic and saline soils. Greater the population growth rate and land requirement for residential and industrial purpose forced rice cultivation under harsh ecosystem such as saline, sodic, drought, tidal and flood prone areas of inland and coastal areas. Its area is expected to increase gradually and at faster rate due to climate change and defective irrigation schemes.

IPCC REPORT:

According to IPCC 4th assessment report, sea level may rise about 0.8 to 1 metre form present mean sea level due to climate change and its effects. A 1.0 m sea level rise may cause significant losses (25-46 %) of the world's coastal wetlands. So, there is a dire need of new rice plant types that can tolerate more saline, alkaline and submergence conditions effectively without compromise in productivity.

Seawater Rice

Sea Rice is not irrigated by sea water, as the name suggests it can grow well in sea water soaked lands, *i.e.* saline and alkaline lands, for a short term and can resist sea water soaking, but it is the land where its growth differs from common rice, hence earning its name as Sea Rice. SR86 is a new rice variety domesticated from a wild variety strain of rice, by Chen Risheng, praised as the "Father of Sea-water Rice of China".

Seawater Rice – A Magical Rice

Characters of Sea Rice 86 (SR 86)

SR86 is a relatively ancient Indica subspecies phylogenetically close to the divergence point of the major rice varietals of Indica and Japonica. It can grow in saline & alkali soil in coastal areas and inland areas even with pH 9.3, where trees cannot grow. Sea-rice can be cultivated in heavily saline & alkali soil for six years, and the soil becomes ameliorated.

Indian Sea Rice

The rice varieties that are available in India with higher salt tolerance capacity can be named as Indian sea rice as these varieties are also has salt tolerance on par with SR 86. In India, hundreds of traditional rice and few high yielding developed rice varieties are having a very good salt tolerance capacity with taste and nutraceutical properties growing all along the coastal areas and inland salt affected lands.

Advantages and Disadvantages of Sea Rice

- **Advantages:** The favourable and unique features of sea-water rice, such as fertilizer-free, antipests, saline and alkali-soil resistance, indicate that it has great significance in green and resource-saving agriculture development.
- **Disadvantages:** There may be danger of heavy metal accumulation and other toxic compounds into food chain from sea water irrigation resource.

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8. Mulberry based Integrated Farming System

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Mulberry (*Morus spp*., Family: Moraceae)

The important character of the members of the family Moraceae (especially *Morus* spp.) is the presence of idioblast, an enlarged epidermal cell in the leaf. They are used for silk work rearing.

Mulberry cultivation Practices:

Climate and Soils:

Mulberry can be grown up to 800 m MSL. For the optimum growth of mulberry and good sprouting of the buds, the mean atmospheric temperature should be in the range of 13°C to 38°C. The ideal temperature should be between 24 and 28°C with relative humidity of 65 to 80 per cent and sun shine duration of 5 to 12 hours per day. Mulberry can be grown in a rainfall range of 600mm to 2500mm. Under low rainfall conditions, the growth is limited and requires supplemental irrigation. The slightly acidic soils (6.2 to 6.8 pH) free from injurious salts are ideal for good growth of mulberry plant. Saline and alkaline soils are not preferred.

Propagation of mulberry:

Mulberry is mostly propagated through cuttings. Cuttings may be planted straight away in the main field itself or nursery.

Selection of planting material:

Generally, the mulberry plants are raised from semi-hardwood cuttings. Cuttings are selected from well-established garden of 8-12 months old. Only full grown thick main stems, free from insect and disease damages having a diameter of 10-12mm are chosen for preparation of cuttings. The cuttings should be of 15-20 cm with 3-4 active buds and should have 45^0 slanting cut at the bottom end. Care should be taken to make a sharp clean cut at both the ends of cuttings without splitting the bark.

Nursery:

The 800 sq. m. area of red loamy soil near water source for raising saplings for planting one hectare of main field. Apply Farm Yard Manure (FYM) @ 20 t/ha and mix well with the soil. The raised nursery beds of 4m × 1.5m size. Irrigate the nursery once in three days.

Pre-treatment of cuttings and Age of sapling:

Mix one kilogram of *Azospirillum* culture in 40 liters of water. Keep the bottom end of the cuttings for 30 minutes in it before planting. *Azospirillum* is applied for inducement of early rooting. The saplings are ready for transplanting in the main field (90 × 90 cm) after 90-120 days of planting.

Pruning methods

1. **Bottom pruning:** The plants are cut at ground level leaving 10-15 cm stump above the ground. This type of pruning is done once in a year.
2. **Middle pruning:** The branches are cut at 40-60 cm above the ground level. After bottom pruning, subsequent cuts are made at 45-50 cm height.
3. **Kolar or Strip system**: In closely planted area, this type of pruning is done. The branches are cut at ground level every time. Thus, it receives five pruning every year. This type of severe pruning requires heavy fertilization and irrigation.

Harvesting:

The method of leaf harvest depends on the type of rearing practiced. There are three methods of harvesting of mulberry leaves. It is preferable to harvest the leaves during morning hours.

Preservation of leaves

Use leaf preservation chamber or wet gunny bags to store the leaves or cover the bamboo basket with wet gunny bags to keep it cool and fresh.

1. Leaf picking:

Individual leaves are harvested with or without petiole. Leaf picking starts 10 weeks after bottom pruning and subsequent pickings are done at an interval of 7 - 8 weeks.

2. Branch cutting:

The entire branches are cut and fed to the worms. Before that, topping is done to ensure uniform maturity of the lower leaves.

3. Whole shoot harvest:

The branches are cut at ground level by bottom pruning. Shoots are harvested at an interval of 10-12 weeks and thus 5 to 6 harvests are made in a year.

Importance of mulberry based farming system

Pasture land development, fertility sustainability (high biomass and foliage with rich in protein), fodder, quality animal products, efficient land management, intercropping is possible, agro-forestry leading to ecological sustainability and higher income.

Integration of farm enterprises depends on

Soil and climatic features of the selected area, availability of the resources, land, labour and capital, present level of utilization of resources, economics of proposed integrated farming system, managerial skill of farmer.

Integration of Mulberry Farming

Sericulture, Fishing, Intercropping, Olericulture, Dairy, Grasses and Agro-forestry

Mulberry and sericulture

Mulberry and sericulture system is highly remunerative compared to sole cropping. From Table 1, it can be inferred that mulberry cultivation with sericulture increases farm income.

TABLE 1: Income under mulberry and sericulture system.

Returns	
Gross return	157989.96
Total cost (1+11)	105920.64
Net return	52039.32

The experiment conducted by Ruchira, 2012 indicated that Sugarcane alone recorded lower income compared to mulberry-sericulture system (Table 1).

Seri-Fish system:

In this integration, mulberry is the producer; silkworm is the first consumer while fish is the secondary consumer, ingesting silkworm faeces directly. The seri-fish system provides linkages between mulberry and pond sub-system. Mulberry plants are grown on and around pond dikes which are irrigated with pond water. The system is commonly practiced in China and newly introduced in other countries. Pupae are fed to the fish which excels the growth of fish. The feed conversion ratio of pupae to fish is 2:1 such that 2 kg of pupae can produce 1 kg of fish.

Mulberry and Crop

Intercrop is always a benefit in Mulberry based IFS. It increases farm income (Table 2) and integration with legumes increases soil fertility.

TABLE 2: Net Income of mulberry-soybean intercropping system.

Mulberry-Soybean Intercropping	Net Income (Rs. Acre^{-1})
1:3 row ratio	17240
1:2	16430
1:1	14860
Sole mulberry	12250

Mulberry, Cropping and Dairy:

Integration of cropping with 2 milch animal, 6 goats in 1.25 ha rainfed land, out of which 0.25 ha with mulberry cultivation for sericulture results in the net return of Rs. 28, 580/year. The combination of various farming system with sericulture increases employment generation (Table 3).

TABLE 3: Employment generation in Mulberry based IFS.

Enterprise	Employment generation (in man days)
1. Crop + Dairy + Sericulture	75
2. Crop + Sericulture	59
3. Crop + Dairy	32
4. Crop Production	29

Olericulture:

During winter, vegetables are inter-planted with mulberry. After pruning land can be cultivated with vegetables. A production of 30 tonnes of mulberry-leaves/ha, 3.75 tonnes of vegetables/ha can be attained. The net income obtained was higher in mulberry-oleri based system (Table 4).

TABLE 4: Net income of mulberry-Oleri system in comparison with other enterprises in IFS.

Enterprises	Net Income (Rs. / ha / annum)
1. Mulberry + Vegetable	2,83,500
2. Mulberry + Dairy	1,79,175
3. Mulberry	56,015

Mulberry and Dairy

Combination of enterprises 'silk and milk' is very popular even now in Kolar district of Karnataka. One of the main features of mulberry as a forage, it is highly palatable. Animals consume the leaves avidly. They often prefer mulberry to other forages when they are offered simultaneously.

Mulberry and Agro-forestry:

Mulberry based agro-forestry system has great potential to generate larger income. It is easiest fruit tree to cultivate and most consistently productive.

Conclusion:

Mulberry based IFS increases farm income and it supplements as an input for other enterprises. Mulberry based IFS is capable of meeting the present challenges of shortage of fuel wood, fodder, timber, unemployment, environmental degradation, protection and improvement of wastelands.

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9. Microbial Retting of Jute: A Recent Approach

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Introduction

Retting can be defined as the process of separation and extraction of fibres from non-fibrous tissues and woody part of the stem through dissolution and decomposition of pectin, gums and other mucilaginous substance.

Bacteria enter the plant tissues through the stomata, epidermis or the cut end, when immersed in the retting tank/pond. After this, enzymatic actions take place, which loosens the fibre strands from the woody core of jute plant. The fibres can be mechanically extracted, washed, dried thereby ready to be marketed. This whole process is an integral part of retting. If the retting process is carried out properly, the extracted fibre exhibits genetic quality of the variety. Improper retting may lead to inferior quality of fibre even if the crop was good. This may ultimately lead to lower net return to the farming community.

Mechanism of Retting

The mechanism of retting of jute involves the absorption of water by jute plants and liberation of soluble constituents like sugar, glucosides and nitrogenous compounds from jute plants favouring initial microbial growth. Again, these microbes utilize free sugars, pectin, hemicellulose and proteins from jute plants as essential nutrients for their development and multiplication under favourable condition. Secretion of specific enzymes like pectinase, hemicellulose or xylanase by microbes and degradation of the respective complex organic materials follows. The decomposition of free sugar present in jute plants takes place at early stage of

retting, followed by pectin during middle stage, and hemicellulose, sugars and nitrogenous compounds (mainly proteins) at later stage of retting.

Methods of Retting

There are different methods of retting, which as follows:

1. Conventional method
2. Chemical Retting
3. Microbial Retting

Microbial Retting

The procedure of 'microbial retting' is as follows:

1. Harvested jute bundles are to be arranged radially up to three layers keeping base of the plants towards periphery of the pond.
2. Microbial consortium @ 4 kg for retting of 1 bigha of land is then applied to the jute bundles in the pond.
3. The jute bundles are then covered with straw/ aquatic weeds etc.
4. After retting, the fibres have to be washed in the retting pond itself after removal of 50 % retted water and addition of fresh water in the pond.
5. The fibres are then sun dried on the embankment of retting pond.

Economics

Considering the longer duration of retting of jute, a front line demonstration was conducted in Udalguri district of Assam, on fibre quality improvement of jute through microbial retting in 2019. Microbial consortium CRIJAF SONA @ 4 kg for retting of 1 bigha of land was applied for retting of the jute bundles. Microbial retting of jute yields a fibre quantity of 32 q/ha, which is much higher as compared to conventional retting (27 q/ha). Net return and B:C ratio of microbial retting of jute was Rs. 96,000.00 and 3.0 respectively. Whereas, net return and B:C ratio of conventional retting was Rs. 75500.00 and 2.6 respectively.

Advantages of microbial retting of jute:

The advantages of microbial retting jute retting are as follows:

1. Retting is completed within 12 to 15 days compared to 18 to 21 days under conventional retting.
2. Transportation cost of harvested jute bundles to the retting spot under conventional method (35 to 40 men days/ha, amounting Rs. 3500 to 4000) will be eliminated in this method.
3. The pond can be used for fish cum paddy culture after retting.
4. The quality of fibre will be improved at least by 2 to 3 grades.
5. The famer will be benefitted by Rs. 5000 to 6000/ha over conventional method as the fibre yield is around 35 q/ha.
6. The pond embankment can be utilized for plantation of high value vegetable crops (early cauliflower, cabbage, brinjal, tomato and capsicum etc.).

Conclusion

Microbial retting with the use of microbial consortium can be used for efficient retting of whole jute plant during water scarcity situation, utilizing minimum amount of ground water. It is a suitable option left for jute farmers as an alternative to conventional method of retting in less time, reduced volume of water with quality improvement.

Jute crop in Udalguri

Distribution of microbial consortium by KVK Udalguri

Microbial consortium for retting of jute

Bundles ready for microbial retting

Inoculation of microbial consortium

Jute fibres

Jute fibres after extraction

Jute fibres on the way to Marketing

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10. Digital Farming: Prospects and Obstacles in India

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Introduction

In the Present situation, whenever you are booking an Uber or making payments directly through apps on the phone, you are using a digital platform for performing tasks that were once manual. The incorporation of technology in everyday tasks to improve functionality is known as Digitalization. Digitalization has reduced manual work - which was time-consuming, error-prone and inefficient thus saving corporations millions. With advancements in artificial intelligence, the data analysis capabilities have improved further so much so that all the appliances in our house can be managed by virtual assistants that can understand human voice commands and respond. Proving to be a boon to every sector, Digitalization is slowly also revolutionizing the vast and complex Agriculture sector that remains the center of the world economy as still over 60% of the global population depends on it for survival.

"Digital farming can be defined as the use of technology by farmers to integrate financial and field level records for complete farm activity management and it is the consistent application of precision farming and smart farming technology, external and internal networking of the farm and use of the web-based data platforms together big with data analyses".

The data of each plot can be analyzed to provide information on soil status, weather conditions, crop growth patterns, and give actionable geographically relevant timely insights to prevent losses and optimize the productivity of each plot on the farm. Farmers can even get their queries solved and manage supply chain directly through applications on their phones. Through pre-harvest and post-harvest management of farms, digital farming aims to take over all the aspects of farming from farm to fork.

The technology uses

The technologies using include communication networks, sensors, Unmanned Aviation Systems (UAS), robotics, Artificial Intelligence (AI) and other advanced machinery and often draws on the principles of the Internet of Things. Each of these brings on something valuable to farming from the data collection, through to management and processing, as well as guidance and direction. This integrated system offers new insights that enhance the ability to make decisions and subsequently implement them.

Why is digital farming need?

The United Nations projects that by the year 2050 the population of the world will be 9.8 Billion. With consistent over sixty percent of the world population

on agriculture for food, the pressure to increase the production to meet demands does not seem to ease. Conjugate with climate change, which is increasing in global temperatures, carbon dioxide levels, frequency of droughts and floods, increasing labor costs, production cost, and unpredictability poses a major challenge to the future of agriculture. Hence, the goal is to increase productivity sustainably. To increase sustainability a very precise and calculated set of practices designed specifically for a plot needs to be followed and to follow best practices data needs to be recorded and analyzed digitally. So, digital farming is one of the best alternate options to rectify these challenges.

Prospects of digital farming

- Monitoring the near real-time
- Satellite and weather input based advisory
- Alert log and management of pest infestation, disease, etc.
- Standard packages of practices
- Geotagging for accountability and accurate predictability
- Robust and flexible system for farm management
- Readily available and accessible management through smartphone and PCs
- It will induce agricultural productivity and prevent soil degradation and erosion in cultivable land resulting in sustained agricultural development.
- It will reduce the usage of excessive chemicals in crop production.
- Water resources will be utilized efficiently under digital farming
- GPS allows agricultural fields to be surveyed with ease.
- Moreover, yield and soil characteristics can also be mapped.
- Promulgation of information about agricultural practices to improve the quality, quantity and reduced cost of production in agriculture crops.
- It will reduce the risk to the environment especially for nitrate leaching and groundwater contamination through the optimization of agro-chemical products.
- It offered opportunities for better resource management and hence reduce the wastage of resources.

Barriers of digital farming

- High costs may discourage farmers to not adopt this method of farming.
- Digital agriculture techniques are still under development and require expert advice before actual implementation.
- It is a too difficult task particularly the collection and analysis of data.
- Need more skill to the farmers
- Lack of awareness between the Indian farming communities.

Opportunities and Challenges of digital farming

Past few decades massive technological development and opportunities have transformed people's lives. However, these opportunities have not benefited the agriculture sector in a significant way. Farmers and other Entrepreneurs along the agriculture value chain need significant amounts of information. The information and communication technologies will play a key role in knowledge exchanges, market integration, targeted recommendations and access to finance to make agriculture a profitable enterprise. In digital farming can collect valuable information in a precise manner, also, it has provided a positive impact on environmental quality. The opportunities endure showing producers how changing production practices will not place crops at risk and produce positive economic and environmental benefits.

"**The farmers who succeed are the ones who are going to innovative new technologies**"

HORTICULTURE

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11. Cassava Mealy Bug: A New Threat to Indian Tapioca Farmers!!

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History across the world

Cassava mealy bug *Phenacoccus maihoti* Mat.-Ferr. (Hemiptera: Pseudococcidae) which is of neotropical origin first recorded in 1963 at Argentina then got spread to western countries of Africa from the tapioca cuttings during 1977 and in 20th century its entry gained Southeast Asian countries and now in India introduced in 2020. In southeast Asia alone, about 95% of world total cassava expert is prevails and the introduced pest is considered to be quite threat to cassava cropping systems. It causes yield loss of about 58 -84%. The crop cassava is considered as one of the important staple foods for African peoples

and 39% of people readily deprive food from cassava. Cassava being a food crop it is also used in the bio ethanol production, sago industries, chips making and also used in processed animal feed. In African countries, this insect faces huge loss and there does not exist its own predators or parasitoids and also none of the indigenous bio control agents works well on these invasive mealy bugs and also it also vectors for the Tapioca mosaic virus. It took almost 2 years for the control and were spent about 200$ to 500$. In Asian countries like Thailand, Cambodia, Laos and Indonesia it gains entry in 2010. Dr. Hans Rudolf Herren, recipient of the 1995 World Food Prize for the control of cassava mealy bug using *Apoanagyrus lopezi*, a parasitoid and also reducing the famine caused by this mealy bug.

Recent introduction in India

Cassava mealybug (*Phenococcus manihoti*) was recorded in 2020 first noticed in Thirussur, Kerala experimental plots at the Department of Agronomy, College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala was surveyed and the location was recorded using GPS and also potent to spread over parts of the country. In India it was found that some of predators such as *Spalgius epeus*, *Schymnus coccivora* were found, but unfortunately no parasitoids have been found in this mealy bug till date. In Tamilnadu it is reported that the damage extent for about 3112 hectares of cassava growing districts of Namakkal, Salem, Erode and Kanniyakumari are been affected.

Some scientists already mentioned that in case of any entrance into India, it is advised for the introduction of *Apoanagyrus lopezi* is considered to be more effective in talking this invasive cassava mealy bug. The insecticide application is considered to be most ineffective due to the presence of mealy coatings over these outer cuticles and also formation of the dense colonies.

Biology and nature of damage

Cassava mealy bug is considered to be parthenogenic in nature and it deposits about 200 -600 eggs within the ovisacs on the under surface of leaves along the midrib of the leaves and also in growing terminal shoots. The dreadful invasive cassava mealybugs are also able to cause the damage on various crop families such as fabaceae, euphorbiaceae, malvaceae, solanaceae of economically important crop families and also the crop other than damaged were Lime, Basil and *solanum* species other than cassava. *P. manihoti* affected plants causes the deformation in the in the plant growth and formation of rossetting appearance. High infestation with mealybug causes drying of apical tissues, shortening of internodes and formation of excessive branching. Further, it also causes the sooty mould by reducing the photosynthetic activities. Among the various mealy bug complex in tapioca ecosystem like *P. manihoti*, *Paracoccus marginatus* and *P. manihoti* causes about 80% yield loss when compared to other which caused only 40% losses.

Integrated management strategies

Avoid planting the mealy bugs affected setts for the cultivation purposes. Cassava crop intercropped with the maize about 57-83% causing the population pressure on mealy bug but had a detrimental effect on infested plants. The cultivars with the large quantity of rutin a phenolic secondary metabolite in cassava is considered to be resistance and it also it resists to the cassava mealy bug *P. manihoti.* Antibiotic resistance was high at the application of 10kg of Nitrogen and 1kg of Calcium to the field but it does not exhibit tolerance for Calcium fertilizers. Hydrogen cyanide (HCN) content in the roots imparts more possibilities of susceptibleness to the cassava plants against the major sucking pests. The use of indigenous biological control and frequent release of predators will be effective to take control on mealy bugs. These are also effective on the entomopathogens like *Beauveria bassiana*, *Lecanicillium lecanii* and *Metarhizium anisopilae.* As, it has been already stated the use of chemical insecticides will not be effective in management of these mealy coated insects.

Conclusion

There should be an immediate and necessary step to be taken for the further spread of this invasive insect around the cassava tracts and possible actions has to be taken on promoting the indigenous biocontrol agents like predatory coccinellids to be encouraged and use of mycopathogens also to be included. A proper quarantine measures has to be taken while transporting the planting material by doing this the further spread will be stopped.

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12. In Vitro Shoot Tip Grafting: The Saviour of Citrus Industry

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Introduction

Citrus is one of the major fruit crops of India and its cultivation is often threatened by various graft-transmissible diseases caused by virus, viroid, bacteria, phytoplasma and spiroplasma. Availability of disease-free planting material and resistant or tolerant rootstock seems to be the only way out for preventing these diseases from becoming rate limiting factors in citrus production. Citrus is one of the few fruit crops where apomictic mode of reproduction is prevalent and most of the varieties are polyembryonic in nature. Besides producing uniform true to type planting materials, nucellar seedlings of polyembryonic cultivars have also been used to recover pathogen-free citrus plants as most citrus viruses are not transmitted through the process of embryogenesis. However, use of this technique is often limited by the fact that the nucellar seedlings are juvenile, excessively vigorous, thorny and late in bearing. Additionally, psorosis-like pathogens and citrus leaf blotch virus have been reported to be transmitted by seeds. In order to recover pathogen free citrus plants without juvenile traits, thermotherapy has been tried, but it becomes ineffective for eliminating pathogens that can survive at high temperatures for example diseases caused by viriods like citrus exocortis, catchexia and citrus leaf blotch virus. Hence, it became inevitable to search for a method to produce true-to-type planting materials without juvenile traits and free from graft-transmissible pathogens. By grafting shoot-tips from diseased plants on in vitro grown young rootstock seedlings, Murashige et al., (1972) were successful in recovering few citrus plants without juvenile characters some of which were free from exocortis viroid. This technique named as in vitro shoot-tip grafting (STG) was extensively studied by Navarro et al. (1975) who established a standard protocol to produce grafts with 30-50% success and the resulting plants were mostly free from graft-transmissible pathogens and did not have juvenile characters.

In Vitro Shoot tip Grafting technique

The standard protocol developed by Navarro et al. (1975) is mostly used for in vitro shoot-tip grafting and it includes five main steps namely rootstock preparation, scion preparation, grafting, in vitro culture of grafted plants and transfer of successful grafts to soil. For rootstock preparation, surface sterilized seeds are grown in vitro in culture tubes containing plant cell culture salt solution of Murashige and Skoog media. Degree of tissue differentiation of the rootstock which is affected by its age determines the success of grafting. Hence, performing grafting at appropriate age and suitable stem height and diameter is of utmost importance for grafting to be successful. When Troyer Citrange is used as a rootstock, two weeks old, 3-5 cm tall seedlings with a diameter of 1.6-1.8 mm at the point of grafting, gives highest rate of graft success. Once the rootstock seedlings attain appropriate age, they are taken out of culture tubes under aseptic conditions and decapitated leaving around 1.5 cm of epicotyl. Further, the root is cut up to a length of 4-6 cm and cotyledons as well as axillary buds are removed. For grafting, it is recommended to put the shoot-tip in an inverted-T incision made by a 1 mm long vertical incision initiating from the point of decapitation followed by a horizontal cut of 1-2 mm wide (Navarro et al., 1975). For preparation of scions, young vegetative flushes are used as a source of shoot tips. The size of shoot tip has a bearing on the number of healthy plants recovered by STG. Increase in shoot-tip size was found to be associated with increase in graft success with a decrease in number of healthy plants. Therefore, shoot-tips composed of apical meristem and three leaf primordia with a length of 0.1-0.2 mm are considered to be optimum for grafting. The reason why shoot-tip grafting eliminates pathogens is because shoot-tip does not have any vascular connection with the remaining plant parts. Micro-grafted plants are then cultured in vitro in liquid nutrient medium composed of Murashige and Skoog media, modified White's vitamins and sucrose and kept at a constant temperature of 27°C and 16 hour illumination (Navarro et al., 1975). Practically no growth regulators are used in STG. The grafts become ready for transplanting to soil when they have at least 2-4 expanded leaves and this stage is reached after 4-6 weeks of grafting. If the shoot-tips are excised from adult plants, the plants recovered by STG do not possess juvenile traits and can come to bearing within two years of grafting.

Applications

Preventing graft-transmissible pathogens: Sanitation, quarantine and certification are three independents but related programmes which are required for the production of disease free, high quality planting materials needed to prevent graft transmission of pathogens (Navarro and Juarez, 2007). Sanitation programmes aim at recovering healthy plants from

local varieties while quarantine programmes are mainly concerned with preventing introduction of foreign pests and diseases while importing planting materials. STG as a plant propagation method plays a major role in both these programmes and helps in the production of healthy plants for certification programmes, the main objective of which is to ensure the sanitary status of initial plant material is maintained during its commercial propagation at nurseries.

Sanitation programmes: STG has been found to be very effective in recovering plants free from diseases like cachexia, canker, exocortis, huanglonbing (greening) leaf blotch, psorosis A and B, tristeza etc. Among these diseases, 100 per cent plants recovered by STG were free from cachexia, exocortis (caused by viriods), huanglonbing and tristeza while for diseases like seedling yellows-tristeza and yellow vein, about 80 per cent disease free plants could be recovered and only 25 per cent healthy micro-grafted plants could be recovered for diseases like leaf blotch, ring spot and psorosis suggesting that these diseases are difficult to eliminate even by using STG. Since, the plants developed through STG do not possess juvenile traits in contrast to nucellar embryony and produces pathogen free true to type plants it is being used in citrus sanitation programmes round the world.

Quarantine programme: Shoot-tips from imported budsticks are micro-grafted in vitro and cultured to develop disease free materials which are then introduced in the intended areas. This process significantly reduces the chances of escape of pathogen and allows rapid processing of new arrivals.

Conclusion

STG has emerged as a saviour of global citrus industry which is plagued with several diseases and pests. The use of STG in quarantine programmes have led to a reduced risk of entry of foreign pests and diseases via imported plant material. It has also increased the scope of using different rootstocks which was often limited by the variety specific infection. The plants obtained through STG technique lack juvenile traits and starts bearing early which has resulted in increased production and fruit quality. Moreover, STG is being used as a tool for genetic transformation, somatic hybridization, somaclonal variation and haploid production to regenerate disease free elite genotypes.

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13. Phyllody in Jasmine

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Introduction

Jasmine is the second major flower crop grown in Dharmapuri district next to tuberose. Since the crop requires lots of manpower for harvesting and other operations, only small farmers are cultivating the crop. The major problems faced by the jasmine growers are incidence of micronutrient deficiency, budworm and leaf spot diseases. Due to the changes in management practices *viz*., pruning, nutrition, growth regulating hormones and environmental condition flowering behaviour get altered. In that way, the incidence of phyllody or green flower disease is emerging as a problem in jasmine cultivation. In phyllody affected plants, the floral part becomes partially or completely modified to leaf like structures. It is mainly due to the changes in plant hormone balance brought about by abiotic conditions such as environmental stress or living infectious agents. The leaf like structure may be exhibited in any of the flower parts such as bracts, calyx, corolla, gynoecium and androecium. The affected plants may become partially or entirely sterile.

In some cases, the fully opened flowers of the plant turn to green colour due to the loss of pigment in petal cells, without showing any changes in its original floral structure it is called as Virescence. It is more common among the polypetalous flowers where the flowers exhibit corollas of distinct petals.

Symptoms

The visible symptoms of phyllody in jasmine caused by phytoplasma are,

- Plant growth becomes stunted and gives bushy appearance
- Yellowing of leaves due to phytoplasma
- Internode length gets reduced
- The leaves look leathery and dark green in colour
- Flower bud becomes modified and exhibits green leaf like structure
- Flowers looks small and turn to green colour with its normal structure *i.e.*, virescence

Flower buds turn to green leaf structure

Factors responsible for the problem

The occurrence of phyllody or virescence in plants may be due to

- infections of plant pathogens
- infestations of ectoparasites
- environmental factors
- hormonal imbalance

Infections of plant pathogens

Infections of mycoplasma like organisms (phytoplasma) control the gene involved in petal formation and maintenance of apical meristem. The phytoplasma disrupt the normal hormone production thereby inducing phyllody in plants. The presence of phytoplasma's in the phloem breakdown the chlorophyll that leads to yellowing of leaves.

Infestations of insects and ectoparasites

The insects and ectoparasites serves as vectors and it can spread the phyllody disease to other adjacent crops. There are various insects (leaf hoppers, broken-backed bug), mites (eriophyid mite, rose leaf curl mite, chrysanthemum rust mite), viruses and fungi are responsible for the spreading of the phytoplasma caused phyllody in plants.

Environmental factors

The most common cause of phyllody is environmental factors such as water stress and high temperature during flower bud formation may cause the imbalance in plant hormones level within the plant. It leads to the development of floral parts into leafy structure.

The occurrence of phyllody due to the effect of environmental factors leads to the simultaneous production of healthy normal and abnormal flowers. When the environmental conditions become normal, the plant restarts production of normal flowers. The symptoms exhibit due to environmental factors can be transmitted to next generation.

Hormonal imbalance

Plant hormones are the chemicals that are produced within the plants at low concentration and are involved in regulation of plant growth. The commonly produced plant hormones are abscisic acid, cytokinin, auxins, gibberellins and ethylene. Each of them has its own functions like cell division, elongation, rooting, enhancing flower production, fruiting, seed formation, germination, dormancy *etc*. in the plant system. Accumulation of cytokinins in plants leads to apical dominance and auxillary bud growth thereby induce the production of leafy structure.

Management

- Selection of cuttings or planting materials from healthy plants
- Spraying of plant protection chemicals to control the insect vectors
- Pruning of affected blooms or plant parts
- Foliar application of plant hormones especially gibberellins or naphthalene acetic acid along with zinc sulphate to induce stem elongation and flowering

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14. Off-Season Production of Vegetables in Protected Structures

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Growing of vegetable in normal season generally we do not fetch returns due to the huge obtainability of vegetable in market. Cultivating of vegetable in protected structure in off season increase the farmers income by producing vegetable extensively. Production of fresh vegetable after or before their normal season is called off-season vegetable production. The objective is to produce and supply vegetables to market during their lean period of supply.

Advantages

- The farmers can learn specific techniques of vegetable production.
- It also helps to develop confidence and make vegetable production as their main profession.
- Through off season production farmers can get higher profit.
- Consumers can get fresh vegetables during off-season.
- By growing of fresh vegetables possible to export and earn foreign currency.
- Growing of off-season vegetable creates employment for farm laborers all the year round.

Disadvantages

- Off season vegetable production requires highly specialized techniques of vegetable production.
- Sometimes it becomes a risky setup due to probability of incidence of diseases and pests.
- It necessities regular observation and follows up from the government agencies concerned.
- It is possible on a commercial scale only in areas where marketing is not a problem.
- It may be a source of pollution.

In northern plain India cultivation under plastic tunnels in off-season is one of the most profitable technologies for cucurbits vegetables cultivation. Off-season vegetables cultivation and raise off-season nursery in walk-in tunnels is effective and suitable due to their low initial cost. For virus-free cultivation of tomato, chilli, sweet pepper and other vegetables we can be used Insect proof net houses during the rainy season. Low cost greenhouses used for high quality vegetable cultivation for long duration (6-10 months) mainly in peri-urban areas of the country to fetch appropriate price of produces. Polytrenches have proved tremendously useful for growing vegetables under cold desert conditions in upper reaches of Himalayas in the country.

These low-cost structures are suitable for growing of vegetables free from pesticide.

Off-season production requires the same management practices as ordinary vegetable production, with extra attention paid to the following factors: temperature and moisture

Temperature:

In the process of seed germination and plant growth and development temperature plays important role. For seed germination different vegetables required different range of temperature.

Beet, cabbage, cauliflower, celery, parsley, pea, radish, swiss chard, turnip require a minimum of 4°C and an optimum of 27-29°C. Bean, cucumber, brinjal, okra, pumpkin, pepper, squash, tomato, need a minimum 16°C and optimum range of 24-35°C.

Techniques for winter season:

Seed germination in the cold can be improved by germinating seed in compost piles or plastic tunnels.

A. Seed germination in compost pit:

1. Place seeds on a piece of cloth roll the cloth and moisten it.
2. Keep the roll in a compost pit.
3. Plant the newly germinated seed.

B. Germinating Seeds and Growing Seedlings Under Plastic Tunnel:

To promotes the seed germination a tunnel of half hoops of bamboo set in the ground/nursery and covered with plastic sheet in cold weather helps to keep the soil warm. For ventilation purposes close the ends at night and open them during the day time.

C. Seedling Production in Plastic House:

For those areas where a ready market is nearby (such as in the vicinity of urban centres/along trekking trails) large-scale production of off-season vegetables might be both feasible and profitable. The large number of seedlings needed can be produced in a plastic house. High value vegetables can be produced during the offseason in that house.

- During cold season and even peak of the rainy season seedlings is produced in plastic house.
- In rainy season high value crops like sweet pepper and tomato and by forcing culture cucumber may be produced in winter season.

Practices of off-season vegetable production

Netting:

The net breaks the rain drops into small particles and reduces the temperature. It also protects from insect pests.

Plastics:

In the tropics protect the crop from excessive rain by using plastics roofing materials.

If plastic is coated with white wash, partial shade can be achieved during hot summer days. The main problem from the use of plastics is building up heat. To prevent the raising of temperature in plastic house, we can practice to build roof from the plastics and sides are made of the net to reduce the building up of heat in the plastic house.

Misting:

Misting is practice done with cold water to reduce the temperature in glass or plastic house.

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15. Production Technology of Brinjal (Solanum melongena L.)

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Brinjal is one of the most common tropical vegetables grown in India. It is known by different names like Begun in Bengali, ringna in Gujarathi, baingan in Hindi.

Climate

Brinjal is a hot season crop that needs a long, hot growing season. It's very sensitive to frost. The temperature of 13-21 oC is the most desirable for successful production and can be grown at an altitude of 1200 m above sea level.

Season

It can be grown in plains throughout the year but rabi season is the best.

- Rainy Season - June – July
- Winter Season - October – November
- Summer Season - February – March

Soil

Brinjal is a hardy crop and is grown on a wide variety of soils. Well-drained and fertile soil is favoured for the crop as a long-lasting crop with high yield. Crops grown in sandy soils yield early, and more are yielded by those grown in clayey soils. The optimal pH is 5.5-6.6 for the production of crops.

Some famous varities of brinjal

1. **IARI:** Pusa Shymala, Pusa Purple Long, Pusa Purple Cluster.
2. **IIHR:** Arka Sheel, Arka Shirish, Arka Kusumkar.
3. **PAU:** Punjab Chamkila, Punjab Sadabahar, Punjab Barsati.

Seed rate

Normal seed rate of brinjal 350-500g per ha But in case of hybrid its required 150g per ha.

Seed treatment

Harzianum @ 2g100 g of seeds to prevent seed and soil borne infection.

FIGURE 1. Brinjal flowering and fruiting stage

Nursery

Seeds of Brinjal are sown on nursery beds to collect seedlings in the field for transplanting. In order to avoid water logging problems on heavy soils, raised beds are required. However, in sandy soils, in flat beds, sowing may be taken up. The raised beds are 7.2 x 1.2 m in size and 10-15 cm height.

Land Preparation

Apply four to five ploughings with an appropriate interval between two ploughs, the field is ploughed to fine tilth. For proper levelling, planking should be carried out. The area is then divided into beds and channels. At the time of land planning, the well-decomposed FYM is fully integrated.

Spacing

Generally, 60 x 45 cm of long fruit varieties are transplanted, 75 x 60 cm of round varieties and 90 x 90 cm of high yielding varieties are spaced. In light soil, seedlings are transplanted into furrows.

Manure and fertilizers

The dose of fertiliser depends on soil fertility and the quantity of organic manure added to the crop. 15-20 tonnes of well-decomposed FYM is introduced into the soil for a better yield. In general, the application of 150 kg N, 100 kg P2O5 and 50 kg K2O for optimal yield is recommended.

Irrigation

A continuous supply of humidity should be maintained across the plant's root zone. On the first and third days after transplantation, light irrigation is given. Irrigation is then applied at periods of 8-10 days in winter and 5-6 days in summer, respectively.

Intercultural Operations

To keep the crop free of weeds, two-three hoeing and the earthing up are appropriate. The pre-emergence of Fluchloralin (1.5 kg a.i./ha) in combined with one-hand weeding 30 days after transplantation is effective for weed control.

Pests

Important Pests in brinjal crop like Fruit and shoot borer, jassids etc.

Diseases

Major Diseases in brinjal crop like Bacterial wilt Fusarian wilt, Phomopsis blight, little leaf etc.

Harvesting

Depending on the variety, the fruits become ready for the first picking in around 120-130 days of seed sowing. The picking of the fruits should be done as soon as a suitable size and colour is attained. When they become greenish yellow or bronze, fruits are harvested and their flesh becomes dry and tough. The fruits are harvested for 8-10 days interval.

Yield

The average yield of brinjal varies from 20-30 t / ha depending on variety and season.

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16. Role of Arbuscular Mycorrhizal Fungi in Fruit Crops

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Introduction-

Fruit crops are rich, natural and abundant source of nutrients and minerals in human diet. Increased use of chemical fertilizers and pesticides in fruit cultivation system affect quality of fruit. Therefore natural biofertilizer like Arbuscular Mycorrhizal Fungi can be use to enhance crop productivity and to rejuvenate soil of fruit orchard.

AM Fungi are soil-borne fungi which form a mutualistic symbiosis with the roots of higher plants. It penetrates the cortical cells of the roots of a vascular plant forming arbuscules. It assist host plants to grow vigorously under stressful conditions by conciliating a series of complex communication events between the plant and the fungus leading to enhanced photosynthetic rate and other gas exchange-related activities as well as increased water uptake. AMF form hyphal network with plant roots therefore significantly enhances the access of roots to a large soil surface area, causing improvement in plant growth and development. It improve plant nutrition by enhancing the availability as well as translocation of various nutrients. 15-25degree Celsius soil temperature is suitable for mycorrhizal growth and roots.

Role of AM Fungi in Fruit Crops -

Fruit crops require fertilizers when the soil is unable to supply sufficient amount of nutrients. However excessive use of chemical fertilizers may deteriorate the quality of soil of orchard by affecting viable soil organism negatively. Therefore, seedlings bioprimed with inocula of AMF result into improved vigorous and healthy crop. Mycorrhiza hyphae is more efficacious as compare to roots of plant in uptake of nitrogen, phosphorus, and micronutrients like Cu, Mg, Al, Zn, Mn and their transportation in fruit crops.

AMF inoculation in fruit crops have been *reported* to numerous benefits as per reports of many experimental research. The evaluation is mostly done by pot culture trials and few field trials also.

Various benefits of AM Fungi Symbiosis with Fruit Crops are as follows-

1. Around 20-30% loss occur every year in fruit crops due to infestation of pathogens. Thus AMF act as bio-control agent in fruit crops as they reduce the damage caused by soil-borne plant pathogens.
2. AM Fungi act as plant growth promoters by acquisition of several nutrients and encouraging plant growth in soils.

3. AM Fungi enhance plant community.
4. AM Fungi enhances uptake of low mobile ions.
5. Encouraging nutrient cycling.
6. AM Fungi ensure mineral nutrients and water needed by the plant and increases ability to tolerate abiotic stress, including salt stress, drought stress, high temperature stress, and diseases and insect pests in fruit crop like citrus as citrus is devoid of root hairs, thus relying on its symbiotic fungi, arbuscular mycorrhizal fungi (AMF), to partly replace nutrient acquisition of root hairs.
7. Improvement of fruit quality and plant growth and optimization of root system architecture in citrus.
8. Increase of soil fertility through hydrolases and glomalin (microbial glue) contribution of soil organic carbon.
9. Through photosynthesis and a series of complex physiological and biochemical changes, plants form a variety of complex organic compounds, some of which are transported down to their roots and feed the symbiotic fungi for life.
10. Mycorrhizal inoculation plays an important role in the production of qualitative fruit trees with balanced mineral nutrient uptake in crops like grapevine, fig and banana rootstocks.

Different Mycorrhiza species used in fruit crops can be listed in the following table-

S.No.	Mycorrhiza species	Fruit crops
1.	*Gigaspora margarita* inoculum	Peach Seedling
2.	*Glomus fasciculatem* inoculum	Litchi (air layering)
3.	Glomus mosseae	Papaya
4.	Glomus etunicatum	Apple seedling
5.	Glomus *mosseae*	Sapota

Conclusion

Selective arbuscular mycorrhizal fungi (AMF), can be used to produce horticultural seedlings for growth and improvised nutrient uptake as different AM Fungi differently affect nutrient uptake. Fruit seedlings can be easily inoculated with AM fungi in nursery and bio-enriched seedlings are then transplanted to main field. Since most of the fruit crops are vegetatively propagated therefore more research work should be conducted on effect of AM Fungi on various techniques of propagation like grafting, cutting and layering under given field conditions to enhance fruit crop productivity and soil productivity as well by excluding harmful impact of pesticides and fertilizers.

*AMF- Arbuscular Mycorrhizal Fungi.

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17. Importance of Organic Manures in Horticultural Crops

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Cattle Manure or Farm Yard Manure

The manures produced by horse, cattle's or other animals are included in this category. They contain 0.6% of nitrogen, 0.35% phosphorus and 0.6% potash, however the percentage of these nutrients may vary depending upon the substances the animal feed, age of the animals, conditions of animals and storage and handling including the kind of litter used.

Night Soil

It is powerful manure rich in nitrogen. The chief objection to its use is based on sanitary and sentimental grounds on account of its offensive odour when it is not sufficiently decomposed. On the dry basis, it contains 5.5% of N, 4.4% P and 2.0% K. As

it is strong manure, regular watering should be done when it is used.

Guana

It is well known manure rich in nitrogen (10.15%) and phosphorus (9.82%). It occurs as deposit in large quantities, principally off the islands of the coast of Peru and South America. The pure form of guana is practically exhausted now. Guana may be mixed with about six times its weight of soil.

Bones

They are rich in phosphoric acid and lime. Steamed bone meal contains not less than 3.5% of nitrogen and 23% phosphoric acid. Bones are especially beneficial to soil deficient in lime.

Oil Cakes

They are residues left after the oil is extracted from the seeds of ground-nut, castor, gingelly, pongamia etc., and they contain 3 to 5% nitrogen and 1.5 to 2% of phosphorus.

Leaf Mould

Decomposition will be completed within a year. When well decomposed, leaf mould could be powdered and sifted through wire mesh. Leaf mould is rich in humus and is hence applied to both sandy and clay soils. It is usually mixed with soil in the preparation of many pot mixtures.

Wood Ash

It is rich in potash. Vegetables generally require liberal manuring with potash.

Coir Compost

The coir pith, obtained as a waste material from coir industry, is composted with a fungus called *Pleurotus sojarcaju*. This compost is having about 25: I C/N ratio, and hence is a richer source of organic manure and it improves the crop growth. They also contain good amount of macro (N: 1.4%, P205 0.06%, K20 1.2%) secondary (Ca.O.98%) and micronutrients such as Fe, Mn, Zn and Cu. Its unique property is to absorb and retain moisture about 5 to 6 times of its volume and hence it is a good material to apply for rainfed horticultural crops.

Vermicompost

Organic waste materials and animal dung when fed with certain species of earthworm *viz Eudrilus eugeniae, Eisenia fetida* and *Perionyx exxelll'allls* the 'worm cast' or excrements of the worms form the needed organic fertilizer called 'Vermicompost'. It is rich in organic carbon content (47%) and humus substances which help in building soil structure and stimulating plant growth particularly that of roots. It can be applied to horticultural crops relatively in small quantity in the places of organic manures or organic cakes along with 50 to 75 per cent recommended quantities of NPK fertilizers.

The major role of various organic manures are:

1. To serve as a source of major, secondary and minor elements.
2. To build up soil organic matter and maintain fertility.
3. To improve physico-chemical and biological properties of the soil.
4. To have residual effect.
5. To control pest and diseases.
6. To improve the quality of the crop.
7. To act as a chelating agent.

The soil organic matter can be increased by the addition of 'synthetic farm yard manure' which is popularly called 'compost'. The final product is usually dark brown in colour and when correctly made, resembles ordinary farm yard manure both in its properties and appearance. By regulating the temperature and moisture and by introducing the required amount of nitrogen, phosphorus, potassium and calcium, the speed of decomposition and the nature of the product can be decided. Well prepared compost contains 0.75 to 1.00 % N, 0.60 to 0.750/0 P205 and 1.00 to 1.50 % K_20.

Sometimes, green manure or green-leaf manures are ploughed into the soil for the purpose of incorporating organic matter, thus supplying humus as well as nutrients contained in them. The green manure crops are generally leguminous plants, raised for the sole purpose of serving as manure. The following are the commonly grown green manure legumes in India

1. Sunhemp (*Crotolaria juncea*)
2. Daincha (*Sesbania aculeata*)
3. Pillipesara (*Sesbania speciosa*)

Green leaf manuring refers to the incorporation of the green leaves and other tender parts of the plants collected from the shrubs and trees grown outside the field and also collected from the waste lands and nearby forests into the soil. The popular plants are:

1. Gliricidia (*Gliricidia maculata*)
2. Sesbania (*Sesbania speciosa*)
3. Pungam (*Pungamia pinnata*)

The green manuring is generally recommended in orchard to build up the humus status of the soil. The following are the important chemical fertilizers with which the farmers may be familiar.

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18. Harvesting Methods, Types, Indices of Horticultural Crops

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Harvesting

It is the process of removal of economic produce from the mother plant.

Harvesting Methods

Based on the species and types of fruits, the harvesting may be single (once over harvest) as in the case of agricultural crops like rice, wheat, sorghum etc., or multiple harvesting (pickings) as in the case of vegetables.

Single Harvest

Manual Harvest

When a seed crop is raised in a small area *e.g.*, Nucleus seed production. It is done by either removal of entire plant or by harvesting the ear heads or panicles *i.e.* matured economic part alone can be harvested.

Mechanical Harvest

Combined harvester can be employed for harvesting the seed crop when it is raised in large and vast area with a single variety.

Multiple Harvest

It is mostly done manually. As and when the economic part comes to maturity it is harvested. eg. Most of the vegetables are picked once in week or twice in a week. In legumes, the matured pods are plucked and dried under sun.

Seed Crop Maturity

The maturity is of two types depends on the purpose. If the crop is for grain production, it is enough to harvest the crop during harvestable maturity (HM). But when the crop is meant for seed purpose it is advisable to harvest the crop during physiological maturity (PM).

TABLE 1. Difference between HM and PM

Physiological maturity	Harvestable maturity
First stage – prior to HM	After PM and followed by field maturity
Moisture content – maximum compared to HM	Moisture content minimum compared to PM
The stage at which the seed attained maximum vigour and dry matter production	After PM the seed start to lose the vigour
Metabolic activities minimum	Fluctuating depends on environmental conditions
Optimum stage to harvest seed crop	Optimum stage to harvest grain crop

TABLE 2. Maturity indices for horticultural crops

Crop	Maturity indices
A. Dry seeds	
Chillies	Turning of fruit colour from green to red, yellow or brown.
Bhendi	Pods become grey or brown, hard according to cultivar, appearance of hairline crack
Beans	Earliest pods dry and parchment like and remainder have turned yellow
Broad bean	Pods become relatively dry, sponginess and is usually proceeded by a general blackening
Carrot	Secondary and 3rd order head turn brown
Radish	Brown pods and parchment like when the seeds are near maturing
Cabbage	On ripening, plants become dry and turn brown / light yellow
Onion	Seeds become black on ripening in silver coloured capsules. Ten percent heads expose black seeds
B. Wet flesh fruits	
Tomato	Skin colour changes to red and softness of fruits
Brinjal	Turning fruit colour to yellow / straw
Capsicum	Green coloured fruit changes to red or yellow depending on variety
Cucumber	Fruit develops external ripening colour, stalk adjacent to the fruit withers. For confirming actual seed maturity, several fruits are cut longitudinally and mature seeds separate easily from the interior flesh
Bittergourd, Snakegourd	Fruit and seed become red

Special care in Harvesting Hybrid Seeds

Since the hybrid seed production involves two parents

either in the same field (or) in separate blocks, at most care has to be taken to avoid mechanical admixture of seeds of parental lines. As the hybrid seeds are set in female parent, the female lines are to be harvested separately.

Single Harvest

To ensure genetic purity, first the male parental lines should be harvested and taken to threshing yard separately. The field has to be checked for any leftover male parental lines / plants and if any found to be removed immediately. After ensuring complete removal of male parents, female parental lines are to be harvested and taken to another threshing yard for further processing.

Multiple Harvests

In case of vegetables (tomato, brinjal and bhendi *etc*.,) multiple harvests are advocated. The matured fruits from female parents are to be collected separately and the hybrid seeds are extracted with at most care.

Number of Picking / Harvest

In case of multiple harvesting, number of harvesting are to be restricted to first 6-7 pickings as the seed quality of early formed fruits will be superior compared to later formed fruits. Therefore, the rest of the pickings can be utilized for vegetable purpose.

SOIL SCIENCE

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19. Role of Nitrogen in Plant Nutrition

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Introduction

Nitrogen is one of the first major essential nutrient elements required by plants. Although N is protoplasm of chlorophyll and coenzyme, it is also essential constitute of protein. It is involved in nearly all processes needed to sustain the plant life. Nitrogen is important element for plan growth and development. It is also playing an important role in Physiological and biochemical functions of the plant.

Nitrogen generally taken up in the NO_3^- FORM UNDER aerobic condition and as NH_4^+ ions under anaerobic condition (95 to 98%), a method that takes this reserve nitrogen into account is a better index of nitrogen supplying capacity of a soil.

TABLE 1: Rating limits for soil test value of Nitrogen

Rating	Value (Kg/ha)
Low	< 280
Medium	280-560
High	>560

Nitrogen content of soils

Nitrogen content in soil is 0.02 to 0.4 % in the surface soils. In peat soils, N content is above 2.5 %. In Indian soils, N content is 0.03 to 0.06 %.

Forms of soil Nitrogen

Organic Nitrogen: A bulk of total N is present in organic form, organic nitrogen present in two forms: hydrolysable and non-hydrolysable. The hydrolysable form of nitrogen is mineralized slowly and transformed into three processes- Aminization, Ammonification and Nitrification. And available to the plant. Non hydrolysable form of nitrogen is resistant to mineralization due to the formation of complex organic molecules formation. Organic form of Nitrogen example- organic manures, green manures, FYM, compost, crop residues, organic waste, biological nitrogen fixation and biofertilizers -Although about 78% of the earth's atmosphere is composed of nitrogen, the majority of the plants cannot utilize from of nitrogen. Only some bacteria, some blue-green algae, leguminous plants (having root nodules) etc. can fix atmospheric nitrogen.

TABLE 2: Nitrogen present in different forms in soil-

Forms		
Organic	**Inorganic**	
e.g.,	**Ionic**	**Gaseous**
Protein	e.g.,	e.g.,
Free amino acid	NH_4^+	N_2
Amino sugar	NO_3^-	N_2O
Other complexes	NO_2^-	NO
		NO_2
		NO_3

Inorganic Nitrogen: only 2 % nitrogen present in inorganic form. Inorganic form of Nitrogen is NO_3^- - N, NO_2^- - N and NH_4^+-N is important plant growth point of view.

Role of Nitrogen in Plants

- Impart green colour to plant
- Encourages vegetative growth

- It is present in most of substance of cells
- Nitrogen is essential constituted of protein
- Nitrogen is protoplasm of chlorophyll and coenzyme
- Play and important role in synthesis of auxins

Nitrogen is paramount to plant health – it's a core component of the plant structure and vital to the metabolic processes, such as photosynthesis

- It's an essential element of all the amino acids in plant structures; these are the building blocks of plant proteins and are important to the development of plant tissues such as the cells, membranes, and chlorophyll.
- This means that plants with sufficient levels of nitrogen experience higher rates of photosynthesis, and will typically grow and develop vigorously.
- Nitrogen is also a factor in the development of DNA, which contains the genetic blueprint of the plant – it's a component of nucleic acid.
- Nitrogen Deficiency in plants

Plants can neither use nor take nitrogen directly from the atmosphere – it must be absorbed from the soil through nitrogen forms that include ammonium and nitrate. An insufficient supply of nitrogen can lead to several plant disorders.

- Nitrogen promotes the creation of chlorophyll, A lack of it will affect the plant's ability to create sufficient starch and proteins, this undermines the overall health of the plant and will also affect flowering and fruiting.
- Lower leaves become yellow or light green in colour
- 'V' shaped chlorosis on older leaves
- Yellowing at tip
- Plants look thin, pale and the condition is called Starvation disease
- Buttoning in cauliflower

Protein is essential for all living organisms, and is required for growth and development. Nitrogen is one of the main elements in protein; Nitrogen is also a component of nucleic acid, DNA, RNA, genes, chromosomes, enzymes, chlorophyll, secondary metabolites (alkaloids), and amino acids. Nitrogen accounts for about 1 to 6 % of plant dry matter, depending on the species.

Nitrogen nutrition deficiency slows down the growth and development of plants. Nitrogen deficiency symptoms in plants manifest in distinct manner. The plants appear stunted with light green lower leaves, while the upper leaves remain green, with prolonged Nitrogen nutrition deficiency, yellowing (chlorosis) of older or lower leaves occurs. This is followed by leaf tip death and leaf margins developing a brown discoloration (necrosis). In some instances, the leaves fall off. The plant sterns become woody.

Management strategies of Nitrogen

- By applying most of Nitrogen in June month
- To reduce the potential for nitrogen losses due to leaching and dinitrification
- If nitrogen applies prior to planting, consider using a nitrification inhibitor (these products delay the conversion of ammonium to nitrate by 4 to 6 weeks

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20. Toxic Chemical Elements their Sources and Effect on Plant and Human Health

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Introduction

Toxic chemicals (Heavy metals) are natural elements that identify by their rather high atomic mass and high density. Although generally occurring in low concentration, they can be found mostly in the earth's crust. The industrial revaluation and anthropogenic effects have caused more and more hazardous toxic chemical elements releasing to environment. Soil is the basic and most essential part of the ecological system, they are heavily contaminated, too. They are different from other organic pollutants such as

hazardous heavy metals are indestructible, as they can't be chemically or biologically degraded. Even worse, some toxic chemicals can concentrate along the food chain and finally accumulate in the human body due to we are at the top of the food chain that causes various diseases for the human body.

The toxicity of heavy metals contaminants released into the environment every year is now estimated to outrun that from organic and radioactive sources combined. A fair share of these inorganic substances ends up contaminating soils. The greatest problems most likely involve mercury, cadmium, lead, arsenic, nickel, copper, zinc, chromium, molybdenum, manganese, selenium, fluorine and boron. To a greater or lesser degree, all of these elements are toxic to humans and other animals. Cadmium and arsenic are extremely poisonous; mercury, lead, nickel, and fluorine are moderately so; boron, copper, manganese, and zinc are relatively lower in mammalian toxicity.

There are many sources of the inorganic chemical contaminants that can accumulate in soils. The burning of fossil fuels, smelting, and other processing techniques release into the atmosphere tons of these elements, which can be carried for miles and later deposited on the vegetation and soil. Lead, nickel, and boron are gasoline additives that are released into the atmosphere and carried to the soil through rain and snow. Boron as the mineral borax is used in detergents, fertilizers, and forest fire retardants, all of which commonly reach the soil. Superphosphate and limestone, two widely used soil amendments, usually contain small quantities of cadmium, copper, manganese, nickel, and zinc.

Source of Toxic Chemical Elements

There is different source of toxic chemical elements (heavy metals) in the environments. These sources may be both of nature or anthropogenic origin. In this chapter given the different heavy metal source as like magmatic, sedimentary and metamorphic rocks, weathering and soil formation, the rock cycle, the origin of toxic chemicals in the surface and groundwater as well as in the atmosphere and anthropogenic source from human activities such as industrial production and agriculture.

Heavy Metals from Rocks and Soil

Rock and soil are the naturally source of heavy metals in the environment. Magmatic rock means primary or igneous rocks, solidification of molten magma from volcano. Magma contains a various variety of chemical elements. Toxic chemicals are adsorbed as trace elements into the crystal lattice of the primary minerals, which form during the solidification of magma. The trace elements occurring in the common rock forming minerals are given in the in Table 1.

Organic Materials

All type soils present organic material in form of living organisms, humic substance and decomposed organic product. That May be greatly influencing the chemical reaction occurring in soils. Humic acid are yellow to blackish polyelectrolytes of intermediate atomic weight. Humic acid show a various functional group as like carboxy group, phenolic hydroxyl groups, carbonyl, ester and methoxy group.

TABLE 1. The trace elements occurring in the common rock forming minerals

Mineral	Trace Element	Resistant to weathering
Olivine	Ni, Co, Mn, Li, Zn, Cu, Mo	weathers easily
Hornblende	Ni, Co, Mn, Se, Li, V, Zn, Cu, Ga	
Augite	Ni, Co, Mn, Se, Li, V, Zn, Pb, Cu, Ga Rb	
Biotite	Rb, Ba, Ni, Co, Mn, Se, Li, V, Zn, Cu, Ga	
Apatite	Rare earth elements, Pb, Sr	
Anorthite	Sr, Cu, Ga, Mn	
Andesine	Sr, Cu, Ga, Mn	
Oligoclase	Cu, Ga	
Albite	Cu, Ga	
Garnet	Mn, Cr, Ga	intermediate stability
Orthoclase	Rb, Ga, Sr, Cu, Ga	
Muscovite	F, Rb, Ba, Sr, Cu, Ga, V	
Titanite	Rare earth elements, V, Sn	
Ilmenite	Co, Ni, Cr, V	
Magnetite	Zn, Co, Ni, Cr, V	
Turmaline	Li, F, Ga	
Zircon	Hf, U	
Quartz	-	resistant

Heavy metals source from Anthropogenic

Toxic chemicals are released into environment through many human activities. They are mostly used industrial products, which are deposited waste at ground surface for the long term. Toxic chemicals release into the environment occurs at the beginning of the production chain. Parent rocks and metallic minerals are dominated in the natural source, while the anthropogenic sources such as agriculture activities, where fertilizers, compost and manures and pesticides containing toxic chemicals are widely used, and metallurgical activities are mining, smelting, metal finishing etc. toxic chemicals can be released into the environments in form gaseous, aqueous, solid and particulate from both diffuse or point sources.

Agricultural activity

Day to day growing world population, while requiring intensive land use for the production of food, that includes repeated application and heavy input of fertilizers, pesticides and soil amendments.

Phosphatic fertilizers

Phosphatic fertilizers contain large amount of Zn, Cd and other heavy metals looking on from which parent rock the fertilizer has been produced. Those fertilizers made from sedimentary rock to have high concentration of Cd or made from magnetic rock to have low level Cd. The differences in toxic chemical

content are caused by impurities coprecipitated with the phosphates. Therefore, Cd input into cultivated soils varies considerably according to the Cd concentration of the fertilizer used.

Pesticides

Pesticides used for insect or pest and plant diseases control in high-production agriculture and can be used as seed treatment, through spraying, dusting and soil application. Increased accumulation of toxic chemicals by repeated application of Pesticide, especially of Hg from Methyl mercurial, As and Pb from lead arsenate into cultivated soil and ground water.

TABLE 2. Toxic chemical elements their effect on plant and human health

chemical	Major uses and sources of soil contamination	Organisms principally harmed	Human health effects
Arsenic	Pesticides, plant desiccants, animal feed additives, coal and petroleum, mine tailings, detergents, and irrigation water.	Human, animal, fish, birds.	Cumulative poison, cancer, skin lesions
Cadmium	Electroplating, pigments for plastics and paints, plastic stabilizers, batteries, and phosphate fertilizers.	Human, animals, fish, birds, plants.	Heart and kidney disease, bone embrittlement.
Chromium	Stainless steel, chrome-plated metals, color agent, refractory brick manufacture and leather tanning.	Human, animal, fish, birds.	Mutagenic; also essential nutrient.
Copper	Mine tailings, fly ash, fertilizers, windblown, copper-containing dust, and water pipes.	Fish, plants.	Rare; mental problems, fatigue essential nutrient.
Lead	Combustion of oil, gasoline, and coal; iron and steel production; solder in water pipes; paint pigment.	Human, animal, fish, birds.	Brain damage, convulsions.
Mercury	Pesticides, catalysts for synthetic polymers, metallurgy, and thermometers.	Human, animal, fish, birds.	Nerve damage.
Nickel	Combustion of coal, gasoline, and oil; alloy manufacture; electroplating; batteries and mining.	Fish, plants.	Lung cancer.
Selenium	High Se geological formations and irrigation wastewater in which selenium is concentrated.	Human, animal, fish, birds.	Rare; loss of hair, nail deformities; essential nutrient.
Zinc	Galvanized iron and steel, alloys, batteries, brass, rubber manufacture, mining and old tires.	Fish, plants.	Rare; essential nutrient.

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21. Micronutrient Deficiency in Indian Agriculture and its Management

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Introduction

Soil is the most important factor for crop production. Healthy soil is a significant component of productive farming. Green Revolution has increased total food grain production by bringing different types of agrochemicals, high yielding varieties and farm machinery in Indian agriculture. The application of micronutrients was almost neglected during the Green revolution and post-green revolution time. Long-term cultivation of high yielding, nutrient-exhaustive crops steadily depleted the soil nutrient reserve. As a result, multi-nutrient deficiency has been identified in various parts of India (Singh 2008). Nutrient deficient soil leads to poor production. The sustainability of the production system relies on 17 basic nutrients, 8 of which are micronutrients. The basic function of each micronutrient proved to be important for the completion of the crop life cycle. Even though it is needed in less quantities for the overall growth and development of plants, it plays a crucial role in plant metabolism. Deficiency of micronutrient can affect both the quality and quantity of produce. Out of the 8 micronutrients (Fe, Zn,) zinc is perhaps the most widespread deficient micronutrient. In India, 36.5 per cent of soils are under zinc deficiency followed by boron (23.4 per cent), iron (12.8 per cent), manganese (7.1 per cent) and copper by 2.1 per cent (Shukla et al. 2019). Coarse textured soils, low in organic carbon and calcareous soils, are usually deficient in zinc. Eastern India soils are low in boron due to heavy rainfall and high nutrient leaching. Old alluvial and grey brown soils are deficient in iron. It is clear that crops grown in India are subjected to more than one deficiency, either due to soil type or due to inadequate management practices. Micronutrient deficiency is commonly seen in cereals, oilseeds, pulses and vegetable crops. In terms of damage, the

quality of the harvest is more affected than its yield, hence contributing to malnutrition (De Valenca et al. 2017) In order to produce a healthy output, it is therefore important to resolve the deficiency with micronutrient supplementation.

Importance of micronutrient in crop production

Micronutrients are very important since they regulate various biochemical and physiological processes in a crop. Each micronutrient has a specific function that affects plant growth and development.

Important functions of micronutrients in plants

Iron	It is involved in synthesis of chlorophyll Important role in enzymes and RNA mechanism Key element in redox reactions of respiration photosynthesis Reduction of nitrate and sulphate
Manganese	Constituent of enzymes (decarboxylase, kinase and oxidase) Essential for formation of chlorophyll Nitrogen metabolism Translocation of iron
Zinc	Component of various enzymes and enzyme activation Production of growth hormone N and P assimilation Participate in various metabolic reactions
Boron	Regulate hormone levels Transport of carbohydrate Pollen tube germination and elongation Formation of flowers and fruits
Copper	Necessary for enzymatic activities Chlorophyll and seed production Lignin synthesis Ethylene production Important for plant respiration Carbohydrate and protein metabolism disease resistance
Molybdenum	Nitrogen fixation Nitrogen assimilation Nitrogen, oxygen and sulphur cycle
Chlorine	Osmotic and stomatal regulation Oxygen evolution during photosynthesis Disease resistance and tolerance
Nickel	Component of enzymes Urea metabolism in plant

Causes of its deficiency:

Different factors such as soil pH, temperature and moisture, organic matter, presence of $CaCO_3$ and other nutrients influence the availability and absorption of micronutrients. With an increase in soil pH, zinc supply declines. Since 70% of Indian soils are extremely alkaline in nature, zinc deficiency is prevalent in India. Boron deficiency is identified in coarse texture soil prone to intense leaching. In alkaline or calcareous soils, B supply also declines. Depletion of organic matter, increase in soil alkalinity decreases the supply of iron and manganese. Sandy, calcareous and acidic soils are copper deficient. The only nutrient that is highly available in alkaline environments is molybdenum. Other management factors such as the indiscriminate usage of synthetic fertilizers, the lack of organic manure addition, the extremely unbalanced supply of nutrients, intensive cropping, faulty irrigation methods and the ignoring micronutrient application also prolonging the deficiency.

Management

The optimal micronutrient requirements for crop production needs to be established. It would foster nutrient balancing. Basal application or foliar spray of the necessary micronutrients is performed to provide micronutrients to the growing crops. It has been observed that 5-10 kg ha^{-1} of zinc application can give the residual zinc to the next 6 crops without reducing the yield. The deficiency of Zn, Fe and Mn can be corrected by foliar application of its sulphates @ 0.5 percent. In oilseed-based cropping system, soil application of Boron @ 1-2 kg ha^{-1} has achieved a positive result. Chelated salts of micronutrients are also highly effective in treating the deficiency, but they are highly cost-effective. Scientists have suggested that one of the efficient ways to improve crop yields is to supply micronutrients by adding organic manure. Application of FYM @ 10-12 t ha^{-1} can correct zinc and other micronutrient deficiencies. Customized fertilisers containing micronutrients such as zincated urea, boronated super phosphate can also mitigate the deficiency. Agronomic bio-fortification is the new approach to overcome the micronutrient deficit both in the diet of human and soil. It helps in enhancing crop productivity and food nutritional quality.

Conclusions

Healthy soil is the base of Sustainable production. The degradation of nutrient reserves can be managed with balanced nutrient management. Micronutrients play very crucial role in plant functions which is visible in quality of crops obtained with application of micronutrient. To obtain a good yield enriched with nutrients it is necessary to consider the micronutrient application to replenish the soil.

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22. Biofortification: Progress towards Nutrition Enrichment and Health Improvement

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Introduction

An ancient proverb "**A healthy mind is in a healthy body**" holds good for the sound and happier life. But in today's fast life, people are stressed and racing for their daily activities. Hence, one is neglecting nourishment to bodies, and thus underestimating health. Malnutrition and hunger has thus become a major concern to human health due to increasing population, low income, inadequate food supply and heavy dependence on cereal-based diets.

Malnutrition is associated to the cellular imbalance in the body due to failure in taking healthy food containing various nutrients, minerals, vitamins as well as several phytochemicals and deficiency of all this results in **poor growth and development of children, reduced immunity, fatigue, muscles weakness, sterility and death.**

According to WHO, there are about 170 million underweight children globally, of which 3 million die before reaching age of 5 every year as a result of being underweight. As an alternative, Bio-fortification of underrated crops has been recently over-viewed as a new concept in India to improve the nutritional quality of the plants and to alleviate the malnutrition problem.

Biofortification

It is the process of adding nutritional value by genetically increasing the bio-available mineral content of the food crops. It can be recognized as a complementary, nutrient sensitive, rural-targeted agriculture intervention which provides a feasible means of reaching remote regions, including malnourished rural community who may have limited access to commercially marketed fortified foods and supplements, as they face greater risk of micronutrient malnutrition.

Methods of Biofortification: Basically three approaches that may be used to increase the nutrient content of edible crops.

1. **Agronomic Biofortification:** Agronomic efforts like the application of mineral fertilizers, appropriate crop rotations, intercropping, or the introduction of beneficial soil microorganisms to increase the phyto availability of mineral elements could be important tools of agronomical biofortification.

2. Biofortification can be achieved **through conventional plant breeding**, when parental lines with vitamins, antioxidants and micronutrients levels are crossed over several generations to produce plants having desired nutrients and agronomic traits.
3. **Transgenic approaches** using **genetic engineering** when lack of sufficient variation among the genotypes for the desired trait within the species or when the crop itself is not suitable for conventional plant breeding (due to lack of sexuality; *e.g.* banana) then genetic engineering offers a valid alternative for increasing the concentration and bioavailability of micro nutrients in the crop.

For example, one of the first bio-fortified crops was **golden rice**, which was engineered to produce pro-vitamin A as a means of alleviating vitamin A deficiency in the diets.

Importance:

Vegetables are rich source of carbohydrates, proteins, fibers, vitamins and minerals. Neutraceutical can help in overcoming malnutrition in human beings and are important to achieve nutritional security in the country by sustainable and cost effective means. Several neutraceuticals *viz*., glucosinolates, lycopene, folates, allyl propyl disulfide, quercetin and alliin helps in curing of various cancers, diabetes, blood pressure and cholesterol etc. Biofortification is a feasible and cost-effective means of delivering micronutrients to populations that may have limited access to diverse diets and other micronutrient interventions.

1. Biofortification can help in combating nutritional deficiencies in humans.
2. Biofortification through biotechnological applications is a cost-effective and sustainable solution alleviating malnutrition.
3. Improvement of crop quality and enhancement in variability of germplasm.

Biofortification in vegetables

Pioneer research work on developing neutraceutical varieties have been initiated by Indian Council of Agricultural Research (ICAR), New Delhi. In cauliflower, **Pusa Betakesari** the first ever released indigenously bred bio-fortified beta carotene (800-1000µg/100g) rich to tackle beta carotene deficiency related malnutrition problem in India during 2015-16. **Bhu Krishna** is a bio fortified variety of **sweet potato** rich in anthocyanin (90.0 mg/100g) content. An improved nutritionally rich brinjal variety '**Pusa Safed Baigan-1**' has been released in 2018. It is white coloured oval round fruited variety with high total phenol content and high antioxidant activity.

Applications:

- **Iron**- biofortification of rice, beans, sweet potato, cassava and legumes;
- **Zinc**- biofortification of wheat, rice, beans, sweet potato and maize;
- **Pro vitamin A carotenoid**- biofortification of rice, sweet potato, maize and cassava;

To reach one billion people by 2030, there are three key challenges:

- Mainstreaming biofortified traits into public plant breeding programs;
- building consumer demand; and
- Integrating biofortification into public and private policies, programs, and investments.

Conclusion

Hunger and malnutrition are major issues which need attention on priority. Neutraceutical biofortified vegetables are having potential to handle these issues. Development, production and consumption of such vegetables need to be popularized for preventing and controlling various health issues. Restrenthening the augmentation, collection and evaluation of germplasm, development of hybrids, to induce mutants with higher nutritional values, exploitation of molecular biology and cellular genetics, close interaction between nutritionists and breeders to increase awareness, strengthening research on indigenous vegetables are the necessary steps to enhance biofortification of neutraceuticals in vegetable crops.

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23. Trunk Injection: An Effective Way to Correct Iron Deficiency in Tree Crops

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INTRODUCTION

Iron (Fe) is an essential micronutrient element for healthy plant growth and development because it is necessary for the formation of chlorophyll, which is responsible for the green color in plants and necessary for photosynthesis (sugar production in plants). Any reduction in chlorophyll during the growth period will reduce the crop growth, vigor, and stress tolerance conditions. Plants may have iron deficiency symptoms from soil due to lacking of this element in sufficient quantity. Sometimes, the soil may be rich in iron content, but plants show Fe deficiency because they cannot use this iron due to improper pH or poor drainage condition. Plants cane taken up the iron, only if it is present in soluble form, so that that the plant roots can easily take up this element. In most of the cases, if the soil pH is above 6.5, soluble form of iron may be converted into an insoluble form (Fe^{2+} to Fe^{3+}), which makes it unavailable to plants and causing Fe deficiency. If the soil is more acidic, more amount of soluble form of iron is produced which leads to toxicity of Iron (Fe^{2+}). Generally, the higher pH value ties up with iron and other micronutrients to making them as an unavailable form except molybdenum. Most of the tree crops prefer a pH range of 5 to 7. Changing the soil pH to be more acidic will solve the problem.

IRON DEFICIENCY

Iron is very immobile element in plants, so the deficiency symptoms appear in young leaves, causing stunted growth of the plant *i.e.* leaves may be smaller than normal size. Leaves may eventually curl, dry up

and fall down. Fruits may be small with a bitter taste. Mildly affected plants become unsightly and grow poorly. In severe cases individual limbs or the entire plant may die. It is common for iron chlorosis to show on a single branch or on one side of a tree. This is particularly common for plant species with marginal winter hardiness following winter injury. Chlorosis usually develops as an overall yellowing of needles on junipers, pines, and other evergreens.

Affected leaves turn a yellowish color while the leaf veins remain a dark green. Iron chlorosis is caused by the plant not being able to obtain the iron when it needs. Iron is needed for the production of chlorophyll. Therefore, a lack of iron results in a loss of the green color in the leaves. In severe cases, leaf color may change from yellowish to white and finally brown colour. If the deficiency not corrected in this stage, which leads to twigs and eventually branches may die leading to the death of the tree. Symptoms may appear over the entire tree, on one side only, or be limited to individual branches depending upon the iron concentration.

Iron chlorosis refers to a yellowing caused by an iron deficiency in the leaf tissues. The primary symptoms of iron deficiency includes interveinal chlorosis, *i.e.*, a general yellowing of leaves with veins remaining green colour. In severe cases, leaves may become pale yellow or whitish, but veins retain a greenish cast. Angular shaped brown spots may develop between veins and leaf margins may scorch (brown along the edge). To correct iron deficiency, application of iron sulfate, chelated iron and other micronutrients in combination with elemental sulfur as soil application, foliar spray as iron compounds or chelated iron and trunk injection in case of woody tree crops is recommended.

TRUNK INJECTION OR IMPLANTATION

Trunk injection is a new innovative methodology of applying iron or manganese-containing compounds to chlorotic trees. By adopting this method, recovery is often quick and treatments are effective for two or three years in woody tree crops. Trunk injections should be made by a commercial arborist is the safest and best way to correct iron deficiency. Iron compounds in dry or liquid form which is placed directly into holes drilled into lower tree trunk. Systems also are available that use plastic tubing and tees, capsules of various types, or a hypodermic-like tool to place iron materials into the tree. Though these techniques can be quite effective, they injure the tree's trunk and should be used with care. Minimize injury by using methods and formulations that require small holes (some systems use holes as small as 1/8 inch diameter) and avoid any treatment that would require injecting a tree more than once every few years.

Commercial trunk injection formulations are readily available as liquids or powders and should be used according to directions to get better result. The formulation should contain ferric ammonium citrate (iron citrate) or ferrous sulfate. Holes should be made with a sharp brad-point bit to ensure quick uptake iron and to reduce injury. Particular attention has to be made for manufacturer recommendations on hole placement, angle, depth, and diameter. Studies have shown that uptake is better and more evenly distributed if holes are drilled near the soil surface on the outside of root flares.

Injection treatments generally are most effective if applied in the early spring during bud break, but follow label directions for particular products. Effects can be expected to last for two or more years, after which retreatment probably will be necessary. Avoid injecting materials on hot, dry, windy days since leaves may blacken or burn, though such damage is usually temporary and not serious. Make sure the tree

is well-watered for several days before and several weeks after injection treatments.

Injection of Fe salts mainly **Ferric ammonium citrate** (iron citrate) and **ferrous sulphate** as 1-2% in liquid form into xylem vessels has been reported to alleviate Fe chlorosis symptoms in several woody plants like apple, pear, peach, kiwifruit, olive. Chelated iron compounds can be also used for trunk injection as effective treatments for iron chlorosis in trees.

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24. Biochar: Effect on Soil for Sustainable Agriculture

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Biochar is used as a soil conditioner for both carbon sequestration and soil health benefits. Biochar is a solid, carbon-rich stable, resident for thousands of years in the soil. Biochar is created from biomass through pyrolysis, like most of charcoal. It is being studied as a viable carbon sequestration mechanism because this has a high capacity to mitigate climate change and global warming. The term "biochar" is derived from the Greek word of bios, life and char as it is a resultant output of biomass carbonization, known as charcoal in the early 20th century. For use in sustained crop production, biochar is a promising soil additive and is denoted as a "soil conditioner". However, there are major issues in successfully implementing biochar technologies on various agricultural soils due to the high heterogeneity of biochar properties and variations in the complex soil system. For the successful restoration of soil, the configuration of biochar, in particular with regards to the structure of soils and crop composition problems is crucial. The application of Biochar in soils is seen as a means by which carbon (C) is sequestered and soil functions are simultaneously improved. In the absence of oxygen, it consists of the direct thermal rupture of biomass, which prevents combustion thus producing a mixture of solids with a blend of fluids *i.e.* biological oil and a combination of syngas. The pyrolysis specific output depends on various processing conditions like temperature (400–500, 700 °C), retention time and pyrolysis temperature. The physical and chemical properties of biochars are based on varieties of feedstock, surface heterogeneity and technology by suitable modifications to make use of biochars in industrial and environmental industries. The suitability of each feedstock for application depend on variable chemical, physical, environmental and economically logistic considerations that is based on many different materials being suggested as biomass feedstock that includes wood, agricultural residues and manures. Science indicates that carbon parts in biochar are highly recalcitrant throughout soil, whereas wood biochar has been declared having a residence time of between 100 and 1000 years, or roughly 10 to 100 times more soil organic matter (SOM). Therefore, it can be a potential sink for C resulting through biochar addition in soil. There are various uses of Biochar of which are as following:

1. **Soil Amendment:** Having a wide range of soil health benefits Biochar is considered as a water and water-soluble nutrient retainer having a very porous nature. For several beneficial soil micro-organisms, biochar is best suited as a habitat. Biochar becomes a very excellent soil modificator that supports soils and promotes plant health when exposed with multi beneficial organisms. Plants that have high potash requirement this can increase its substantial yield as it works well in soils that are poor or degraded. Biochar improves quality of water, reducing greenhouse and soil emissions, reduces nutrient loss, reducing soil acidity, irrigation and high fertilizer demands.
2. **Carbon Sink:** In the terrestrial ecosystem (soil) over the century's biochar has provided a steady way to store carbon that could reduce the increasing greenhouse gases, principally carbon dioxide and methane. At the same time this being present on earth; increases the quality of water, fertility status of soils and crop productivity. For decades or centuries, biochar can sequester C in the soil. Through the use of biochar in a sustainable manner use can cause reduction in the global greenhouse gases particularly carbon dioxide, methane and nitrous oxide up to 1.8 Pg Yr^{-1}.
3. **Water Retention:** Biochar being a water loving *i.e.* Hygroscopic is a beneficial soil material in many places because it is capable of attracting and retaining water due to its porous design and highly specific surface area. Having such a nature plants get benefit from various nutrients like phosphate and agrochemicals thus plants are healthier and fertilizer leaching is less.
4. **Fodder:** The utilization of biochar as stock fodder mixed with molasses is relished by herbivorous animals lie cattle, goats. Biochar assists in digestion and reduction in the production of methane.
5. **Slash and Char:** Slash and burn reformation to slash and char can help decrease deforestation and CO_2 fluxes and increase crop yield. Only 3 percent of the organic carbon in the soil is a result of Slash-and-burn. Slash and char can maintain extremely reliable levels up to 50 percent of carbon.
6. **Energy Generation:** Biochar can be used to conduct and generate energy instead of using it as a soil amendment or any other application

which uses coal may be directly replaced by it. Pyrolysis may even be the most economical way to generate electricity from the usage of bio-materials. Bio-oil and syngas can be used efficiently through pyrolysis modifications as it generates power.

With the use of Biochar it is an intrinsic approach for sustainable Agriculture due to its various impacts on the soil and productivity of crops for the need for human being on this planet. Biochar has great potential to mitigate global climate change by reducing greenhouse gases of which the main contributor in CO_2 thus the approach of C sequestration by Biochar has considerable impact influencing not just the C fractions in soils but also alters microbial population functioning.

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25. Importance of Vermicompost for Soil Health

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The earthworm is an important soil organism in development and maintenance of the nutrient value of the soil by converting biodegradable material and organic waste into nutrient-rich vermicompost. They are also known as ecological engineers. Earthworms have capacity of consumption of huge range of unstable organic matter such as animal waste, industrial waste, sewage sludge, etc.

Vermicompost has been coming up as innovative technique for converting the various types of wastes products into very valuable form as vermicompost. Vermicompost is hummus-like, finely granulated, and stabilized material, which can be used as a soil conditioner to reintegrate the organic matter into the agricultural soils. Earthworms are usually considered as farmer's friends and nature ploughmen. Earthworms are essential in soil formation, mainly by their activity in using up organic matter, fragmenting, and mixing it thoroughly with mineral particles to form stable aggregates. During their feeding, earthworms significantly promote microbial activity, accelerating the breakdown of organic matter and stabilizing soil aggregates. Some earthworms' ability of consumption of a wide range of organic residues such as sewage sludge, wastes of animal, crop residues, and industrial waste has been fully established. In the process of feeding, earthworm fragments the waste substrate, enhance microscopic activity and the rates of decomposition of the material, leading to a composting or humification effect by which the unsteady organic matter is oxidized and stabilized. The end product commonly referred as vermicompost is the organic wastes that pass through the earthworm gut, is quite different from the parent waste material.

Vermicomposting is a simple biotechnological process of composting, in which some species of earthworms are used for enrichment of waste transformation and produce a superior end product. Vermicomposting contrasts from composting in many ways. It is a mesophilic process earthworms and microbes that are functioning are active at 10–35°C. The process is faster in comparison to normal composting as the material passes through the earthworm gut, and leading to significant transformation taking place, whereby the resulting earthworm castings (worm manure) are rich in microbial activity and plant growth regulators and enriched with pest repellence attributes as well, earthworms leading to living transformation have potential of transforming waste into 'gold.'

Organic waste ⇒ Earthworms ⇒ Processing ⇒ Vermicompost

Vermicompost is finely divided peat-like materials which is highly porous, aerating, improving drainage, and capacity to hold water. They possess high surface area, providing strong absorption capacity

and nutrient retention. Nutrients in vermicompost are in the forms that are easily taken up by plants such as nitrates, exchangeable phosphorus, soluble potassium, calcium, and magnesium. Decomposition of various organic substrates (kitchen waste, agro-residues, institutional and industrial wastes including textile industry sludge and fibres) into valuable vermicompost has been extensively studied using an exotic earthworm species *Megascolex Mauritii, Eisenia Fetida, Eudrilu Eugeniae, Perionnyx Excavatus, Lampito Mauritii, Eisenia Andrei, Lampito Rubellus and Drawida Willis.*

Nutrient Composition in Vermicompost

Nutrient content in vermicompost is dependent on raw material means it is dependent on the input used for the preparation of vermicompost. So, its range varies from place to place and component to component.

Nutrient	Content
Organic carbon	20-25%
Nitrogen	1.5-2.0%
Phosphorous	0.5-1.5%
Potassium	0.5-1.5%
Calcium	0.4-0.8%
Magnesium	0.3-0.6%
Sulphur	100-500 ppm
Iron	6.7-9.3 ppm
Copper	2.0-9.5 ppm
Zinc	5.7-11.5 ppm

Source: https://www.greenvisionecoorganics.com/pages/what-is-vermicompost

Advantages of Vermicompost on the Physio-chemical and Biological Properties of Soil

The consequences of a few long-term studies indicate that the inclusion of manure improves soil physical properties by diminishing bulk density and improving the soil water holding limit. As compared to mineral fertilizers, compost creates much better increments in soil natural carbon and some plant nutrients. The utilization of organic means of improvements, for example, traditional thermophilic compost has been perceived commonly as a successful method for improving soil aggregation, structure and fertilizer status, improving microbial diversity and number, improving the water holding limit of soils, expanding the cation exchange capacity (CEC) and improving crop yields.

Vermicompost contains most of the nutrients in plant-accessible forms, for example, nitrates, phosphates, and exchangeable calcium and soluble potassium. Vermicompost has been appeared to have elevated levels of the total and available nitrogen, phosphorous, potassium (NPK) and micronutrients, microbial activity. Sufficient use of vermicompost with appropriate management can build soil organic carbon, retention of soil water and physical properties of soil like bulk density, and aggregation along with gainful impact on plant growth. Application of compost is known to improve stable soil structure, population of bacteria and fungus along with biological activity. The more prominent pore volume in worm casting and compost altered soils have been appeared to expand the accessibility of both water and supplements to microorganisms in soils. Along with the improvement in physical and chemical properties, treated soil materials clearly affect soil biological properties, for example, increments in microbial biomass and increase in enzymatic activity in soil. In the arid and semiarid area in additions to local factors in precipitation, soil surface condition such as soil characteristics, plant cover and topography are the essential elements in the produced runoff. In these areas, residual moisture in the soil has a significant role in conjunction with runoff. One of the most important advantages of vermicompost is buffering that prevents from phocilation during plant element adsorption. Water and soil analysts did a great deal of studies on the impacts of vermicompost on various features of soil. They inferred that vermicompost by making soil structure light improves bulk density, stability of aggregates and soil structure thus leading to improved water conductivity and aeration.

Conclusion

The macronutrients and micronutrients are generally available in higher quantity in vermicompost as compared to the traditional compost and inorganic fertilizer, establishing that vermicompost is a better supplement to improve and stimulate plant growth. Thus, vermicompost has massive potential for use on agricultural crops. In the near future, vermicompost should be mostly and extensively applied to agricultural land to replace or, alternatively, combine with inorganic fertilizers. Vermicompost is shown to improve soil fertility in terms of the physical and chemical properties of the soil. Physical improvements include better aeration, porosity and bulk density of the soil. Chemical properties such as pH, electrical conductivity and organic carbon content are also enhanced for better plant growth and also improved the microbial population.

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26. Zinc Biofortification: A Systematic Way to Enhanced Zinc Content in Food

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Micronutrients however required in exceptionally limited quantities, are required for legitimate development and improvement of the human body. Micronutrient inadequacies called as 'Hidden Hunger' influences the wellbeing, learning capacity just as profitability attributable to high paces of sickness and incapacity adding to endless loop of unhealthiness, underdevelopment and destitution. It is assessed that around two billion individuals on the planet are lacking in at least one micronutrient. Micronutrient insufficiencies, (for example, iodine, iron and nutrient inadequacy) not just influence the wellbeing. Zinc (Zn) is one of the most bountiful minor components in human bodies, with 1.5–2.5 g present in the normal grown-up. As a reactant and a significant auxiliary segment in an expected 3000 zinc proteins, Zn is fundamental for sugar digestion, DNA and RNA formation, and different cycles. Zinc insufficiency, be that as it may, is predominant in numerous pieces of the world and particularly in creating nations. Accessible writing on zinc levels has demonstrated high predominance of zinc insufficiency among children of 6-60 months (43.8%), teenagers (49.4%) and pregnant ladies (64.6%). Biofortification is the process by which the healthful nature of food crops is improved through agronomic practices, traditional plant rearing, or current biotechnology (Fig:1). Biofortification contrasts from conventional fortification in that biofortification expects to build supplement levels in crops during plant development instead of through manual methods during preparing of the harvests. Biofortification may accordingly be introduce as an approach to arrive population where supplementation and regular fortification exercises might be hard to execute.

Figure 1. Different techniques of biofortification

Micronutrient Availability into the Soil

The elements and transformation of micronutrients (Zn, Cu, Fe, Mn, B and Mo) in soils, are represented by different variables like pH, EC, soil natural issue and so forth. Micronutrient accessibility in soils is profoundly connected with the kind of parent materials and condition where soils are created. On a worldwide scale, soils in moist places are acidic in nature and generally high in accessibility of Fe, Mn, and Zn, while soils in arid areas are alkaline in nature and B accessibility is moderately high. The accessibility of Cu and Mo in soils appear to be more connected with soil organic matter content. As per certain soil conditions and plant micronutrient necessity levels, we may attempt to control micronutrient accessibility in soils by considering certain methodologies portrayed in this section. It is difficult to completely foresee the conduct of micronutrients in soils. However, the utilization of micronutrient-containing fertilizer, both chemical and organic, is the principal choice. In spite of the fact that it isn't adoptable for all area and yield types, water management is likewise a practical way to deal with control soil micronutrient accessibility, particularly for Fe, Mn, Zn, and Cu.

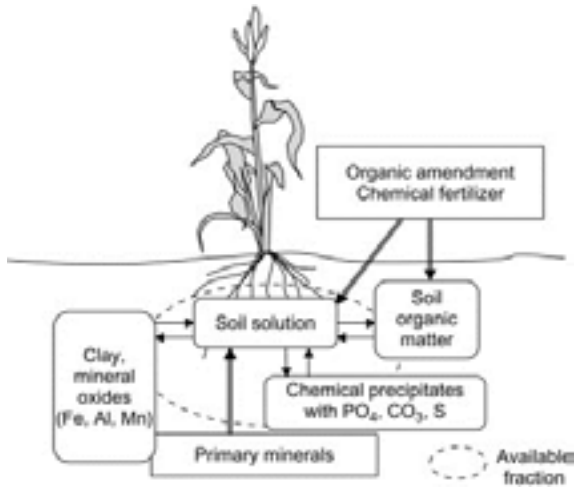


FIG:2 Source of micronutrient into the soil

Role of Zinc

In Plant

Zinc, one of the fundamental micronutrients and a significant constituent of a few chemicals and

proteins, is just required by plants in little amounts. It is one of the important to plant advancement, as it has a significant influence on a number of cycles occurring in plants. The ordinary range for zinc in plant tissue is 15-60 ppm and in the developing medium between 0.10-2.0 ppm. Zinc is a synergist and auxiliary protein cofactor in many catalysts and has important role in the protein interaction. Zinc plays a significant role capacity in the plant reaction to pest and diseases. The multifunctionality of Zn in all living creatures gives this component key functions in basal metabolic activity.

In Human Body

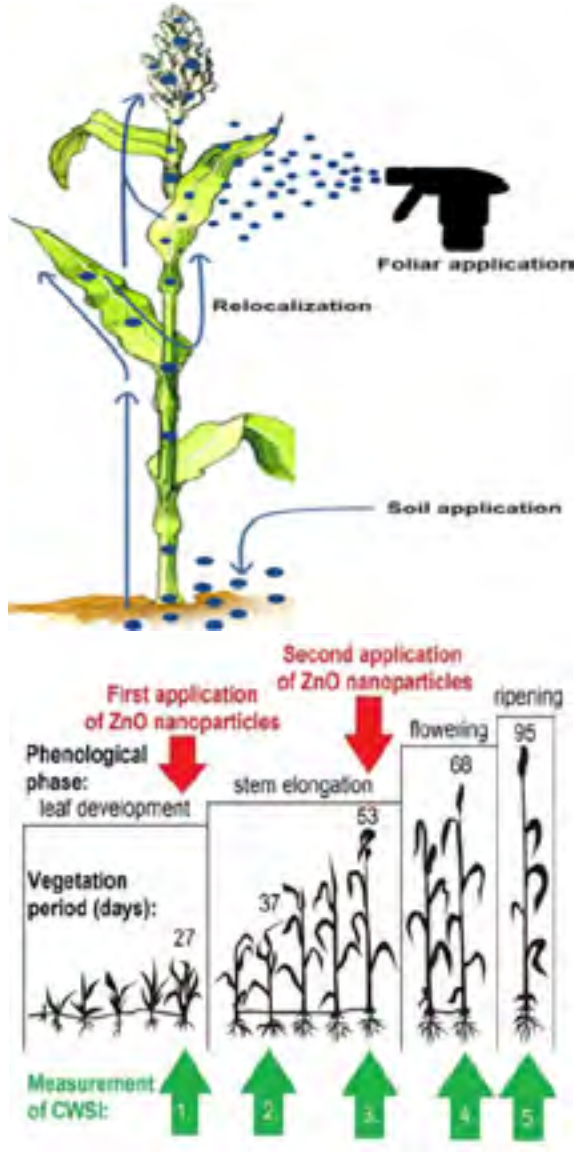
Zinc is a basic micronutrient for human wellbeing. Disregarding the demonstrated advantages of sufficient zinc nutrition, roughly 2 billion individuals actually stay in danger of zinc insufficiency. Zinc is found as a component in excess of about 300 catalysts and hormones and has a vital impact in the soundness of our skin, teeth, bones, hair, nails, muscles, nerves and cerebrum work just as it is basic for development. Zinc controls the compounds that work and reestablish the cells in our bodies. Various zinc metalloenzymes are involved in synthesis of DNA and RNA.

Way to Agronomic Biofortification of Zinc

Water-soluble fertilizers containing zinc is found to prevent its deficiency when applied at sufficient quantity. Single component fertilizers, for example, zinc sulfate, zinc ammonium nitrate or chelated zinc can be applied; but it is smarter to use a total micronutrient fertilizer to ensure that inadequacies of different micronutrients do not occur. Agronomic biofortification by means of Zn preparation, particularly by foliar Zn application, is believed to be the most valuable, practical, and appropriate answer for accomplishing Zn biofortification in wheat. With foliar application, Zn is consumed by the leaf epidermis and effectively moved to the developing grain through the phloem. So, foliar utilization of Zn is more compelling in increasing grain concentration of Zn than soil application (Fig:1a). To abstain from burning of leaves and environmental pollution, Zn must be applied to leaves at low portions, normally as $ZnSO_4$ at the rate of 1–2 kg ha−1 with solute concentration of 0.3%–0.5%. Just a little segment (<6%) of applied Zn is taken up by the plant. So, optimization of foliar applied zinc use efficiency and accomplishing sufficient content of Zn in grain Zn while causing no harm to plant and environment stays a challenging task. It has also been indicated that the foliar use of inorganic nano-materials on grain plants during their development cycle upgrades the pace of productivity due to sufficient supplementation.

Zinc Solubilizing Microorganism

Soil borne plant growth promoting rhizobacteria (PGPR) colonize the rhizosphere and multiply in number and compete with other bacteria to promote plant growth. Plant growth is promoted by PGPR either by solubilizing the micronutrients or by release of phytohormones or protect plant from various pathogens. Different PGPR have discovered to be successful zinc solubilizers.



(a) (b)

FIG. a) Agronomic biofortification is the application of micronutrient-containing mineral fertilizer; b) Foliar spray application of zinc oxide nanoparticle concentration at different crop phenological phases.

These microscopic organisms improve the plant development and advancement by colonizing the rhizosphere and by solubilizing complex zinc mixes into simpler ones, in this manner making zinc accessible to the plants at different phenological phases (Fig:1b). Zinc solubilizing microorganisms solubilize zinc through different ways, one among them is acidification. These microorganisms produce natural acids in soil which sequester the zinc cations and reduce the pH of the soil. Additionally, the anions can likewise chelate zinc and upgrade zinc dissolution. Different PGPR have indicated

improved development and zinc content in plants. These incorporate Pseudomonas, Rhizobium strain, Bacillus sp. and Azospirillum.

SEED SCIENCE AND TECHNOLOGY

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27. Bridging the Gaps in Seed Supply Chain Management

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Active seed supply system is important to make excessive quality seed accessible to farmers at the opportune time and at minimum price. This requires seed demand and supply to be adjusted by method of a protected seed supply structure. This would give farmers access to sufficient amounts of good quality seed of the ideal kind at the required time and at reasonable price.

Tamil Nadu has an enormous institutional system for seed production in both open and private segment. Strength of public sector in seed supply is important to monitor the interest of the marginal and resource poor farmers who can get to the significant seeds at moderate cost. Tamil Nadu Agricultural University has a fine history of reproducing high yielding varieties and hybrids over the crop series, and furthermore has well system framework to help and encourage the seed production program of the State by providing required amount of breeder seeds, which shapes the first generation of the 'Seed Multiplication Chain'.

The need of great importance is to recognize the lacuna and attract up procedures to tap the prosperous assets and overcome any issues between seed demand and supply. Consequently the analysis of supply chain management explains the specialized details identified with the seed production and distribution, other than giving a solid setting on 'Seed Replacement Rate, Seed Multiplication Models, Seed Supply Mechanisms, Seed Quality Control System and so on., will give the necessary lucidity on the significance of seed multiplication, seed distribution and seed replacement to all concerned in seed planning, production and distribution.

Seed programme and seed supply systems

According to the seed supply system in Tamil Nadu, Breeder seeds for the public bred varieties are delivered by the Tamil Nadu Agricultural University against the indents got from the State Department of Agriculture and Private seed organizations. State Department of Agriculture and Private seed organizations increase the breeder seeds further into foundation and certified seeds. The investigations of information on breeder seed provided by the Tamil Nadu Agricultural University and certified seed produced by the Department of Agriculture and private segment exposed that expected level of certified seed production has not been accomplished in a large portion of the crops. This illuminates the way that the suggested 'Generations of Seed Multiplication' has not been followed sensibly, bringing about lower certified seed production with extreme negative effect on the Seed Replacement Rate.

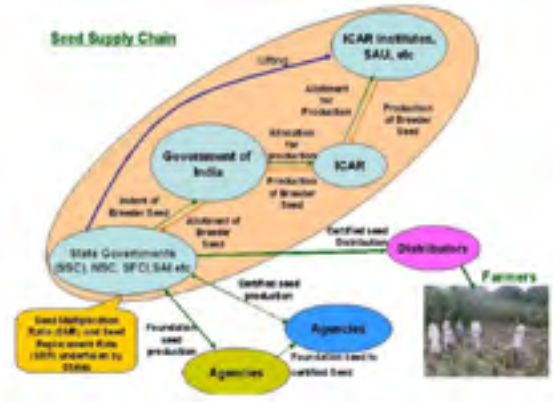

FIGURE 1: Seed supply chain

FIGURE 2: Entry to exit ways of seed chain in rolling plan

At present, the seed multiplication program is taken care of by the Department of Agriculture and Department of Horticulture (by using the Oilseeds Farms, State Seed Farms and State Horticultural Farms) other than private sector. Since the supply of seeds should be improved in crops like groundnut, millets, sesame, pulses and so on., there is a lot of scope to improvise the current seed supply system. Presently it has been recognized that the onus for improving the agricultural production of the state lies in figuring procedures to follow the Generation System of Seed Multiplication' thoroughly with no missing connection so certified seed production is accomplished up to the standard level. Consultations have been made on Structure of Seed Industry, Seed Quality Control System and Seed Legislations, Seed Multiplication Models, Seed Supply System, Seed Replacement Rate, Seed Demand and Supply in the state and Needed Policy Interventions and powerful supply chain dynamics.

For any successful quality seed program, it is obligatory to deliver adequate amount of source seed with suitable examination reinforcement on different parts of seed technology viz., research on production, quality maintenance, quality confirmation, seed handling and processing, seed storage, seed protection, seed quality improvement and so on., In an offer to fortify seed research in frontline areas and to encourage guidance and coordination of platform (basic seed) for generation system of seed multiplication through the seed division, involvement was incredible which has prompted see change and seen by increment from a meager breeder seed production of 3914 quintals during 1981-82 to a near of 94987.61 quintals during 2012-13, despite the fact that slight deficiency in few crops was seen because of atmosphere notions in alluded year. The ICAR-SAU framework additionally keeps on encouraging upgraded accessibility of breeder seed and different classes of seeds that comprises the foundation of value seed accessibility of notified varieties and parental lines of hybrids, which is consecutively increased to produce foundation and certified / quality seeds (Annual report, DSR, Mau, 2014).

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28. Role of Late Embryogenesis Abundant (LEA) Proteins in Seeds

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Introduction

Seeds can be considered as desiccation tolerance based on availability of moisture content in seeds. Due to environmentally prevailing stress conditions like salinity, cold stress and drought stress, results in dehydration of cells. Desiccation tolerance is the ability to survive under conditions of dehydration and can perform its normal functions. Seeds can be classified as orthodox, recalcitrant and intermediate based on their tolerance to desiccation. Orthodox seeds are more desiccation tolerant due to presence of late embryogenesis abundant (LEA) proteins. These LEA proteins are found during the seed developmental stages and decreases during later stages. Their expression can be found during stress conditions.

Late embryogenesis abundant (LEA) proteins

LEA proteins were first found in seeds and they are located in nucleus, mitochondria, cytoplasm and amyloplasts. They are moved to other cell organelles after the production, where they involve in regulation of essential functions of cells like respiration. The expression of LEA proteins can be affected by stress conditions and abscisic acid. They play a major role in survival of seeds in dry conditions and mechanism involved in cryoprotection. Among the different groups of LEA proteins, dehydrins forms the major proteins which are involved in seed longevity. Orthodox seeds are more resistant to desiccation than recalcitrant seeds. In recalcitrant seeds, production of LEA proteins can be induced by ABA treatments which acquire desiccation tolerance.

The LEA proteins mostly falls under the category of hydrophilins. Hydrophilins are a group of protein possess higher amino acid, serine, glycine, threonine, etc. But in most of the cases, they do not contain cysteine and tryotophane. In some cases, LEA proteins are also found in meristematic regions and vascular tissues. They are accumulated in pollen grains and dormant seed embryos and play their role in desiccation tolerance and prevents dehydration of cells. LEA proteins can be classified into seven groups based on hydrophilic and hydrophobic characters.

Seed development, desiccation and storage

LEA proteins are mainly associated with desiccation tolerance during seed maturation and also conditions of osmotic stress. LEA proteins are the hydrophilic proteins which accumulates especially during later stages of seed maturity and water stress conditions. At this time, embryo acquires desiccation tolerance. Acquisition of desiccation tolerance can be analysed by quantity of LEA proteins present in seeds, leakage of electrolyte and rate of seed germination. During the seed maturity stages and dry state of the seed, mRNA of LEA genes can be found predominant. The mRNA

of LEA genes gets decreased after the imbibition process. In desiccation tolerant seeds, polar groups of LEA proteins involve in hydration by replacing water within the cells. Presence of LEA proteins is more predominant in orthodox seeds than recalcitrant seeds. Treatment of ABA to the seeds was found to induce expression of LEA in desiccation sensitive and tolerant types.

The glass matrix is formed during seed storage enables stability of cell during dehydration. The glass state formation depends on carbohydrates, composition of cytosol, temperature, moisture content, etc. LEA proteins and oligosaccharides involve in glass matrix in seeds. Intracellular glass formation protects from membrane fusion and changes in protein structure. There also exists a correlation in life span of cells that significantly affects the seed longevity. The glassy state occurrence was found in orthodox seeds that are important in extending the storage life of seeds. LEA proteins are also involved in free radical scavenging and stabilize membrane structures. Analysis of cellular level reveals that LEA proteins are found in cytoplasm and nucleus.

Genetic expression

LEA genes are usually expressed during later stages of embryo maturity during seed development. The expression of genes for LEA proteins also known to improve tolerance conditions in transgenic plants. The group 1 *LEA* genes found in most plant species and their induction occurs with increase in abscisic levels in embryo. They are expressed during late developmental stage and early germination stages. The expression of gene in barley *HVA1* found to increase drought tolerance in rice and wheat. Expression of CuCOR19 gene in citrus encodes the LEA protein to induce cold tolerance in tobacco. Expression of wheat gene *WCOR410* increase freezing tolerance in strawberry. The *RAB18* gene expression was found to be increased under drought stress rather than salinity and cold stress. There are also reports that LEA gene expressions was higher in seeds compared to other plant tissues. A novel dehydrin Y2K was found in seeds of *Vigna radiata* induced by treatment with ABA and abiotic stress conditions. In Arabidopsis, 51 genes encoding LEA proteins were identified which respond to cold stress, drought stress and abscisic acid. Expression of CsLEA gene plays an important role in acquisition of seed desiccation, seed development and responses to abiotic stress. This also helps to prolong the storability of the recalcitrant tea seeds.

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29. Antioxidant Enzyme Activities in Seed during Seed Ageing

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Antioxidants

Antioxidants are the substances that are present in plants or in seeds at lower concentration compared to that of oxidizable substrates. These substances significantly delay or prevent oxidation of substrates. As the name indicates, antioxidant is a molecule capable of preventing the oxidation of other molecules. Oxidation is a chemical reaction in which oxidizing agent removes electrons or hydrogen from a substance. Oxidation reactions can result in generation of free radicals. These radicals can further start the chain reactions. An antioxidant defence system is different from species to species. The presence of antioxidant defence system is known to be universal.

Enzymatic and non-enzymatic antioxidants

Antioxidants can be either enzymatic or non-enzymatic in nature. Enzymatic antioxidants function by breaking down and removing free radicals, whereas non-enzymatic antioxidants function by disrupting free radical chain reactions. It fulfills the electron requirements of free radicals that are fiercely searching for their missing electrons, without becoming free radicals themselves. Tocopherol, phenols, carotenoids, ascorbic acid and thiols are examples of non-enzymatic antioxidants, whereas catalase (CAT), ascorbate peroxidase (APX), superoxide dismutase (SOD), peroxidase (POD) glutathione reductase (GR), dehydroascorbate reductase (DHAR) and monodehydroascorbate reductase (MDAR) are the major enzymatic antioxidants.

Types of antioxidants

Antioxidants are classified into three categories.

1. **Primary antioxidants**: Primary antioxidants function by preventing the formation of oxidants.
2. **Secondary antioxidants**: Secondary antioxidants are involved in scavenging of reactive oxygen species (ROS).
3. **Tertiary antioxidants**: Tertiary antioxidants work by repairing the oxidized molecules through sources like dietary or consecutive antioxidants.

Mode of action of antioxidants

Mode of action of antioxidants can be understood in two ways:

1. **Primary or chain breaking antioxidants**: This type of antioxidants works by breaking the chain reaction and resulting radical is less reactive.
2. **Secondary or Preventive antioxidants**: They may function either by, chelators/deactivate metals, scavenge singlet oxygen (highly toxic) and remove reactive oxygen species (ROS).
3. **Reactive oxygen species (ROS)**

When seeds are exposed to various environmental stresses, it results in change in their moisture content during different stages of development, maturation, desiccation, germination, storage and ageing. Consequently, the photosynthetic electron transport and mitochondrial respiratory chain within its cells get disturbed which may result in free radical toxicity by increased production of reactive oxygen species (ROS). The accumulation of reactive oxygen species (ROS) leads to disturbances in normal physiological processes and leads to damage of biomolecules, cells and tissues. Enzymatic antioxidants function as detoxifying mechanism which stops the degradative radicals produced during stress thus preventing the damage or deterioration of seed.

Ageing and enzyme activity

All enzyme activity is positively correlated with germination of seed because as ageing progressed germination also decreased and enzyme activity also decreased which showed significant deterioration in both in natural aged and accelerated seed lot. Seed quality is considerably deteriorated when stored for long time because of ageing especially in the humid tropical regions. Demirkaya et al. (2010) observed that the activities of catalase (CAT) and super oxide dismutase (SOD) decreased due to seed ageing in each cultivar of onion. The decreases recorded in CAT and SOD activities were more obvious when seed viability decreased below a 60% level. Moreover, a high level of correlation between the loss of seed viability and the decreases in CAT and SOD activities were reported in the seeds. According to Blackman and Leopold (1993) model, ageing overlaps with protein denaturation and degradation, enzyme inactivation, breakdown of phospholipids and depository lipids, lipid peroxidation and alteration of membrane permeability. Bailly et al. (1996) observed that a decrease in antioxidant enzyme activity is connected with increased lipid peroxidation and accelerated ageing. Goel and Sheoran (2003) noted the decrease in peroxidase, catalase, ascorbate peroxidase, glutathione reductase and superoxide dismutase enzyme activity as the ageing progressed in cotton seed.

Conclusion

Most of these studies reveal that antioxidant enzyme activities such as superoxide dismutase, catalase, peroxidase and glutathione reductase get decreased in aged seeds. The general decrease which occurs in enzyme activity in the seed results in lower respiratory capacity, which in turn reduces both the energy (ATP) and assimilates supply of the germinating seed. Therefore, several changes in the enzyme macromolecular structure may lead to their lowered germination efficiency.

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30. Innovative Advancement and Strategies for Increasing Seed Production in Fodder Crops

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India is an agrarian nation where 65 percent of the populace relies upon farming as a wellspring of employment. India holds 13 percent of world steers populace. Despite the fact that India is first situation in milk creation, the profitability is far low (1538 kg/ year) than world normal (2238 kg/year). One of the principle explanations behind low profitability is non accessibility of value feed and grain. At present the nation is confronting serious (36 %) shortage in green grub. The region under grain crops is 8.34 million hectares and it covers 4 percent of absolute edited region which stayed static over decades because of firm rivalry from food crops.

Seed is the primary input for successful spread of plant species over generations. Based on an estimate, only 25-30 per cent of required quantity of quality seed is available in cultivated fodders and 20 per cent and 15 per cent in range grasses and legumes in India (Anon., 2011). Seed creation in feed crops is troublesome especially of range grasses and vegetables which are not trained like developed species. Even though there is a lot of demand for fodder but the indent for the breeder seed of forage crops is very meagre. This leads to non-availability of sufficient foundation and certified seed.

Thus, there is a need for further increment in quality fodder seed production to meet the increasing demand. Regardless of whether raiser seed creation meets the indent prerequisite, there are a few bungles and creation imperatives which should be tended to for fortifying the seed chain of grub crops through different procedures and advances.

Malaviya *et al.* (2014) normalized germination approach for *Lasiurus sindicus* was utilizing various synthetics for breaking the seed lethargy and found that absorbing 0.05 percent of gibberellic corrosive for 17 hours end up being the best treatment for beating the presence of physiological torpidity in seeds.

In *Centrosema pubescens* seeds an effective treatment method to improve germination rate of the seed lots without causing mortality of potentially viable seeds was hot water treatment and seeds can also be stored for a minimum period of seven months with better seed germinability (Vinod kumar *et al.*, 2014).

Vijay kumar *et al.* (2014) opined that the pollen availability and viability are not the are not the explanations behind the watched low seed set in *Chrysopogon fulvus*, anyway exogenous use of 100 ppm kinetin during booting and anthesis stages helps in upgrading seed number just as seed to ovule proportion.

Malaviya *et al.* (2015) detailed two novel advancements for the upgraded augmentation of brassica-napier hybrid without disturbing the mother plants. The two node stem cuttings are the best one both for both high density nursery and *invitro* rooting. The high-density nursery not only helps in faster multiplication but also easy to handle with limited resources while the *in-vitro* rooted slips wrapped with paper are more suitable for transportation to longer distances.

Krishna Kumar *et al.* (2015) converted inter simple sequence repeats (ISSR) marker to sequence characterized amplified region (SCAR) marker which are connected to apospory in buffel grass (*Cenchrus ciliaris*) by testing 25 ISSR in DNA masses from apomictic and sexual progenies. Out of which, they detected polymorphism in 5 primers and opined that these markers are useful in marker assisted selection in breeding programme of this forage crop.

Conclusion

Production of quality seeds in fodder crops assumes paramount importance in light of nutritional security. The overall scene of fodder production is very alarming and corrective measures have to be taken to overcome this problem. Even though fodder seed production is often neglected component in Indian Agricultural Research and Development which needs to strengthened in future years for sustenance of human population.

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31. Elements Affecting Seed Longevity in Storage

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1. **Kind/variety of the Seed**: The seed storability is extensively affected by the kind/variety of seeds. A few kinds are normally short lived, E. g onion, soybeans, peanuts, and so on some similar kinds, E. g Tall fescue and annual rye grass, however they look particularly indistinguishable, contrast extensively in storability, comparatively, the hereditary make-up of the lines/assortments in a similar kind additionally impacts storability.
2. **Initial Seed Quality**: The seed lots having vigorous, undeteriorated seeds store longer than decayed parts. Contingent on the seriousness of damage, or level of deterioration, E. g degree of weathering damage, mechanical injury, flat, wrinkled or in any case damaged seed, even seed lots of good germination, at initial storage time do decrease quickly inside a couple of months. The significant ramifications of this is just high quality seed ought to be extended. The mediocre quality seed might be used as following plating seasons. The inferior quality seed ought to constantly be rejected.

Moisture Content:

Seed Moisture Content	Percent Storage Life
11 to 13	½ Year
10 to 12	One Year
9 to 11	Two Years
8 to 10	Four Years

The measure of moisture content in the seeds is likely the most significant factor impacting seed viability during storage, over a high range of moisture content, the rate of decay increases as the moisture content on seed storability. Moisture Content and Storage life of Seeds at Temp not above 90 ^{0} F of seeds having high Germinability and more vigor at initial period of Storage reported by scientists Harrington and Douglas, in the year 1970. Further, if seeds are kept at higher moisture substance than referenced in table the losses could be quick because of mold development on and in the seed (12 to 14 percent moisture content), or because of warming (18 to 20 percent moisture content). In addition, inside the ordinary range, natural movement of seeds, in organizations and shape further increments as the temperature increments. The higher moisture substance of the seeds, the more they are un-favourably influenced by both upper and lower scopes of temperature. It is imperative to take note of that low moisture content (under 4 percent) may likewise harm seeds because of extraordinary desiccation. Since the life of seed and its range generally rotates around its moisture content, it is important to dry seeds to safe moisture content. The sheltered moisture content, in any case, relies on capacity length, sort of capacity structure, kind/verity of seed, kind of bundling material utilized. For grains in common storage conditions for twelve to eighteen months, seed evaporating to ten percent moisture content shows up very acceptable. Be that as it may, for capacity in fixed holders, evaporating to 5 to 8 percent moisture content, contingent on the specific kind, might be fundamental.

4. **Relative Humidity and Temperature During Storage:** Relative moisture and temperature by a long shot are the most significant elements deciding the capacity life of seeds. Seed achieve a fairly explicit and attributes moisture content when exposed to given degrees of air humidities. This qualities moisture content is alluded to as equilibrium moisture content, for a specific kind of speed at a given relative humidity, will in general increment as temperature diminishes and as crumbling advances. Subsequently the upkeep of speed moisture content during stockpiling is an element of relative moistness and less significantly of temperature, at equilibrium moisture content, there is no net addition or deficit in seed moisture content. Seed put in a domain with a relative moisture higher or lower than that with which its moisture content is in balance, will pick up or lose moisture until a balance is built up with the new condition. In fixed capacity, seed moisture content decides the overall humidity of the earth in the holders. Foundation of moisture equilibrium in seeds is a period subordinate cycle. It doesn't happen quickly. Under open storage conditions, seed moisture content, varies with changes in relative moistness. In any case, ordinary diurnal change in relative humidity have little impact on moisture content. Table gives the balance moisture content for significant field and vegetable crops.

Moisture Content of Cereals Seeds in accordance with air (Harrington, 1959):

Sr. No	Crop	15%	45%	75%	100%
1	Shelled Maize	6.4	10.5	14.8	23.8
2	Rice, Milled	6.8	10.7	14.4	23.6
3	Sorghum	6.4	10.5	15.2	21.9
4	Hard Red Winter	6.4	10.5	14.6	25

Estimated Moisture Content of Vegetable Seeds in Equilibrium with Air

Sr. No	Crop	20%	30%	45%	75%
1	Garden Beet	4	5.8	7.6	11.2
2	Cabbage	4.6	5.4	6.4	9.6
3	Okra	7.2	8.3	10	13.1
4	Onion	6.8	8	9.5	13.4
5	Peas	7.3	7.3	10.1	15

Temperature likewise assumes a significant part in life of seed, despite the fact that if doesn't seem, by all accounts, to be a controlling one. Inside the typical scope of biological activity of seeds, insects and molds increments as temperature increments. The higher the moisture substance of the seeds, the more they are unfavorably influenced by temperature. Diminishing temperature and seed moisture, hence, is a successful methods for keeping up seed quality away. Low temperatures are exceptionally compelling in keeping up seed quality, even though relative moistness may be very high. Great cold stockpiling for seed ought not surpass 60% in relative moistness.

5. **Provenance**: It has just been expressed that various components, working previously and during harvest can influence seed reasonability. It is surprising then that examples of seed got from various sources may show contrasts in viability behaviour. It isn't in every case simple to know and agreeably evaluate what the reasons for these distinctions are, or even in some cases to realize how significant they are, in view of wide fluctuation between tests from various sources. All things considered, the seed starts its reality before it is gather. Also, it is just normal that seeds collected in various pre-reap condition which will have caused various measures of weakening when seeds are gathered.
6. **Impacts of Fluctuating Environment Conditions on Vi**ability: There have been a couple of reports such that fluctuating conditions are destructive, in any case, at present there isn't from the earlier motivation to assume that adjustment in temperature, or moisture content, would in itself be deterious spare, perhaps, for exceptionally quick changes in seed moisture content. More basic examinations are required on the impact of fluctuating natural conditions.

PLANT BREEDING AND GENETICS

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32. Speed Breeding: A Rapid Generation Advancement Method to Evolve Crop Plants

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Plant breeding plays a significant role in future food and nutrition security in the world. During the past decade, traditional/conventional breeding significantly contributed to the world food production, but the current developmental rate in several crops is insufficient to meet the future food demand. This slow progress rate is partly due to the long generation time of crop plants. A United Nations report revealed that conflict and climate change were key elements withholding the countries' progress in achieving the Sustainable Development Goals (SDGs). Hence, to alleviate the undernourishment and starvation, accelerated breeding approaches could indisputably contribute much to a changing climate. Under traditional breeding methods, in which one-two generations per year are advanced, the evolution of a new variety could take 10-12 years. This has penalties on rate of the genetic gains and crop improvement. In reducing the breeding cycle, thus improving the rate of product (defined breeding lines, varieties, techniques, etc.) delivery, plant breeders have come up with innovative breeding schemes including; shuttle breeding, double haploid technique, genomic selection, genome editing. Nonetheless, these approaches have severe limitations: like winter nurseries are costlier, and not guarantee successful seed production, logistically difficult to manage, doubled haploids are not obtainable for many crops and often demands expert personals to handle and costlier approach; and transgenic or genome-edited crops are often not a viable option because of regulatory issues in many parts of the world or societal skepticism.

Speed Breeding in Long Day and Day Neutral Crops

Space experiments led by NASA, USA, to grow crop seeds in space has stirred scientists of the University of Queensland and University of Sydney in Australia to develop a speed-breeding platform. John Innes Centre scientists have instigated a way to reduce the line development time necessary for new cultivar development. They call it *Speed breeding* and with this protocol, the generation time halved in comparison to the original cycle. They tested on Triticum wheat, durum wheat, barley, chickpea, pea and canola. They could be able to achieve up to 6 and 4 generations per year in Triticum wheat, durum wheat, barley, chickpea, pea and canola respectively in contrast to the 2-3 generations annually under normal greenhouse conditions (Fig 1).

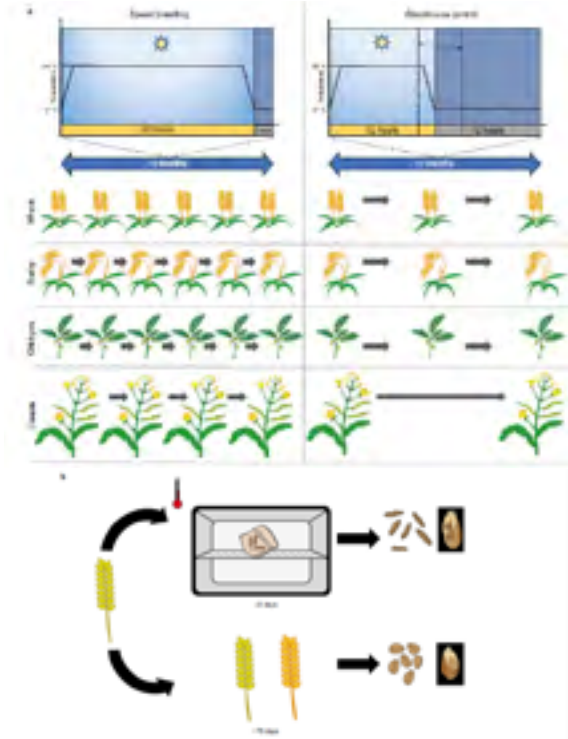

Fig.1. Speed breeding accelerates generation time of major crop plants for research and breeding. **a**, compared to a glasshouse with a natural variable photoperiod (10–16 hours), where only 2–3 generations of wheat, barley, chickpea and canola can be achieved per year (right), speed breeding enables 4–6 generations of these crops to be grown in a year (left). These values are representative of relatively rapid cycling cultivars of each crop. **b**, harvesting of immature spikes and drying them in an oven/dehydrator (~3 days) enables faster seed to seed cycling compared to the normal seed ripening process, which takes about 15 days, although it comes with a loss of grain weight (Adopted from Watson et al. 2018).

To attain this, they employed controlled environment set-up with a light/dark period of 22/2 hours in contrast to the plants grown in greenhouses with no auxiliary light. Along with harvesting of immature seeds, post flowering for instance, wheat seed was harvested before maturity: 14 days post anthesis in speed breeding conditions, and following 4-day cold treatment seed viability was high, signifying that generation time can be further reduced by harvesting immature seed without the need for labour-intensive embryo rescue. Seed viability of all other species under speed breeding conditions was either unaffected or improved compared with day neutral conditions. The plants exposed to the *speed breeding* conditions advanced to the anthesis stage in approximately half the time of those in the greenhouse environment. The 22-hour daily photoperiod was realized by using LED illumination as an additional source of light. They demonstrated that SB in fully enclosed, controlled-environment growth chambers can fast-track plant development for research purposes, including phenotyping of plant characteristics, mutation and transformation studies. The use of additional light source in a glasshouse environment permits quick generation advance through single seed descent (SSD) and possible for adaptation to larger-scale crop improvement programs. SB has great potential for combining with other contemporary crop breeding technologies, including high-throughput genotyping, genome editing and genomic selection, accelerating the rate of crop improvement (Watson *et al.* 2018).

Speed breeding short-day crops by LED controlled light schemes

The above-mentioned protocol of speed breeding shortens the generation time of long-day crops by an extension of the photoperiod to an almost full day and harvest of immature seeds. Conversely, this approach is limited to long-day crops and cannot be useful to short-day and photoperiod sensitive crops, such as the globally vital food crops like soybean and rice, because the prolonged photoperiod will avert their flowering. Also, the above protocol does not consider the light quality to optimize the speed breeding procedure. Jahne et al. (2020) devised a speed breeding protocol for short day plants based on light-emitting diodes (LEDs) that permit to adjust light quality, and demonstrated its effectiveness for the short-day crops' soybean, rice and amaranth (*Amaranthus* spp.). Modifying the photoperiod to 10 h and using a blue-light enriched, far-red-deprived light spectrum facilitated the growth of short and sturdy soybean plants that flowered ~ 23 days after sowing and matured within 77 days, thus allowing up to five generations per year. In rice and amaranth, flowering was achieved ~ 60 and ~ 35 days after sowing, respectively.

Current status of speed breeding in different crops

Watson et al. (2018) standardized a speed breeding recipe for spring wheat, durum wheat (*T. durum*), barley chickpea and pea and 4 generations for canola (*Brassica napus*). University of Queensland, Australia used speed-breeding technique to develop wheat variety DS Faraday, which is tolerance to pre-harvest sprouting being a major problem in Australia. In India ICRISAT based in Hyderabad,

established speed breeding platform and initiated work with chickpea and pigeonpea. Alahmad et al. (2018) applied speed breeding protocol to durum wheat for multiple quantitative traits in durum wheat integrating selection for key traits along with phenotyping for traits such as seminal root angle (RA), seminal root number (RN), tolerance to crown rot (CR), resistance to leaf rust (LR) and plant height (PH). Very recently Jahne et al. (2020) developed and standardized speed breeding protocol for short day plants such as soyabean, rice and Amaranthus in State Plant Breeding Institute, University of Hohenheim, Fruwirthstr, Stuttgart, Germany. It is underway for most of the food crops, within next few years protocols for majority of the food crops will be ready.

In conclusion typically, speed breeding facilitates the introgression of monogenic traits that are easily recorded within the climate chamber but also permits crosses between genotypes from different maturity groups, which may broaden the genetic variation of the breeding material and hence enhances response to selection. By attaining up to five generations per year in a speed breeding system, it will lead to an almost doubled annual genetic gain in comparison to other breeding programmes like shuttle breeding program which uses winter nurseries. Additionally, tools such as marker-assisted or genomic selection can easily be combined in a speed breeding system, since logistical difficulties, which may arise in winter nurseries, are bypassed. The fast generation of homozygous lines not only allows speeding up workflows in practical plant breeding but also for research purposes. Owing to the specificity of the LEDs, this system can also be used to dissect the interaction of specific wavelengths and the plant's physiological responses.

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33. Genetic Garden: An Integrated Plant Genetic Resource (PGR) Conservation Approach

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Biodiversity and genetic resources play crucial role in food security, sustainable livelihoods, ecosystem resilience, coping strategies for climate change, adequate nutritional requirements. Conservation and sustainably managing biodiversity is necessary for mitigating climate disruption, water and food security. Maintaining the diversity of the full range of genetic variation within a particular species or taxa is the fundamental objective of biodiversity conservation. Genetic resources in the form of crop, livestock, fish, microbial, and tree germplasm can be conserved both in-situ and ex-situ. However, ex-situ conservation holds good for scientific and educational purpose through different conservation strategies such as zoos, captive breeding, aquarium, botanical gardens including genetic garden, and gene banks.

Botanical garden is a tract of land devoting for the cultivation of a diversity of plant species. It is like an institution for botanical research especially on native flora of the region and also as an educational institution for scientific workers and general public or layman to awake and enlightened interest in plant life. The components of botanical garden are green houses, Herbarium, library, photographic studies, lecture pavilion and recreational facilities/culture etc. The broader and main botanical garden types are as follows:

1. Morphological gardens: To display plants from the point of morphological traits descriptions. For instance, seed dispersal mechanism in plants.
2. Taxonomic garden: To display plant families.
3. Genetics or breeding garden: To display the laws of heredity.

The modern concept of a botanical garden originated in Europe (Italy's Padova Botanic Garden was built in 1545). There are about 2500 botanical gardens in the world (Golding *et al*., 2010) together holding more than 6 million accessions of living plants, representing around 80,000 taxa, or about one-quarter of the estimated number of vascular plant species in the world (O'Donnell and Sharrock, 2017). The different activities conducted by botanical gardens are conservation, propagation, horticulture, seed science, taxonomy, systematics, genetics, biotechnology, education, restoration ecology and public education. Thus, they include herbarium, lecture rooms, laboratories, libraries, museum, small gene & seed banks and experimental or research plantings to conduct those activities. The genetic variation within species which is most concern of conservation genetics, is totally underrepresented in

botanical gardens (Hurka, 1994). In contrast to this Genetic garden focused to capture variations within species or individual by collecting diverse PGR and further utilizing such genetic resources to understand the genetic cause and mechanisms responsible for such variations. An overview on important genetic gardens at global and national level was given below.

Genetic gardens at international level:

Genetic Garden at Oxford University:

Cyril Dean Darlington a geneticist and eugenicist established Genetic Garden and which was dedicated to highlight the diversity, flexibility and evolution of the plant kingdom. At present garden comprises mature trees and shrubs remain from the first plantings in 1964, together with herbaceous plants and bulbs which were also part Darlington's collection. The garden displays the natural variation within plants along with a wide range of mechanisms important in evolution and exploited by plant breeders.

Genetic Garden at school of life sciences, University of Dundee

The Plant Sciences Division of University of Dundee developed a 'Genetics Garden' at the Botanic Gardens. Different plots were established at Genetics Garden to highlight the importance of plants in understanding of genetics and the critical contribution of plant variation in selecting and breeding better crops. This Garden now acts as a hub for science engagement activities. The Genetics Garden comprised three plots:

1. The History of Genetics: This plot showcased many model plant species used in the study of genetics including primroses, maize and carnations.
2. Cereal Diversity: This plot was planted with both ancient and modern varieties of barley, oat and wheat, showing how height has altered through breeding selection.
3. The Living Chromosome: This plot was divided into the shape of the barley chromosome 2 and each row marks the position of a specific gene. Barley plants in the row represents a mutation in that gene which causes a change in plant development; for instance, changes in plant height or color.

Genetic gardens at National level:

Genetic garden of bio-fortified plants

M S Swaminathan Research Foundation (MSSRF) in association with DBT-BIRAC established genetic gardens of bio-fortified plants in partnership with the Krishi Vigyan Kendras in Kanpur Dehat, Uttar Pradesh, Palghar, Maharashtra, Thirur, Tamil Nadu and Jeypore Campus of MSSRF, Odisha. The aim of Genetic garden of bio-fortified plants was to implement the diversification of the 'diet' and 'Bio-fortification' in the Farming System for Nutrition model and developing nutrition responsive agriculture among 2000 small-holder farmers by providing quality planting materials of nutri-rich plants for adoption in the farming systems.

Genetic garden of halophytes:

M S Swaminathan Research Foundation (MSSRF) in association with the Society for Integrated Coastal Management also established a genetic garden of halophytes near Siruthalaikadu in Vedaranyam in Nagapattinam district of Tamil Nadu. The aim of this garden was to conserve over 1,600 species belonging to 550 genera and 117 families of Halophytes plants to conduct research and to explore collected genetic resources for food, nutritional and fodder purpose.

Genetic garden of native fruit crops:

It is a living laboratory for rare crop and fruit diversity and India's first ever genetic garden established by Bioversity International to safeguard rare species that are important for food and medicine. Besides this, the Bengaluru centre of Bioversity International in India also established an ex-situ genetic diversity park to explore, collect, characterize and conserve underutilized fruit species from tropical and subtropical regions. More than 150 varieties of 95 species have been planted in this ex-situ gene bank. For each variety of fruit, a description about its beneficial agrobiodiversity properties are recorded, such as a fruit's origin, flowering and fruiting season, the number of varieties, food value composition and use.

From the above overview on global and national level genetic gardens, the role or purpose of genetic garden can be summarized as:

- To collect, cultivate and conserve genetic resources
- To provide rare and promising planting materials/ PGR to farmers
- To share planting material/ genetic resources for research purpose
- To multiply and maintain identified genetic stocks/ plant materials
- To create awareness among general public, students, researches
- To maintain, popularize and sharing planting materials/seeds of underutilized crops
- To develop propagation and multiplication protocols
- To understand the genetic cause and mechanisms of variations exist in diverse plants

The promising breeding/germplasm lines and research materials like mutant, genetic, or chromosomal stocks developed or identified by different organizations or associations/ trusts/ seed banks can be cultivate, multiplied and displayed in the genetic garden. Further, diverse PGR such as landraces, local cultivars and wild relatives explored or collected and maintained by farmers, SHGs, farmers associations, NGOs, seed banks, tribal communities can also be grown and maintained in genetic garden. The collected plant genetic resources at genetic garden can utilized for multipurpose as mentioned above. Besides conservation of potential plant genetic resources (PGR), genetic garden provides large set of

experimental materials to conduct basic research to unravel the mechanisms responsible for phenotypic variation at molecular level and also diverse plant species to study functional trade-offs between species traits and plant performance under changing climatic scenario. Therefore, genetic garden plays an important role as an integrated conservation approach by its multiple activities such as conservation, education, research and sharing PGR.

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34. The Story of Golden Rice in India

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Introduction

According to data collected at the Center for Health Indicators and Evaluation, health risks linked to inadequate diets are the leading cause of life-altering impairment in India. Nutritional deficiencies are particularly common among children in India. That is inappropriate as well as preventable. Rice is the main dietary staple for most of India's population, as it is inexpensive and marginally nutritious. But it is a precursor to vitamin A, without an adequate amount of β-carotene. Often deficiencies occur due to a lack of diversity in many Indian diets. Large rice intakes without adequate nutritional diversity will potentially lead to a deficiency in vitamin A. Vitamin A deficiency, or VAD, may cause respiratory, gastrointestinal, and urinary infections, as well as blindness and a severely compromised immune system which can contribute to a variety of other related conditions. Vitamin A deficiency symptoms are most severe in kids. Recent studies, such as those reported by the WHO, have identified a range of reasons for VAD ranging from under-standard schooling, poor health practices, lack of strict food production rules, and lack of efficient surveillance and control systems. People continue to suffer in many instances because of the government's economic instability in developing nations, such as India. However, with the lack of dietary diversity the root of this problem still remains.

The story of golden rice in India

Continuous advances in plant genetics have given these incessant, but preventable woes a strong candidate for a solution. Golden Rice is a form of Asian transgenic rice produced for humanitarian purposes. Its formation was celebrated by a predominance of the scientific community, as this rice species contains ample β-carotene levels within its edible part. The dispersal of golden rice seeds to Indian farmers has the potential to curb the growing VAD rate within one generation. Rice consumed in India will no longer be vulnerable to the same failure as vitamin A supplements, which were ineffective for a variety of reasons including inadequate government regulation and increasingly possible linkages between vitamin A supplementation and certain cancers. India is spending about 1.5 per cent of its GDP on public health, well below the 5 per cent global average.

This is a concern often discussed by critics and India is in the process of drafting a new national health policy scheduled to be published later in 2015 with a view to addressing a rapidly industrializing nation's poor health more appropriately. The need for controlled levels of vitamin A helps good vision, tissue regeneration and resistance to infection to be preserved in the body. The most successful approach with the lowest likelihood of failure is to introduce Golden Rice into rural India's rice fields. This rice, enriched with carotenoids, would greatly help those all over India who suffer from VAD. Since rice is the staple food that provides these people with most calories, it's the best solution to curb the problem. Golden Rice is also supplied with additional quantities of iron and zinc to continue battling hunger in developing countries. Indica rice cultivars, specifically IR64 and BR29, have been used as a basis for completing modification of this enhanced rice, as it is the most common type cultivated and consumed worldwide, including India. The technology for producing this form of enhanced rice through traditional plant breeding currently does not exist because the required genes for this scenario are not present in the established rice gene pool. With that in mind, the most ideal one is Golden Rice, produced with a transgenic approach. In this process, genes originating from other sources are introduced into the rice, which is then expressed in new rice seed. The production of β-carotene has had differing results in a variety of different rice cultivars, with some expressing more than others. It has been noted, for example, that IR64 has less β-carotene expression than BR29. Differences in speech may have any number of reasons including the particular histories

of the selected varieties of plants, or simply due to the basic section of an occurrence of the transgenic lines of rice.

With respect to plant genetics, the desired additional feature depends entirely on the phenotype. Most of the phenotypes are quantitative characteristics, such as height or yield. This means that these phenotypes are influenced, to a very limited extent, by hundreds, perhaps even thousands of genes. By comparison, a relatively small number of genes regulates basic traits, or pathways, to a great extent. This means, luckily, discovering a transgene that would significantly affect crop yield is virtually unlikely, which is good news when considering introducing Golden Rice in developing world. The carotenoid pathway is pretty easy, further speaking to the ease with which Golden Rice can be produced. Using traditional methods of plant breeding would be suitable in most situations, but in the case of desirable phenotypes with specific pathways such as that of carotenoids, the Golden Rice transgenic approach is much more rational. Golden Rice is currently undergoing field evaluation in both Louisiana, the United States and further research in the Philippines, Bangladesh and Indonesia.

Data in the Philippines has been the most comprehensive at this stage, according to results obtained by the International Rice Research Institute, but data is also distorted due to violence by insurgent groups with regular unrest occurring in the countryside. The findings were positive with the first round of field studies being conducted in the Philippines from 2012-2013 but there was still work to be done. During this run, the target amount of β-carotene was achieved, although crop yields were lower than anticipated as they did not perform as well as rice cultivated by other nearby farmers, although some of the blame falls on the militant vandalism.

Conclusion

Fortunately for India, much of the rice it grows is eaten nearby, largely alleviating the global concern. Present regulations to be adopted by Cartagena Protocol signatories, with respect to GM crops, result in increased costs and delays. Under the protocol, for example, GM crops must first be grown in glass houses, then screen houses, then open fields for further research before they are permitted to grow openly in these nations. This may sound like a smart idea but bear in mind the years of field experiments that are already taking place worldwide. These additional tests are redundant and unnecessary, especially when more Indian women and children are being killed each year by malnutrition. India has been a contributing party to the Cartagena Protocol as of 23 January 2001. This needless red tape is just going to waste time on a problem so badly in need of a solution. Global opposition to the use of GMOs is overwhelming. As a result, there is a desperate need for global education on the subject, as much of the opposition is focused on fear mongering or the issue's misunderstandings. Certainly, there are a small but a number of advocacies organizations aimed at creating a better-informed public but their impact is negligible.

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35. Speed Breeding: An Emerging Shortcut for Food Security

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Increasing Population and the need of the Era

Agriculture is the basis of sustainable development of the society. The major problem faced by the society is the increase in the population at an alarming rate. To satisfy the needs of this huge population which will reach 8 billion in the near future, intensive development in the agriculture sector is needed. Even though the technological advances including crop improvement are positively contributing to the yield, the growth is not satisfying the global demand especially for the food crops like rice. In this era of drastic climate change and decreasing land resources, increasing the agricultural production to meet the demands is the major challenge of farmers as well as the plant scientists. So, to attain that goal, intensive

research should be done in this field.

Breeding, the science dealing with improvement of crop productivity requires time for the development. So major concern is that, the current crop improvement rate of several crops is not adequate to meet the food and the nutritional demands of the world population. The development process of a new variety or the other crop improvement programs is too slow because of the long generation time in the crop plants. Also, the condition get worsens when there are erratic climatic conditions.

Speed breeding- A hope

Speed breeding is a novel technology in which the breeding cycles of the plants are shortened, which can accelerate crop research through rapid advancement of generations. The techniques in speed breeding modify the processes like plant growth, flowering and maturation to reduce the life cycle of plants. The plants are grown in glass houses or growth chambers and can reduce the growing time by 5 when compared to the normal field conditions. It can be carried by modifying the light exposure and temperature combined with the early seed harvest thus by reducing 'seed to seed' duration.

The idea and development

The concept of speed breeding was originated from the scientists of NASA where they were thinking about growing plants in the outer space. They had the concept that why we can't supply more light period so that their growth is accelerated. Their plan was to grow plants in chambers with all the necessary conditions needed for their development with extended light period.

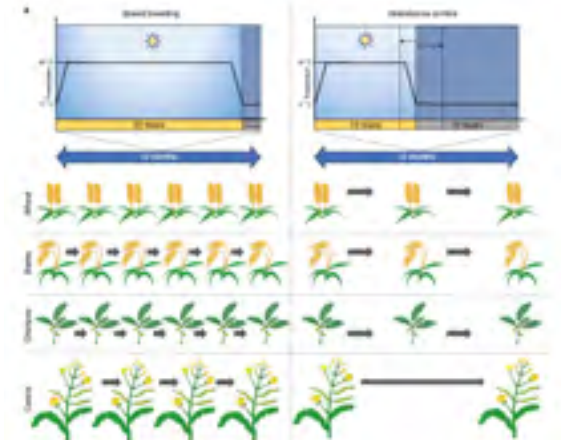

FIG: Comparison of growing plants in speed breeding chambers and glass houses (Watson *et al.*, 2018)

The speed breeding concept of NASA was realized by a team of scientists from John Innes Centre, University of Queensland and University of Sydney and used artificial environment in glass house with an enhanced light source to speed up the breeding procedures. They succeeded in shortening the life cycle of wheat and yielded the seeds within 8 weeks. Several protocols have been developed till now for pre-breeding experiments in a cost-effective manner

The early flowering can be induced by exerting physiological stresses like restricting nutrients needed for plant growth and imposing intense light on the leaves. Speed breeding utilizes some of these techniques but the protocols have been developed to avoid deficiencies and stress induced growth retardation. So, the light and heat parameters are managed and even the responses to light varies according to the wavelength. The purple and red spectrum showed a positive impact on the growth.

The achievements

This technique has already experimented in many crops. The scientists were succeeded in growing 6 generations of wheat, barley chickpea and pea annually which was two times more than that of normal glass house conditions. The possibility of some *Brasssica* species is also well proven. The conditions of growth vary according to the crop. The standard conditions for most of the crops is growing 1000 plants/m^2 with 22 hours of LED light at 22^0C and 2 hours without light and at a temperature of 17^0C. with these conditions, the scientists induced flowering in spring barley within 24 days. This is also helpful in adjusting the flowering according to the crossing programs to get uniform flowering of parents in different varieties. The LED lightning can reduce the cost and also helps in fast growth of different generations of the breeding program. Once the seeds are set after crossing, the seed ripening can be attained earlier by limiting the water supply or by increasing the temperature. The seeds thus can be harvested within one week of seed set.

Speed breeding in controlled conditions also helps in accelerating crop improvement programs and helps in growing more generations for phenotyping, mutation breeding and genetic transformation. This enable more generations at high plant density which could shorten the time required for varietal development. Also, the protocols have now standardized for the efficient growth of the plants without affecting the phenotypic traits. A wheat variety 'DS Faraday', which is tolerant to pre-harvest sprouting, developed by Dr. Hickey in partnership with Dow seeds was commercially released and can be considered as a proof of efficiency of this process

Integrating this technique with advanced crop breeding technologies will solve the main challenges faced by the crop scientists for sure.

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36. Genetically Modified Crops (GMCs): A Necessary Evil

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Genetically Modified Crops, popularly called GMC are those crops whose genes have been genetically engineered in a lab, ultimately yielding a crop species with "desirable" traits that do not occur in nature. Genetic modification in plants is as old as 10,000 years when for the first-time human beings cultivated plants by means of artificial selection and selective breeding in South East Asia. It was then that development in plant genetics, breeding and biotechnology has induced the current GMC revolution. GM crops have the potential to mitigate the present and upcoming issues associated with commercialization of agriculture which can jolly well be justified with the examples of cotton in India and canola in Australia. In 1983, the first plant was produced using an antibiotic resistant tobacco plant. China was the first country to commercialize a transgenic crop in the early 1990s with the introduction of virus resistant tobacco (Bawa et. al. 2013). The largest share of GMCs in the world is from the seeds developed by Monsanto; a US based firm. In 2007, Monsanto's trait technologies were planted on 246 million acres throughout the world (Panda, 2016). Genetically Modified Crops (GMCs) is a revolutionary technology of the 21st century which has evolved as a result of consistent and innovative efforts of scientists in the field of plant breeding & genetics and biotechnology. This revolutionary technology which was intended to help millions of farmers around the globe has now become a bone of contention among stakeholders of ethical agricultural community (Panda, 2016). GMCs of today have been modified with different desirable traits such as shelf life, disease resistance, herbicide resistance, pest resistance, stress resistance, enrichment of nutrition, production biofuels, drugs and crops having the capacity to absorb toxins for bioremediation. Let us discuss each component in detail.

Increasing shelf life: The FLAVR SAVR tomato was the first genetically engineered crop to be commercialized (Bruening and Lyons, 2000) and had an increased shelf life. It is no longer in the market now (Panda, 2016). Of late, in the year 2017, non – browning *Arctic apple* received regulatory approval in the US to be sold in the market. These apples have been developed by shutting down the genes which were responsible for producing polyphenol oxidase. When an apple is cut or damaged, polyphenolics; a chemical present in apple reacts with polyphenol oxidase, making the apple brown. Recently, research and development has been targeted to enhancement of crops that are locally important in developing countries, such as insect-resistant cowpea for Africa and insect-resistant brinjal for India (Panda, 2016).

Disease resistance:

Some pesticides are rapidly losing efficacy due to pathogen evolution, and their use faces increasingly strict regulations to minimize unwanted side effects (Geiger et al., 2010; Bolton et al., 2012; Lamichhane et al., 2015; Wieczorek et al., 2015; Godoy et al., 2016; Berger et al., 2017). Crop breeding can produce resistance to individual diseases, but it is challenging to select for genetic resistance against multiple diseases simultaneously while main taining the strong performance traits of elite varieties. For example, wheat blast is an emerging disease that will require wheat breeders to select for blast resistance while maintaining resistance against stem rust (Islam et al., 2016).

Wheat blast is an emerging disease that will require wheat breeders to select for blast resistance while maintaining resistance against stem rust (Islam *et al.*, 2016). Genetic modification and genome editing are one of the most effective and sustainable ways of managing plant pathogens in crops.

Herbicide resistance:

Herbicide tolerant crops are designed with genetic modifications to tolerate specific broad-spectrum herbicides, which kill the surrounding weeds, but leave the cultivated crop intact. At present, the varieties cultivated in the U.S. are engineered to be tolerant to glyphosate. Monsanto is the company which introduced glyphosate-resistant soybean and corn in the years 1996 and 1998 respectively.

Pathogen resistance:

Tobacco, corn, rice and many other crops have been engineered to express genes encoding for insecticidal proteins from *Bacillus thuringiensis* (Bt) (Panda, 2016). To resist viruses like cucumber mosaic virus (CMV), papaya and potatoes have been engineered. In Hawaii alone, 80% papayas were genetically modified by 2010.

Stress resistance

The first drought resistant GMC to get approval for marketing in the United States in the year 2011 was Drought Gard-maize; again, a creation of Monsanto. Plants engineered to tolerate non biological stressors such as drought, frost, high soil salinity and nitrogen

starvation are in the phase of development.

Nutrition enrichment and human disease treatment

Camelina sativa, German sesame has been modified to produce seeds having higher level of oil content similar to that of fish oil. Also, there are a few genetically modified soybeans offering good amount of oil meant for processing or healthier eating. Another common example is that of Golden rice, developed by the International Rice Research Institute (IRRI) which has been genetically engineered to target at reducing Vitamin A deficiency among children.

Toxin reduction

United States Department of Agriculture in the year 2014 approved a potato, that prevents bruising and produces less acryl amide. These modifications induced by J.R. Simplot Company prevent natural, harmful proteins from being made via RNA interference in potatoes.

Negative Effects of GMCs

In spite of being a technology full of success, GMC use has been an issue of great controversy and a hotbed for opposition. Studies of controversy like that of Monarch Butterfly study (1999) and the Seralini affair (2012) including the current problems associated with insect resistance and possible health hazards to human beings have jeopardized its progress with the intervention of public and policymakers, so much so as to put up partial bans in some countries, including full ban in others. According to Seralini Affair (2012), GMC can lead to significant chronic kidney deficiencies, cases of necrosis and liver congestions in men and can also cause tumours in humans.

Conclusion

It is proved that GMCs can mitigate many challenges associated with modern commercial agriculture. Also, recent market dynamics project GMCs as a fast-growing global industry possessing the potential to not only benefit the farmers but also consumers and can no doubt shoot the economies of the countries which are major players in this field. It is time that the agricultural industries and science communities work hand in hand to work towards communicating science in an efficient way along with regulatory mechanisms to tackle the misinformation and unethical notions about Genetically Modified. By roping in key innovations in genetic engineering technologies and upcoming and emerging studies in the field of bio fortification and stress tolerance, it is assumed that GM crops are most likely to bring productivity and profitability but still due to the negative consequences they still remain a necessary evil.

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37. Certain New Plant Breeding Techniques for Crop Improvement

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The competition between plant breeders in the global economy requires them to have access to the most efficient techniques. Plant breeders develop new varieties both for the indigenous and exotic market. Plant breeder and researchers throughout the world are using innovative strategies such as genome editing, speed breeding and high throughput phenotyping. The most of the breeding techniques, the rate of yield gain is inadequate to manage with the increased food demand caused by a rapidly increasing world population. Traditional breeding methods accomplished since quite some time, it can take one or two decades to create a new variety. To improve agronomic traits associated with yield, quality and resistant to abiotic and biotic stresses in crop plants. New plant breeding techniques to reduce the time needed to develop new varieties. For example, the time for developing a new wheat cultivar was reduced from 10-12 years to only 5-6 years.

Genome Editing

Recent advancements in the genome editing technologies have taken the place of the impediments of conventional breeding method and commenced

a new crop improvement era. All genome cleavage techniques produce double-stranded breaks (DSBs), blunt ends, or overhangs of the target nucleotide fragment, either by homologous recombination, site-directed insertion or substitution of genes. Site specific nucleases (SSNs) were used for editing of genomes which changes target location of genes present in the genome. The DSBs, produced as a result of the action of sequence- specific nucleases (SSNs), repaired by the non- homologous end joining (NHEJ) mechanism, that adds or removes nucleotides by the homology directed repair pathway, DNA substitution at target-sites. The three predominant SSN systems for genome editing (1) zinc finger nucleases (ZFNs), that is the basis for DNA manipulation (2) transcription activator- like effector nucleases (TALENs) (3) clustered regularly interspaced short palindromic repeats/ associated protein 9 (CRISPR/ cas9) this system is most effective and easiest genome editing tool.

The utilization of ZFNs has certain limitations like, its construct is not easy to design and transform in the plants and it is very expensive approach. Although, TALENs consist of the large and repetitive constructs that require a lot of time and exactitude to edit the target sequence. But due to high efficiency and accuracy in inducing site-directed breaks in double-stranded DNA by CRISPR /cas9 it was found in a bacterial immune system and archaea so recently it has been widely used in plant genome editing studies and replacing the TALENs and ZFNs system. CRISPR/cas9 system mainly consists of three stages; expression, interference and adaptation, system is divided into 2 classes, 6 types and 19 subtypes. The major differences between the classes is the composition of the effecter nucleases. Type II is the most commonly used system in genome editing. Class II has a type V effector named Cpf1, that can be designed with highly specific CRISPR RNA to cleave comparable DNA sequences. The Cpf1 was recently developed as a substitute to cas9 because of its distinctive ability to target T-rich motives through staggered DSBs without the obligation to trans-activate crRNA. On the basis of study report that small molecular compounds can enhance Cpf1 efficiency and they activating or suppressing signaling pathways for cellular repair. The system has been used in wide range of crops to improve quality and nutritional value of food, higher yield, biotic and abiotic stress tolerance. Genome editing has been holed up in most of the countries by legal regulations.

Speed Breeding

Speed breeding technique developed by NASA in 1980s to help grow crops in space, the work was an inspiration for all the scientists. The university of Queensland and university of Sydney in Australia to develop a method to accelerate the speed of wheat breeding. Speed breeding uses a controlled environment with enhanced light duration to create longer daylight to speed up the cycles of the breeding of photo-insensitive crops (22 h light, 22° C day and 17° C night tem. and high light intensity). For early and late flowering in the crops under controlled conditions using different parts of light spectrum (LED light and metal halide). Wheat variety DS Faraday have high protein, milling and tolerance to the pre-harvest sprouting was developed through this technique. It is suitable for diverse germplasm and does not require specific equipment for in vitro culturing like in doubled haploid method, in which haploid embryos are produced completely homozygous line. It is a platform can be collaborating with many other techniques such as genomic selection, marker-assisted selection and genome editing to get the result faster.

The technique suitable for the photo-insensitive crops *i.e.* wheat, barley, pea and chickpea that reduces the generation time, but not suitable for the soybean crop. Recently, Lee Hickey and his colleagues worked on developing protocols for short day crops like millet, pigeon pea and sorghum collaborate with ICRISAT, the project funded by Bill and Melinda Gates foundation. Millets, pigeon pea and sorghum are growing in Africa and Asia by many small holder farmers so, it has significant implications for global livelihood agriculture. The ICAR-Indian Institute of Soybean Research (ICAR-IISR), Indore is ample taking up off season (January- April) generation advancement of segregating material at the University of Agricultural Sciences, Bengaluru. The use of supplemental lighting in a glasshouse environment that allows fast generation cycling through single seed decent (SSD) method. In this technique growth chambers can hasten plant development for different research purpose *i.e.* phenotyping of adult plant traits, transformation and mutant studies. This technique main aim includes improving the protocols and conditions that required for induction of early flowering and rapid crop development.

High Throughput Phenotyping

Plant phenotyping as the set of methodologies and protocols that used for accurately measure the plant growth, architecture and their composition. Crop phenotyping is essential for selecting superior genotypes in plant breeding programs. A basic concern for many breeders is the controlled nature of many of the phenotyping platforms, the perception for most of these are unable to fully replicate the environmental variables that influencing the complex traits on the basis of climate variability and different phenotypes that are required by different breeding programs. High throughput phenotyping is based on proximal remote sensing; it provides the ample resolution of interpret phenotypic traits. There are many types of remote sensing devices, but most of the uses *i.e.* multispectral, hyperspectral, fluorescence, LiDAR and thermal sensor. All these remote sensing tools that allows the estimation of physiological yield components which are related to crop productivity, resource use efficiency, seedling density, ear or inflorescence density, flowering, canopy senescence and maturity. It is remains a bottleneck because of many problems associated with managing these data sets. Phenotypic data is complex and highly circumstances and crucial information, it would help unlocking biological nearing using dialectal and

automatic tool sets. The phenotyping not only has to be high throughput and precise but also reduces costs, resources uses by populations.

Conclusion, recent techniques in plant breeding put up to the development of qualitatively and quantitating improved varieties.

TABLE 1. Application of new breeding techniques for crop improvements (Ahmar et al. 2020)

S.N.	Crop	Method	Character
1	Wheat	Gene editing/ TALENs	Heritable-modification
2	Rice	CRISPR/cas9	Fragrance
3	Maize	CRISPR/cas9	Herbicide resistance
4	Rapeseed	CRISPR/cas9	Controlling pod shattering
5	Barley	Speed breeding	Resistance to leaf rust
6	Chickpea	Speed breeding	4-6 generation/year
7	Spring wheat	Speed breeding	Resistance to stem rust
8	Peanut	Speed breeding	2-3 generation/year
9	Tomato	High-throughput phenotyping	To increase the capacity of plant using water
10	Wheat	High-throughput phenotyping	High yielding improved varieties

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38. Intellectual Property Rights (IPR)

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Introduction: Intellectual Property Rights (IPR) are legal rights, results from intellectual activity in industrial, scientific, fictional and inventive fields. Intellectual Property Rights refers to the legal rights granted to the inventor or manufacturer to protect their discovery or manufacture product. These legal rights discuss an exclusive right on the inventor/ producer or its operator who makes full use of it's his innovation/product for a restricted period of time. In short, we can say that these legal rights exclude all others from using the Intellectual Property for commercial purposes without the prior permission of the IP rights holder. Intellectual Property rights include trade secrets, utility models, patents, trademarks, geographical indications, industrial design, layout design of integrated circuits, copyright and related rights, and new varieties of plants. IPR is essential for better identification, planning, commercialization, rendering, and thus the protection of inventions or creativity.

The term Intellectual property is related to human brain useful for creativity and invention. The final idea by which invention or creation took place is an intangible property of the person, who took efforts for the invention. The Intellectual property rights (IPR) are regional rights by which holder can sell, buy or license his Intellectual Property (IP) similar to physical property **(1)**.

Types of Intellectual Property: On the basis of type of innovation and creation of human mind and their uses the intellectual property rights are classified as follows: i) patents ii) Trade secrets iii) trademarks iv) industrial designs v) geographical indications, vi) copyright and related rights (literary and artistic works, musical work, photographic work, motion films, computer databases and performing arts and broadcasting work)**(2-3)**.

Need to promote and protect Intellectual Property: Some of the reasons for promoting and protecting intellectual property are:

1. Growth and the good of humanity continue in the ability to create and invent new works in the field of technology and culture.
2. It inspires publication, distribution and revelation of the formation to the public, rather than keeping it a secret.
3. Promotion and protection of Intellectual Property promote economic development, creates new jobs and industries, and improves the quality of life.

Patent: Patent is an IPR granted to inventor by concerned government office for his novel technical innovation. "A patent is a special right granted to the owner of an invention to the production, use and market the invention, given that the invention fulfils some conditions placed in law. Exclusive right means that no one can manufacture, use, or market an invention without the permission of the patent holder. For this exclusive right to patent the time period is limited only. Patents are considered the most valuable right among all types of IPR.

There are some criteria to fulfil the patentability of any invention which is as follows:

1. **Usefulness:** The invention must have industrial applicability or use for practical purpose.
2. **Novelty:** The invention must be new technology which has not been published or available before in the country or somewhere else in the world before the date of patent filing.
3. **Non obviousness:** Invention done by any ordinary skilled person is obvious and cannot be patentable. Hence the invention must not be obvious for patentability.

Trademark: "A trademark is a distinguishing mark or symbol that denotes about the particular item is produced or provided by a specific person or industry or enterprise". A company may have different types of trademarks for their goods but to differentiate themselves from other company or enterprise trade name is being used. **(4)**

Important Criteria of Trademark Registration: According to UK Trademarks Act, 1994, there are three main requirements for registering a trademark are as follows,

1. The trademark should be a sign or anything that can express information.
2. The sign should be accomplished of differentiating products or services of one undertaking from that of another. This is obviously a requirement of distinctiveness of trademarks.
3. The trademark is capable of graphical representation to provide specific identification in the trademark registry.

Trade Secrets: "Any invention or knowledge which in not innovative (not patentable) but beneficial for business and provides monetary benefits can be known for trade secret". Along with this creative information is also kept as trade secret when registration of patent, copyright, industrial design, etc. are in process **(5).** The scientific information or procedure such as formula, knowledge, method, software, blue prints, design, formula, maps, architectural plans and manual or any commercial information or business strategy or secret in form of any data composing or databanks, marketing plans, fiscal information, personal records, etc. can be kept as trade secret. **(6)**

Geographical Indications: Applications of geographical origin to identify goods for trade purpose is not a new wonder. Some agricultural products have special qualities that are influenced by topographical climate or soil. "The term Geographical Indication (GI) has been selected by WIPO comprises all existing means of protection of such names and symbols, irrespective of whether they indicate that qualities of a given product are due to its geographical origin or they simply indicate place of origin of a product".

The Alphanso Mango, Nagpur orange, Havana, Darjeeling tea, Champagne, Basmati, Arabian horses, etc are some renowned examples for names those are associated all over the world for their product having explicit quality and recognized as Geographical Indications. Likewise, in the field of handicrafts, cloths, etc., particular qualities of the products are related with human features and their talents **(7).**

Copyrights and Related Rights: Copyrights safeguard expression of idea of author, artist and other creators which is related with mass communication. It defends only form of expression of idea, not the idea by itself. Progress of any country or people depends upon creativeness of their people **(8)**. Thus, copyright inspire such type of activities. The following fictional and inventive works are protected under copyrights.

Industrial Designs: It refer to, "creative activity, which result in the decorative or formal appearance of a creation and design right refers to a unique or original design that is bestowed to the owner of a truly registered design". Industrial designs are an component of intellectual property. Under the Trade Related Intellectual Property Secrets Agreement, minimum standards of protection of industrial designs have been provided for. As a developing country, India has already edited its national law to provide for these nominal standards. The vital purpose of design law is it to promote and protect the design component of industrial production. It is also proposed to endorse innovative activity in the field of industries.

Conclusion: Intellectual Property Rights allows creator or investigator through giving their rights through laws of Intellectual Property Law. In acquaintance-based economy, intellectual property rights are very much essential for enlightened societal development. The IPR is basic requirement to be a part of indigenous as well as worldwide competitive trade as without distribution of IPR knowledge and implementation, generating the innovative environment is really impossible. It is essential for rule makers to include IPR in basic educational system and promote IPR registration by inspiring the innovators and creators. India is having all the resources in terms of available raw material, cheap labour, novel and inventive devoted manpower

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39. Allele Mining: Tool for Crop Improvement

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Introduction:

Progress in plant breeding as far as improvement of unrivaled and high yielding varieties of agricultural crop is conceivable by gathering of gainful alleles from tremendous plant hereditary assets existing around the world. As it were, recognizable proof and admittance to allelic variety that influences the plant phenotype is absolutely critical for the usage of hereditary assets, for example, in plant variety improvement. Considering the immense quantities of increases that are held altogether by genebanks, hereditary asset assortments are esteemed to hold an abundance of undisclosed allelic variations. The test is the way to open this variety. Allele mining is an exploration field pointed toward distinguishing allelic variety of applicable attributes inside hereditary asset assortments. For distinguished qualities of known capacity and essential DNA arrangement, hereditary asset assortments might be screened for allelic variety by allele mining approaches, for example, eco-tilling, sequencing and association mapping.

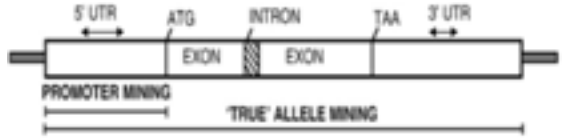
Allele Mining

- Allele mining is the way toward finding the unrivaled allele from the normal populace.
- These important and obscure novel alleles can be utilized for additional harvest improvement, for example, protection from biotic and abiotic stresses, increment more noteworthy supplement use proficiency, upgrade yield in crops and improve quality, for example, cooking, protein, starch including human nourishment.
- Allele mining is direct on explicit qualities that are associated with the specific component of stress resilience express by distinguish increases.

Development of new allele

- Since the hereditary variety is an essential for any hereditary improvement in a yield assortments. Along these lines, in any rearing system, this is consistently the initial step except if hereditary variety pre-exists in the reproducing populace.
- It can be made by a few rearing strategies among them transformation is a developmental main impetus which cause existing allelic decent variety in any harvest species.
- Generally, transformation happen in coding or potentially administrative locales of genome either as Single Nucleotide Polymorphism (SNP) or as Insertion and Deletion (InDel) may tremendously affect changing phenotype of attribute by changing the amino corrosive arrangements and additionally their capacity in protein encoded by focused DNA portion where as those happen in the non-coding areas will silently affect the phenotype of the quality.

True allele mining



True allele mining incorporates coding, non-coding and regulatory regions of gene.

Steps associated with allele mining

- primer designing
- PCR intensification of the gene
- Determination of target gene

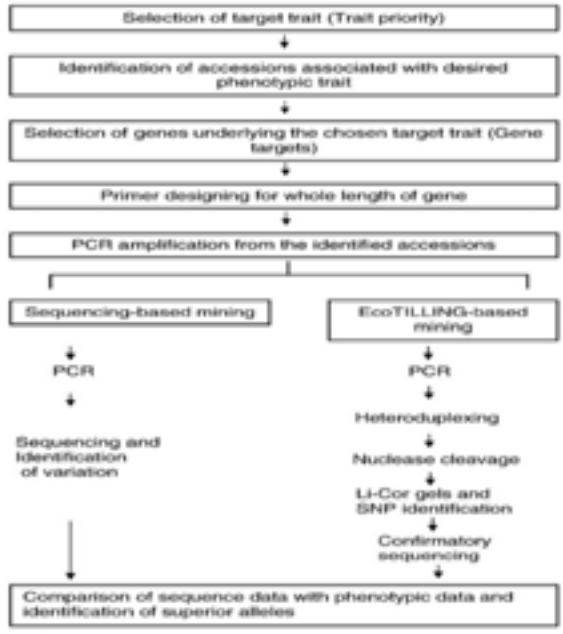


FIG. Steps involved in allele mining (SourceL Kumar et al., 2010)

1. Approaches in allele Mining:
2. ECO-TILLING
3. Sequencing based allele mining
4. Association mapping based allele mining
5. Next generation sequencing for allele mining.

Difficulties associated with Allele Mining

- Selection of genotypes
- Handling genomic assets
- Demarcation of promoter
- Characterization of regulatory region
- Higher sequencing costs

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PLANT PATHOLOGY

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40. Begomoviruses Associated Diseases in Major Cucurbits

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Introduction

Cucurbits, the important group of vegetables are cultivated extensively in India, contributing nearly 18 per cent of total vegetable production in India. More than 59 different viruses were reported to cause wide variety of diseases in cucurbits. Especially begomoviruses in cucurbits crops are emerging problems throughout India, resulting huge economic loss.

Cucurbits belongs to family Cucurbitaceae. It includes crops like Cucumbers, squashes (including pumpkin), luffa and melons. They occupy the largest area of the vegetable crops in India and in other tropical countries. Asia is the largest producer of cucurbits crops, followed by Europe. They have some health benefits, includes Purification of blood, removal of constipation, good for digestion and a rich source of energy. Among those bitter gourd rich in vitamin C and pumpkin rich vitamin A. Some of major cucurbits include cucumber, ridge gourd, pumpkin, watermelon, muskmelon and bitter gourd. Some of biotic and abiotic stresses. Cucurbits are more prone to viral diseases rather than fungal and bacterial disease.

The begomovirus infected plants shows symptoms like yellowing of leaves, leaf curl, Vein thickning, reduction in leaf size, enation and stunting of plants.

Geminiviruses belongs to family Geminiviridae. The Virions are twinned quasi-icosahedral (18 x 30 nm) and Genome is circular ss DNA (2.8-5.5 kb). Based on host range, insect vector and number of DNA components they are classified into two subgroups like Subgroups I and II.

Monopartite members are often associated with a smaller satellite DNA beta, that is responsible for symptoms production. Additional nanovirus like satellite components, known as alphasatellites may also be present.

Bipartite begomovirus, DNA-A contain six genes and DNA-B contain two genes.

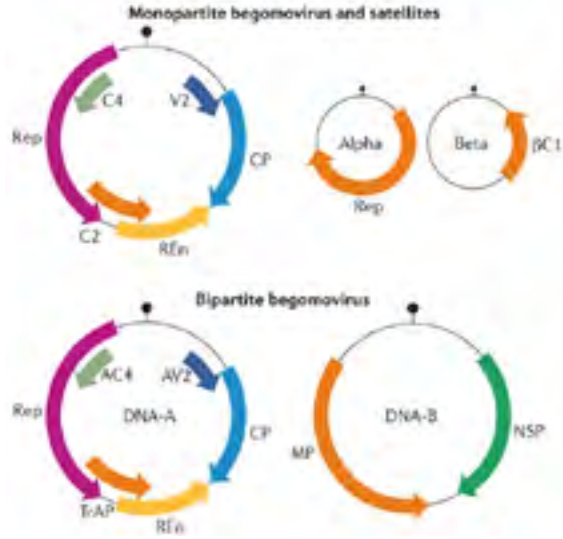

FIG. 1: Genome organization of begomovirus

TABLE.1. Begomoviruses occuring on cucurbitaceous crops in India

Crops	Virus identified	Locations	References
Pumpkin	Pumpkin yellow vein mosaic virus	Central-western India	Varma, 1995
Bitter gourd	Bitter gourd yellow mosaic virus	Tamil Nadu	Rajinimala *et al*., 2011
Bottle gourd	Tomato leaf curl New Delhi virus	New Delhi	Sohrab *et al*., 2010
Sponge gourd	Tomato leaf curl New Delhi virus	New Delhi	Sohrab *et al*., 2003
Ridge gourd	Tomato leaf curl New Delhi virus	Gorakhpur	Tiwari *et al*., 2011
Pointed gourd	Ageratum enation virus	Lucknow	Raj *et al*., 2011
Chayote	Tomato leaf curl New Delhi virus	India	Mandal *et al*., 2004
Cucumber	Tomato leaf curl virus	Lucknow	Raj and Singh, 1996

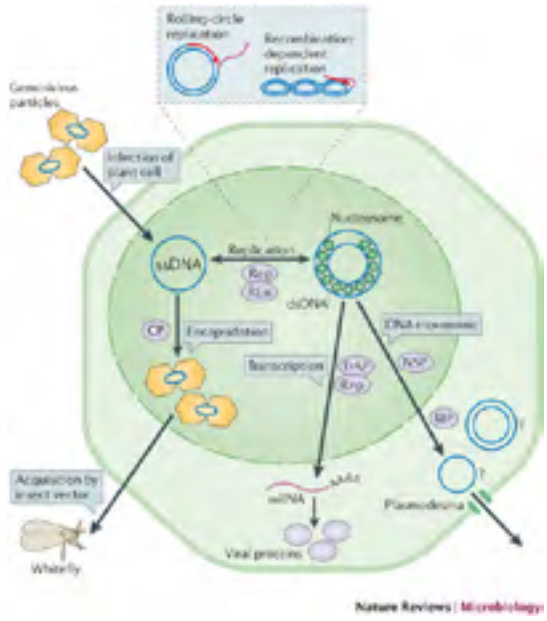

FIG. 2. Gemini virus life Cycle, Virus Movement and Host Proteins

Infection begins in a plant cell when viral single-stranded DNA is released from virions and copied to generate double stranded DNA. The dsDNA, which assembles with nucleosomes, transcribed by host RNA polymerase II, allowing production of replication initiator protein (Rep). Rep initiates rolling circle replication. Rep represses its own transcription, leading to activation of TrAP, coat protein and nuclear shuttle protein. Circular ssDNA can then be encapsidated by CP into virions, which are available for whitefly acquisition.

Rate of transmission depends on population and type of sex, acquisition period, inoculation period and incubation period (Inoue-Nagata *et al.*, 2016).

Approaches to Begomovirus Disease Management

- **Sanitation:** Destruction and removal alternate host plants. rogue out virus affected plants
- **Cultural-** Crop rotation, Grow barrier crops
- **Physical-** Nylon net, Yellow sticky traps and Use of UV-reflective mulchin
- **Insecticide spray**: Triazophos, Imidacloprid

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Inoue-Nagata, A. K. Lima, M. F. and Gilbertson, R. L., 2016, A review of geminivirus (begomovirus) diseases in vegetables and other crops in Brazil: current status and approaches for management. *Hortic. Bras.*, **34**: 1-18.

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41. Entomopathogenic Nematodes Infection Process and its Survival Mechanism

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Entomopathogenic nematodes

EPN'S are obligate or sometimes facultative parasites of insects with soft bodied, non-segmented round worms that are effectively used as bio pesticide in pest management programs.

INFECTION PROCESS

Host finding:

IJs use foraging strategies to find host which vary from ambush and cruise for aging. Foraging strategies were first built on the type of activity established by the IJs. Because the IJ do not feed ordo not mate throughout this life stage and all the activity is directed in the way of finding and infecting a new host.

A gathering of nematode conduct identified with standing have been appeared to expand an ambushing IJ's likelihood of finding a host and have been named "waving" and "jumping". Both of these practices are exhibited by standing IJs when they are invigorated by different natural conditions or unpredictable host

prompts. Waving by IJ nematodes is described by the standing IJ staying in a similar spot and waving to and fro while keeping up a straight stance. Many *steinernema* jump by forming a loop with their bodies when released, propels them through the air. Cruise foraging search through the soil for its potential hosts.

E.g., Ambush predators such as *Steinernema carpocapsae* infect many insects on the surface, but cruising predators like *Heterorhabditis bacteriophora* infect insects that are present deep in the soil.

Host Recognition:

IJ recognises and comes in close association with a potential host, to evaluate host before it is subjected to invasion. The decision of IJ to invade or infect a host is irreversible. EPNs retort to chemical signals produced by their hosts and these cues include Co_2 and volatile compounds produced by their hosts. BAG neurons are crucial for IJ attraction towards *G. mellonella* larvae giving strong evidence that Co_2 is a major chemical signal used for host finding and recognition by *Heterorhabditis*.

Volatile compounds released by potential hosts as environmental signals or insect damage to plants parts. Eg., Maize roots exude a sesquiterpene compound as a result of feeding damage done by larvae of western corn rootworm, *Diabrotica virgifera*. It acts as a chemoattractant for *Heterorhabditis* IJs to an injured plant part.

Penetration:

Potential host once found IJs penetrate the host through natural openings in the insect cuticle such as spiracles, mouth, anus and through wounds into the haemocoel and release of bacterial symbionts. *Steinernema* IJs secrete hydrolytic enzymes that facilitate conveyance from the gut of insect into the haemolymph. *Heterorhabditis* IJs don't produce hydrolytic enzymes but had a dorsal tooth like appendage that may be helped in tearing the insect cuticle to access to the haemocoel

Release of bacteria:

- After entering an insect, IJs finally reach the haemocoel where they release associated mutualistic bacteria (*Xenorhabdus*) in the haemolymph.
- Nematodes develop by feeding on the bacteria.
- Bacteria use the insect tissues as substrate for its multiplication.
- Bacteria multiply in the haemolymph, produce secretions of toxic metabolites that cause insect mortality within 48 hours due to septicaemia.
- Nematodes act as vectors of bacteria, which converts the inner contents of insect into a gummy, nutrient and bacteria rich medium suitable for nematode development and multiplication.
- IJs develop to adults and complete 2 or 3 generations depending upon the variability of nutrients in the insect cadaver. But, when food reserves in host are depleted or scarce, the adults produce new IJs to withstand and adopt the outside environment.
- After about a week in *steinernematids* and 10-15 days in *Heterorhabditids*, thousands of IJs emerge from cadavers and search for new hosts.
- IJ is a specialized third stage juvenile that is analogous to dauer stage.
- Dauer stage has the ability to survive without nourishment for continued periods. The ultimate function is to infect the host.

Nematode and bacterium relationship

Nematode relies on bacterium for creating suitable environment and killing insect host for feeding and development by producing antibiotics that suppress competing secondary microbes, Breakdown of host tissues into usable nutrients.

Bacterium needs nematode for protection from outside environment, penetration, inhibition of host's antibacterial proteins. Bacterial symbionts are gram negative, Facultative anaerobic, rod shaped.

Eg: Steinernema carpocapsae (*X. nematophilus*), *S. feltiae* (*X. bovienii*), *Heterorhabditis* spp. *Photorhabdus luminescens*

Symptoms

Insects infected with *Steinernema* infection imparts creamish colour to the cadaver. Insects infected with *Heterorhabditids* infection imparts reddish to brown colour to the cadaver. Dead cadaver glows in dark because of the bacterium *Photorhabdus luminescence*.

Survival mechanisms

Desiccation

- EPNs do not tolerate fast dehydration, and dehydration must be done by exposure to conditions of high relative humidity but no free water.
- Both *Steinernematids* and *Heterorhabditids* IJs are known to aggregate into clumps of nematodes in dry conditions. Aggregating is thought to offer some level of protection from desiccation.
- *Steinernema* forms coil with their bodies, and this may afford nematodes a way to slow their desiccation by reducing their surface area to volume ratio.
- In desiccating conditions an increase in trehalose and glycogen concentration. The main function of trehalose is to stabilize membrane during desiccation.

Bio chemical changes:

In desiccating conditions an increase in Trehalose/ Glycogen concentrations.

E.g., Increase in trehalose level in *S. feltiae* that had been exposed to low humidity conditions.

The function of trehalose is to stabilize membranes during desiccation. Osmotic stress differs from desiccation because water is not removed from the surroundings of the nematode, but the level of solutes within the water imposes some stress on the nematode. Level of solutes within the water imposes

some stress on the nematode. High salinity level inhibits nematode movement, but do not generally seem to be lethal and often found to be ineffective.

Temperature extremes

Freeze tolerance:

- Nematodes can survive when their tissues experience ice crystallization, but their fluids donot actually freeze as they differ in their response to freezing.
- *S. carpocapsae* and *S. glaseri* were all capable of surviving exposure to -4°C and -20°C showed that when IJs were exposed to these cold temperatures, their infectivity was reduced.
- Often high temperatures are fatal to nematodes. However, nematodes can tolerate heat but varies with species and strains and depends upon particular environmental conditions that occur where the strain is isolated.

E.g., *H. bacteriophora* tolerant to high temperature of short-term exposure to 37°C

These nematodes produce heat shock proteins to protect other proteins degradation that is caused by high temperatures and other adverse conditions.

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42. Nucleic Acid Isothermal Amplification Tools for Detection of Plant Pathogens

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Introduction

Plant diseases are causing huge crop loss both in field and storage conditions affecting the economy of any country. Therefore, effective management practices are essential to bring down the crop losses and to device the effective management practices, proper detection and diagnosis are necessary. Nucleic acid amplification techniques are used as leading methods in detection and analysis using a small quantity of nucleic acids. The polymerase chain reaction (PCR) is the most widely used method for DNA amplification, detection and diagnosis of diseases. However, it requires a thermocyclic machine to separate two DNA strands and then amplify the required fragment. Novel techniques *viz*., Loop-mediated Amplification (LAMP), Rolling Circle Amplification (RCA), Nucleic acid sequence-based amplification (NASBA), Recombinase polymerase amplification (RPA), Helicase dependent amplification (HDA) are being used in molecular biology for amplifying DNA in isothermal conditions without the need of a thermocycling apparatus.

Sl. No.	Platform	Amplified component	Amplification catalyst
1.	LAMP	Probe	Enzymatic
2.	RCA	Probe	Enzymatic
3.	NASBA	Complementary sequence of target (RNA)	Enzymatic
4.	RPA	Target and the complementary sequence	Enzymatic
5.	HDA	Target and the complementary sequence	Enzymatic

Loop-Mediated Amplification (LAMP)

Loop-mediated amplification (LAMP) is an isothermal method that has been shown to display amplification levels that approach that of PCR. LAMP also achieves high target specificity and this is due to the fact that two sets of primers spanning 6 distinct sequences of the target are used that are forward primers and backward primers. Two primers in the forward primer set are named inner (F1c-F2, c strands for "complementary") and outer (F3) primers and similar in backward primer also. The DNA polymerase used is Bst DNA polymerase which having stand displacement activity hear tag polymerase is not used due to endonuclease activity.

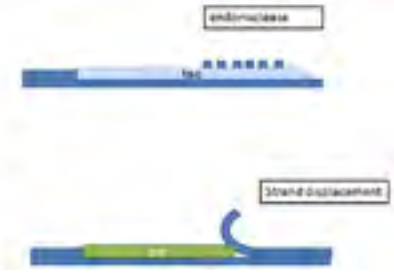

FIG.1. Difference of Tag and Bst polymerases enzyme.

The LAMP reaction accurses in three steps such as Starting material producing step, cycling amplification step, elongation and recycling step. At around 60 ^{0}C, the F2 region of the inner primer first hybridizes to the target, and is extended by a DNA polymerase. The outer primer F3 then binds to the same target strand at F3c, and the polymerase extends F3 to displace the newly synthesized strand. The displaced strand forms a stem-loop structure at the end due to the hybridization of F1c and F1 region.

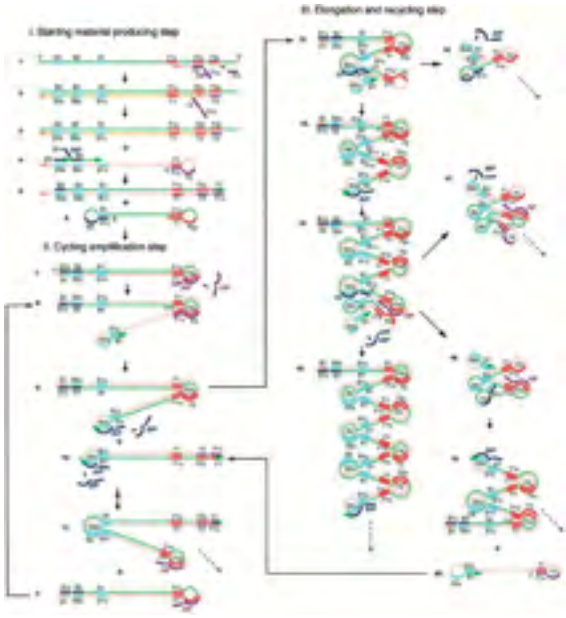

FIG.2. Mechanism of Loop-mediated amplification (LAMP). Four probes (F1c-F2, F3, R1c-R2, R3) are used for this method. F1 is complementary with F1c (c stands for complementary sequence)

At the end, the reverse primer set can hybridize to this strand and a new strand with stemloop structure at both ends is generated by the polymerase. The dumbbell structured DNA enters the exponential amplification cycle and strands with several inverted repeats of the target DNA can be made by repeated extension and strand displacement. LAMP can amplify a few copies of the target to 10^9 in less than one hour, even when large amounts of non-target DNA are present. LAMP has been applied to detect a variety of viral pathogens. The major disadvantage of LAMP is that the design of the primer sets can be complicated, since 6 regions of the target are covered.

Advantage and Disadvantage of Isothermal Amplification Methods

Advantage

- Nucleic acid sequence-based amplification (NASBA), - amplification of more than 10^9 copies in just 90 min.
- Rolling circle amplification (RCA) for detection characterization and for recombination.
- Loop-mediated isothermal amplification (LAMP) is rapid, sensitive, can be seen by eye, making LAMP well-suited for field diagnostics.
- Nicking enzyme amplification reaction (NEAR) -extremely rapid and sensitive & detection of small targets.
- Helicase-dependent amplification (HDA) requires only two primers.
- Strand displacement amplification (SDA)- exponential amplification

Disadvantage

- NASBA - specificity of the reactions is dependent on thermolabile enzymes.
- RCA - analysis of restriction fragments generated mitochondrial sequences.
  - LAMP –many primers & not useful for cloning.

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43. New Approaches to Plant Disease Detection

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Introduction

In agriculture, crop losses due to different pathogen are persistent issues all over the world. To tackle the issue of crop losses and to ensure agricultural sustainability there is a need to detect the pathogen in infected crop earlier than infection reaches to its more damaging stage. Nowadays, several methods are available for disease detection. The oldest traditional method of disease detection method is a visual assessment which was later advanced through the use of colony culture and microscopic observation as several symptoms of different diseases is similar. Likewise, many more advancement has been done in the method of disease detection for rapid detection and confirmation of disease. There are some pros and cons to every method. Here different types of disease detection have been discussed in brief that is available.

Microscopy

In this method, different types of microscopes are used to detect the pathogen. A microscope is a device that magnifies the specimens and resolved it so that too small object that is not visible by naked eyes such as fungal spores, bacterial spores, signs in diseased plant part etc. in case of plant pathology. Various types of microscopes are available such as a simple microscope, compound microscope, transmission electron microscope etc. With the increasing need and desire to know about anything in detail, there is also advancement in microscopes.

Traditional molecular methods for disease detection

1. **Serological assays –** In this method various pathogens are detected through using polyclonal and monoclonal antisera and techniques such as enzyme-linked immunosorbent assay (ELISA), western blots, immunostrip assays, dot-blot immune-binding assays, and serologically specific electron microscopy (SSEM).
   a) **Enzyme-linked immunosorbent assay (ELISA):** In this method, various antigen-antibody combinations are used in which either antigen or antibody is labelled with an enzyme. Here another substrate is used that changes colour when reacting with an enzyme. This colour change is further measured and converted to numeric values.
   b) **Western blots:** This technique is used for the detection of specific protein among the various types of available proteins. This specific type of protein is separated with the help of Sodium dodecyl sulphate (SDS) polyacrylamide gel electrophoresis. It is used for measurement of both size and amount of protein of interest
1. **Nucleic acid-based methods:** This method DNA based or RNA based techniques are used for detection. In DNA based methods fluorescence in situ hybridization (FISH) and the many PCR variants (PCR, nested PCR (nPCR), cooperative PCR (Co-PCR), multiplex PCR (M-PCR), real-time PCR (RT-PCR), and DNA fingerprinting) are there. While in RNA based method reverse transcriptase PCR, nucleic acid sequence-based amplification (NASBA), and AmpliDet RNA are there.
1. **Innovative detection methods:** This method consists of novel approaches that allow detection of the pathogen at pre-symptomatic stage *i.e.* when symptoms are unclear and present in only a few plants.
   a) **Lateral flow microarrays:** These arrays are based on hybridization mediated target capture *i.e.* reliable host and pathogen biomarkers. It is constructed on miniaturized lateral flow chromatography nitrocellulose membrane on which hybridization takes place. Here the biomarkers can be primary metabolites, secondary metabolites or interactive protein such as heat shock proteins or dehydrins, up-regulated by different environmental factors.
   b) **Methods based on the analysis of volatile compounds as biomarkers:** Volatile compounds are low molecular weight biomolecules with high vapour pressure and low boiling point that can indicate the physiological health status of the host plant. A new avenue of research is opened by VOC profiling, which may detect mechanisms for "plant-to-plant" and "plant-to-insect" communication, gaining new insights into host responses to pathogens and abiotic stressors. Novel analytical methods, instrumentation, and multivariate data analysis (MVA) methods are required to make and interpret these data sets.
   c) **Remote sensing of plant disease:** Remote sensing is a more advanced method of disease detection in which information related to any object such as diseased parts is obtained by measuring reflected or emitted electromagnetic radiation. In this physical contact is not required for obtaining information. There is variability in reflectance spectrum under stressed and unstressed condition. This variability in reflectance spectrum is used to distinguish between healthy and diseased plants parts. There are various spectroscopic and imaging techniques based on remote sensing principle are available such as visible, infrared, multiband and fluorescence spectroscopy, fluorescence imaging, multispectral and hyperspectral imaging, thermography, nuclear magnetic resonance spectrography etc.
   d) **Biosensor:** A biosensor is an analytical device that consists of bioreceptor, a transducer and a signal processing system. Here, bioreceptor is a biological component that is generally composed of antibodies, nucleic acids, enzyme, cell, etc. that recognizes target analyte and transducer is a physiochemical detector that converts the biological signal into a measurable signal.

It is based on the principle that when immobilized biological material comes in contact with target biological material that has to be recognized *i.e.* analyte then they bind together to forms bound analyte. During that recognition event, some types of reaction occurs that leads to the production of a new chemical, the release of heat, the flow of electrons and changes in pH or mass etc. As immobilized biological material is in intimate contact with the transducer, it converts the reactions caused by the bounding of biological material and analyte into measurable signals. This measurable signal is further amplified and measured.

Biosensors can be classified based on biological signal and transducing mechanism. Under the group biological signal, it can be enzyme-based, immunosensors based, cell-based, nucleic acid-based and biomimetic. Under the group transducing mechanism, it can be electrochemical, optical, piezoelectric, calometric and Ion-Sensitive FET (ISFET).

Biosensors have various applications in agriculture. It has applications in measuring the amount of herbicides, pesticides and heavy metals in soil, detection of toxins and agricultural by-products etc. Nowadays, it is also playing important role in managing plant diseases. Various types of biosensors are used for managing plant diseases as it is portable, highly sensitive, specific, easy to use and can be used for early detection. Different scientists developed different biosensors for different types of a

plant pathogen. Here are some examples. Biosensors for detection of fungus *Phakopsora pachyrhizi*. An acoustic-based biosensor (the Quartz Crystal Microbalance) for detecting *Ralstonia solanacearum*, *Pseudomonas syringae pv tomato* and *Xanthomonas campestris pv. vesicatoria* etc. Now, nanomaterial-based biosensors are also available for detecting plant pathogens such as Fluorescent silica nanoparticles (FSNP) conjugated with antibodies for detection of *Xanthomonas axonopodis pv. vesicatoria* which causes bacterial spot disease in tomatoes and peppers and Copper oxide (CuO) nanoparticles-based biosensors for detection of the *A. niger* fungi.

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44. Role of Reactive Oxygen Species in Plant Defence against Pathogens

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Introduction

Invasion of plant pathogen into the host plant and further infection extension leads to huge damage of the plant cells and tissues. Plant has its own signalling system in order to combat the infection by the devastating microbes. As soon as it receives the signal of the attempted invasion, there are a number of metabolic activities activated to obstruct the damage. Generation of reactive oxygen species (ROS) is one of the broad range plant defence responses in response to attempted invasion by a pathogen. The toxic properties of these molecules impose challenge to the pathogen invasion and limits the infection. In short ROS act as weapons in mounting defence response against the foreign elements generally through oxidative burst.

Reactive oxygen species (ROS) as preliminary source of defence

The exposure of plants to unfavourable environmental conditions increases the production of reactive oxygen species (ROS) such as, singlet oxygen ($^1O_2$), superoxide ($O_2^{\bullet-}$), hydrogen peroxide (H_2O_2), and hydroxyl radical ($OH^{\bullet}$). Reactive oxygen species (ROS) exhibit a potential role in plant defence against the invasion of pathogens, but their role in defence against insect pests does not have a consistent and firm evidence. There are specific number of ROS which have a central role in withstanding the biotic and abiotic stresses in plants. The most commanding forms of ROS are superoxide anion ($O_2^{\bullet-}$), hydrogen peroxide (H_2O_2), and hydroxyl radical ($OH^{\bullet}$). Apostol *et al*., (1989) stated that generation of ROS like superoxide (O_2^-) and H_2O_2 is a rapid defence action against invading pathogen at the site of invasion. The produced superoxide, H_2O_2 can thereby diffuse into the host cells and in-turn activate many of the plant defence signals, including programmed cell death (PCD).

Since these molecules are highly dynamic and reactive, they have the ability to destruct the cells through oxidative burst. The accumulation of ROS as a response to the pathogen attack through localised oxidative burst or slow release activates the complex regulatory network of numerous signalling cascades either divergent or overlapping that acts as a base for priming the plant to fight against the disease. The rapid accumulation of plant ROS or oxidative burst at the site of pathogen invasion, is toxic to pathogens directly and can lead to a hypersensitive response (HR) that results into localised death of cells in a particular zone, which limits the further spread of the infection. Hydrogen peroxide, produced by host cells in response to pathogen invasion, triggers the HR this further leads to the strengthening of cell walls by enhancing lignin formation by catalysing phenyl-propanoid pathway. These ROS that are directly toxic to the pathogens, activate the oxidative cross-linking of the cell wall at the site of attempted infection and participate in signalling the onset of other defence responses.

Delledonne *et al*., (2001) concluded that SOD-mediated dismutation of O_2 to H_2O_2 is

required to activate cell death, which depends on synergistic interactions between NO and H_2O_2 since Diethyldithiocarbamate (DDC), the SOD inhibitor abolished hypersensitive cell death induced by NO in soybean cells undergoing an oxidative burst.

Sources of reactive oxygen species in the line of defence

ROS generation is a dynamic process which takes into account cross talking of various signalling pathways. Organelles with a highly oxidizing metabolic activity or with an intense rate of electron flow, such as chloroplasts, mitochondria and microbodies, are a major source of ROS production in plant cells. There are certain oxidative ion-generating systems which form the source for ROS production like cellular superoxide-generating systems which includes NADPH oxidase, xanthine oxidase, leakage from electron transport systems (ETS). Depending on the species, tissue or developmental stage of a plant, either the NADPH oxidase-dependent or apoplastic peroxidase-dependent oxidative burst will be in operation as the predominant source of ROS. Apoplastic peroxidase-dependent or the NADPH oxidase-dependent oxidative burst is set into operation depending on the developmental stage, species and tissues of the host plant. These systems lead to the formation of superoxide by reducing the molecular oxygen by a single electron. In addition to these systems, there are mechanisms through which hydrogen peroxide is produced directly from heme proteins, such as heme molecule itself and some class III peroxidases by abduction of iron-superoxide without the intervention of superoxide dismutase (SOD). High pH favours the production of hydrogen peroxide by oxidation by the peroxidases enzymes in the presence of a number of reducing agents.

Apart from these there are certain environmental sources of ROS generation and form a complex correlation with disease obstruction. Ionising and non-ionising radiations, nutrient availability, water scarcity, metal stress etc are the environmental factors that can lead to oxidative burst.

Modulation of ROS signalling

ROS signalling in plants is controlled by production and scavenging. Different biological or environmental signals feed into the ROS signalling network and disturb the ROS stability in a compartment-specific or even cell-specific manner. Abrupted ROS levels are perceived by different enzymes, proteins or receptors and modulate different metabolic, developmental and defence pathways. The localization, intensity and duration of different ROS signals are determined by cross talking between the ROS-producing and ROS-scavenging pathways of the cell. ROS are perceived by different ROS sensors and activate cellular responses. These ROS-scavenging pathways are also responsible for maintaining a low steady-state level of ROS on which the different signals can be initiated. Modulation of ROS levels also involves a positive feedback loop between ROS perception and ROS production. In addition to activating or suppressing different cellular responses, ROS perception can affect growth and development. In this way ROS plays vital role both in defence and developmental processes.

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45. Mechanism of Soft Rot Development

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Soft rots caused by the gram-negative bacteria are one of the most destructive disease in vegetables and fruits resulting in heavy losses by mainly affecting the fleshy storage organs. The bacteria like *Erwinia*, *Pectobacterium* are mainly involved in causing soft rot disease. Soft rots are especially important in cases of soft tissues. For example, when *E. carotovora* is inoculated on potato a white rot occurs: but within 24 hours, a black margin may develop, this is the plant response the virulence is generally associated with

high dehydrogenase activity. It may be recalled that phenols/catechol, etc., may be oxidized in presence molecular 0_2 and phenol oxidize catecholase to dark oxidation products namely, quinones which inhibit the growth of plant pathogens.

In the presence of electron donors (reducing agents). The phenols remain in non-oxidised stage, which is necessary for continued growth of the pathogen. Thus, the initial spread of the pathogen was explained by the action of the cell bound bacterial dehydrogenase which maintained the potato phenols in a reduced state (even in the presence of phenol oxidase). However, the spread of the pathogen is restricted if bacterial pectinase is excreted: because pectinase diffusion spreads in advance of the pathogen and releases by disorganising host cells

Phenol oxidase of the host which oxidises phenol forming black margin the oxidation products of phenol also inhibit pectin depolymerization enzymes. Thus, the symptoms depend on the delicate balance of de-hydrogenase, pectinase and phenol oxidase. Higher reducing opacity of diseased tissue is characteristic of bacterial host pathogen interactions.

Hydrolytic enzymes (pectinase, cellulase, etc.) are generally involved in causing rots and wilts. The pectic enzymes are classified on the basis of the nature of cleavage of 1,4 glycosidic bonds (hydrolytic or trans-eliminative), preference of substrate (pectic acid or pectin/poly methyl) and position of cleavage (random (endoenzyme) or terminal (exoenzyme) thus there are thus, at least, nine pectic enzymes. The pectic enzymes breakdown the middle lamella causing maceration phenomenon, while cellulases help in the breakdown of the cell wall Sometimes, cellulose, hemicellulose proteases, etc. can make hole in the secondary wall to reach the primary cell wall and middle, As the cell wall composition is different in various species, the relative importance of cellulases or proteases also vary.

The released Protoplast after the action of cell wall degrading enzyme lose water by exo osmosis, plasmolysis and collapse, resulting in watery condition and rotting later. The bacterium multiplies in the intercellular space and their enzymes act in advance and prepare the tissue for further maceration, tissue collapse and rotting. The macerating enzyme has been identified as endo-PAG. endo-PMG, endo-PML and endo-PAL. PAL may also cause cellular leakage and cell death. Endo-PAL of *E. carotovora* induced electrolyte loss, maceration and cellular death of potato tissues. When potato tissues were incubated with endo-PAL, it released several enzymes into the incubation medium. PAL and endo-PAG were also involved in symptom production through the generation of peroxidases. It appears that regulation Lpf, PAL synthesis is related to pathogenesis of soft rot bacteria, several pectic enzymes have been purified and the presence of 4 isoenzyme fractions of PAL in *E. chrysanthem*i has been shown; three of these having isoelectric point of pH 7.9 and higher, can injure and a cerate plant tissue; while the fourth fraction having isoelectric point of pH 4.6 can neither injure nor macerate. The involvement of a wall modifying enzyme' which may not degrade pectin/pectic acid has also been implicated.

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46. Applications of Nanotechnology in Plant Disease Management

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Introduction

Nanotechnology, the most captivating and rapidly developing science is succeeding in finding its place in various disciplines of science and technology. Nanotechnology is eagerly being looked for its potentials in different fields such as medicine, biotechnology, industrial sciences, plant sciences, agricultural sciences, electronics and many others. When every other scientific field is eyeing on this novel technology the Plant pathologists are also interested in analysing the ways in which this newly emerging science can be utilised for the management of plant disease. Nanotechnology, as its name indicates, is the technology which deals with study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. The idea of using nanoparticles for plant disease management is very fascinating and can prove very effective with the further development of this technology. The nanoparticle can be directly applied in soil or seeds or foliage to protect plants from pathogen population. Metal nanoparticles like copper, silver, titanium oxide and zinc oxide has extensively been researched for their properties to inhibit fungal, bacterial and viral pathogens.

Application of nanotechnology

When a material is reduced to nano size, it acts differently and expresses new properties which are entirely different from the macroform and thus

needs more attention. Nanoparticles can be used for management of plant disease in two ways- either by providing protection to crops by themselves or by acting as carriers for the application of pesticides. The use of nanoparticles as carriers is considered beneficial over the regularly used chemicals due to its numerous benefits such as increase in the efficacy of nanopesticides even under adverse environmental conditions, enhancing the shelf life, increasing water solubility of poorly soluble pesticides, reduced toxicity, enhancing stability and thus reducing the number of pesticide sprays.

Various nanoparticles themselves act as crop protectants. The very famous and popularly used nanoparticle in the field of plant pathology is Chitosan. It has been reported to show to antimicrobial properties along with low toxicity levels. It is highly favourable because of its biological properties such as biocompatibility and biodegradability. It also induces resistance in plants against various viral diseases such as Bean mild mosaic virus in beans and mosaic virus of potato, cucumber, peanut etc.

Titanium dioxide, silver, copper and many other nanoparticles have been identified for their antimicrobial potential. There have been reports of use of Titanium dioxide as a fertilizer which showed inhibition of bacterial pathogens and inactivation of viral pathogens in plants. Poly-dispersed nanoparticles of gold are also reported to confer resistance against Barley yellow mosaic virus. Silver nanoparticles are very famous amongst various metal nanoparticles used, due to green synthesis production in plant, fungi, bacteria and yeast. Though the silver nanoparticles have immense potential in inhibiting fungal and bacterial plant pathogens, some factors such as its production, interaction with soil and toxicity factors still needs to be considered for its wider applications.

Nanoparticles as Pesticides

Nanoparticles have also proved to be efficient carriers for various pesticides (including insecticides, fungicides and herbicides). In the field of plant pathology initial studies on nanofungicides were conducted on incorporating fungicides into solid wood in 1997. Since then various studies have been conducted on the use of various nanoparticles as carriers. The most commonly studied nanoparticle carriers were polymer mixes, silica, and chitosan. A number of fungicides have been loaded into various nanoparticles, such as Pyraclostrobin, Chlorothalonyl and Tebuconazole, to increase the solubility of these fungicides and their efficacies were observed against several plant pathogens. These studies showed the slow and persistent release of the active compound which resulted in less efficiency in the first few days but after 6-7 days better result was observed. Nanosized calcium carbonate when used for encapsulation of Validamycin against *Rhizoctonia solani* under *in vitro* conditions gave similar results. Similarly, Chitosan–lactide copolymer when used as a carrier for Pyraclostrobin used against *Colletotrichum gossypii* showed increased inhibition after seven days of treatment compared to sole application of Pyraclostrobin. In several other similar studies less efficacy of the nanoparticle-based fungicides was observed due to some faulty parameters such as inadequate size and stability of the formulation or some changes in the properties of the nanoparticle when applied. These are some of the factors that needs to be paid attention while use of nanoparticles.

Nanoparticles in detection and diagnosis

One of the important aspects in the field of plant pathology is detection and diagnosis. Apart from the management of plant diseases, nanoparticles also play vital role in the detection of the plant pathogens and thus broadly contribute to the field of plant pathology. Nanoparticles can be used as biomarkers for detection of disease diagnosis. *Xanthomonas axonopodis pv. vesicatoria* were detected by using Fluorescent silica nanoparticles, in combination with anti- bodies. Karnal bunt of wheat caused by *Tilletia indica* was detected using nano-gold-based immunosensors utilising surface plasmon resonance. Seed certification and plant quarantine are important components of plant disease management and use of these sensors may prove highly effective in detection of microbial patterns.

Advantages

These nanoparticles inhibit the growth of pathogen in various ways such as either by disrupting the fungal mycelium or preventing the spore formation of the fungal pathogens whereas by cell lyses in case of bacterial pathogens and also play a vital role in host pathogen interactions. The advantages of using nanoparticles over the conventional pesticides is that it reduces the use of active ingredient about ten to fifteen times, increases the solubility of compound, reduces the dosage of the chemical, it has a slow release mechanism thus has high efficacy and frequent repetition of the sprays can be avoided which will not only reduce the buildup of chemical load on the environment but also reduce the risk of increased health issues due to increased chemical applications. Some of the nanoparticles also act as plant growth promoters which leads to a healthy plant and a healthy plant is adequately self-sufficient to fight a number of plant pathogens and can be free from diseases, giving its maximum potential for yielding a good produce.

Constraints

Presently most of the researchers are focused on the use of nanoparticles in management of plant diseases and its implications on the plant pathogen interactions. Some of the studies are giving positive results in this regard but practical and broad-based applications will only be possible after a long-term experimentation studying each and every aspect of this uprising technology. Since the field of agriculture studies is closely related to humans the study of the repercussions of this new technology needs to be studied very diligently. Since the conversion of macromolecules into nanopartical leads to variable responses of the compounds in different ecosystems there may be some adverse impacts of their usage under certain conditions which is a major drawback.

Conclusion

With all its pros and cons nanotechnology is slowly and slowly heading towards a successful future. Nanoparticles can be utilised to a greater advantage in the field of agriculture and can simultaneously play a great role in plant protection in the coming future. Since only a handful of studies have been conducted in this regard more research needs to be conducted studying the effect of this technology on the environment and its interaction with the biotic and abiotic components prevailing in its surrounding and its impact on human. For drawing a conclusion on the use of nanoparticles in agriculture long term trials need to be conducted and each and every parameter needs to be observed more closely and specifically. Since every branch of science is interdependent of one another therefore there is a need to study Nanotechnology keeping in consideration various other disciplines of science to get a strong and effective outcome.

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47. Mechanism of Variability in Fungal Plant Pathogens

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Introduction:

Variability is the property or ability of an microorganism to change its personal behavior from one generation to another. The structure and evaluation of population of phyto pathogenic fungus are influenced by mutation, selection, recombination, genetic drift and migration. Variability in fungi play important role to overcome novel sources of disease resistance in crops and acquire tolerance to toxic chemicals. Knowledge about extent, evaluation and occurrence of variability in causing agent is important for sustainable disease control by host plant resistance (HPR) or fungicides (Agrios -2005). Genetic variability, in which the major roles play by population for biodiversity. Because without variability, it becomes not easy for a population to adapt to climatic changes and therefore makes it more prone to extinction. Genetic variability also underlies the differential susceptibility of organisms to diseases and sensitivity to toxins or drugs.

Chen *et al.*, (2009) reported that mutation is the cause for changes in the structures of races, distribution frequency, and diversity among different isolates of *Puccinia striformis f. sp. tritici* collected from different regions. Abang *et al.*, (2006) reported that sexual recombination play an important role in high genetic diversity among population of *Colletotrichum gloeosporioides* collected from different agroecological zones.

Forgan *et al.*, (2007) reported firstly proved of asexual genetic exchange in *Rhynchosporium secalis* in which highly genetic variation observed and also contribution to parasexuality into the variation.

Mechanisms of variability in fungi:

Mutation: A mutation is a more or less abrupt change in the DNA sequence of an organism, which is then transmitted in a hereditary manner to the progeny. It can also be induced artificially exposing the organism to UV lights, X-rays, Y-rays, extreme temperature or to highly reactive chemicals. Mutations can results from DNA copying mistakes made during cell division, exposure to ionizing radiation, exposure to chemicals *i.e.* known as mutagens. Variability through mutation has been observed in *Phytopthora infestans*, *Puccinia graminis* and *Venturia inaequilis*.

Sexual recombination: Recombination occurs primarily during sexual reproduction in organism. It takes place during the time of meiotic division of zygote as a result of genetic crossover. The origin of new pathotypes through meiotic recombination occurs in rusts, smuts, powdery mildew and late blight fungus. Abang *et al.*, (2006) reported that sexual recombination play an important role in high genetic diversity among population of *Colletotrichum gloeosporioides.* For example more than 200 pathotypes of *Puccinia graminis* f. sp. *tritici* are considered to develop through meiotic recombination during sexual reproduction.

Gene and genotype flow: Gene flow is the process by which certain alleles (genes) move from one population to another geographically separated population. It is the process that introduces new genetic variation. Gene flow is very important because it deals with the movement of virulent mutant alleles among different field populations. In pathogens reproducing only asexually, in which no recombination occurs, entire genotypes can be transferred from one population to another. This is known as **genotype flow.** Pathogens that produce hardy spores or other propagules, such as rust and powdery mildew fungi that can spread over long distances can distribute their genomes over large areas, sometimes encompassing entire continents.

Genetic drift: It is a random process that can lead to unpredictable changes in pathogen populations over a short period of time. Pathogens that exist in large populations have a greater potential for evolution than pathogens that exist in small populations. Cultural practices, including chemical control, which regularly reduce pathogen populations in the field are less diverse and much slower to adapt in populations that are allowed to maintain

high populations year round. An extreme example of genetic drift is the population of the *Phytopthora infestans* pathogen that causes late blight of potatoes.

Parasexuality: Parasexual cycle is a process in which karyogamy, plasmogamy and haplodization (non meiotic process) takes place in a sequence but not at specified points in the life cycle of a fungus. It is a mechanism where by recombination of hereditary properties occur within fungal heterokaryons or general recombination can occur in vegetative thallus in the absence of a sexual stage; the process is termed as parasexualism. In this process genetic recombination is achieved through mitotic crossing over and haplodization. It is also called somatic recombination. G. Pontecorvo and J.A. Ropper (1952) discovered parasexuality in *Aspergillus nidulans*, the imperfect stage of *Emericella nidulans*. In majority of Deuteromycotina, true sexual cycle is absent but derives many of the benefits of sexuality through this cycle.

Heterokaryosis: Heterokaryosis –In fungi, a condition in which hypha has nuclei of two different genotypes. Heterokaryosis provides haploid organisms with many of the advantages of heterozygosity enjoyed by diploid organisms. It is certainly a way in which avirulent strains may acquire virulence or weakly virulent strains may achieve increased virulences. Heterokaryosis discovered by Hensen & Smith (1932) in *Botrytis cinerea*.

Formation of heterokaryotic mycelium: By anastomosis, *i.e.*, plasmogamy between two genetically differing hyphae resulting in the entry of nuclei of different strains from one hypha into the cytoplasm of the other. **By mutation** in homokaryotic multinucleate cells of a hypha followed by multiplication and spreading of the mutant nuclei from cell to cell in the hypha. **By diploidization**, *i.e.*, fusion between two genetically similar nuclei of a homokaryon, the multiplication and spreading of the diploid nuclei among the haploid nuclei of the homokaryotic cells of the hypha. **By the germination** of a heterokaryotic spore giving rise to a heterokaryotic hypha.

Variability in fungi studied through: Cultural characteristics**,** pathogenicity**,** fungicide resistance**,** vegetative compatibility**,** nuclear DNA polymorphism – RFLPs, RAPDs

Vegetative compatibility: In fungi, vegetative hyphae of the same colony, or of two colonies of the same species, coming in contact with each other, often fuse and the fusion is called hyphal anastomosis. If, however, hyphae coming in contact belong not to different strains of the fungus but of the same species, no fusion of hyphae takes place and the phenomenon is called vegetative incompatibility. In few filamentous fungi, such as the species *Thanatephorus cucumeris*, the telomorph of *Rhizoctonia solani*, does fusion incompatibility occur between distantly related strains that appear to be different species.

Fungicide resistance: The appearance of fungicide resistance has become an important factor due to variability in phytopathogenic fungi. Fungicide resistance may result from single or multiple gene mutation.

Fungicide resistance mechanisms: An altered target site which reduce the binding of the fungicides. The synthesis of alternative enzymes capable of substituting the target enzyme. The overproduction of the fungicide target. An active efflux or reduced uptake of the fungicide. A metabolic breakdown of the fungicide resistance.

The problem of variability can be managed through: Use of host with polygenic resistance, Use of multiline and mixtures, Constant surveillance and monitoring Rotation in space and time Gene deployment (Regional deployment of R genes), Gene pyramiding

Conclusion: Genetic variability in a population is important for biodiversity because without variability, it becomes difficult for a population to adapt to environmental changes and therefore makes it more prone to extinction. The structure and evaluation of population of phytopathogenic fungi are affected by mutation recombination, genetic drift and parasexual cycle. Knowledge about extent, evaluation and frequency of variability in pathogen is important for sustainable disease management through host plant resistant (HPR) or fungicides.

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48. Wilt Disease of Guava and their Management

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Introduction -

In subtropical countries guava is an important fruit crop. It is mostly grown an all states of India. Guava is a hardy crop and cultivated successfully. In neglected soils and this fruit crop attacked by large number of pathogens specially fungi. Wilt is the most important and destructive disease of guava in India and due to this disease substantial losses occurs. Fusarium wilt disease of guava from India was first reported in 1935 from Allahabad. The disease is soil borne and is difficult to control. Wilt is predominantly caused by the species of Fusarium, of which *Fusarium oxysporum* is generally the main cause. Disease affected plants show complete mortality and causes nutritional as well as monitor total loss.

Disease Symptoms:

First symptoms start with the onset of monsoon. Appearance of light yellow foliage with loss of turgidity and epinasty. Plants at later stage, show unthri ftyness. Subsequently, premature shedding and defoliation. Some of the twigs become bare and fail to bring forth new leaves or flowers and eventually dry up. Fruits of the all affected branches remain underdeveloped, hard and stony. Later, the entire plant is defoliated and eventually dies. The roots also show rotting at the basal region and bark is easily detachable from the cortex.

Symptoms on fruits

Light brown discoloration is also noticed in vascular tissues. The pathogen attacks young as well as old fruit bearing trees but older trees are more prone to the disease. In month of august plants leaves become yellow with intervenial chlorosis and during September generally leaves are droop but in month of October complete wilting of plants show hanging of the branch of dried leaves and black fruits. In this disease partial wilting is common symptom of wilt disease of guava. In partial wiliting terminal branches are drying, yellowing of leaves and drooping of leaves.

Symptoms on Leaves

Causal organism:

Fusarium oxysporum f. sp. *Psidii* and *Fusarium solani*

Disease CYCLE:

Management:

Disease management through cultural practices:

In wilt disease control proper sanitation of guava fruits orchard and uprooted bor burnt wilt affected plant and around the tree truck should be dug a trench. Severely damaged plants are not transplanted. Properly maintenance of tree vigour inter-culture activities, manuring and irrigation them to enable withstand infection. Before transplanting the pits are treated formalin and covered 3 days and after 2 weeks

plants are transplanted. In month of May- June soil solarization with transparent polythene sheet should be followed. Intercropping should be follow with turmeric or marigold to check the wilting of guava.

Disease management through chemicals:

Wilt disease of guava control through chaubatia paste but this control measure is not considered valid, as guava wilt is a soil borne disease during 1949. This disease control by pruning and drenching of soil with 0.2% bavistin or benlate and spray metasystox and zinc sulphate twice. But pruning does not control wilt due to soil borne nature of this disease.

Disease management through varietal resistance:

In India none of the guava verities reported free from wilt incidence. Some guava species *Psidium cattleianum* var. *lucidium* and *Syzigium cumini*, which seldom get attacked with wilt, may be an effective way for the control of wilt disease of guava. In Taiwan was reported resistant a local variety pei-pa and *Psidium friedrichsthlianum* has been recommended as possible rootstock identified f1 population *of Psidium molle* and *Psidium guajava* free from wilt.

Disease management through bioagents:

In wilt disease management use of different bioagent *Strichoderma harzianum*, *Trichoderma viride*, *Gliocladium virens*, and *Streptomyces chibaensis*, *Trichoderma viride* is best for the control of wilt disease.

Disease management through botanicals:

In vitro condition garlic extract produced maximum inhibition of *Fusarium solani*.

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49. Circadian Clock and Plant Pathogen Interaction

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Introduction

The daily environmental changes were attributed by the rotation of the earth which has its influence on the organisms and they are adapted to the 24-h periodic transition in the environment and react accordingly. This endogenous mechanism in the plant is controlled by "Circadian clock". It is defined as the endogenous mechanism responsible for adjusting physiology and metabolism to specific times of day (Harmer, 2009).

Circadian clock

"Circadian" is the Latin word which means "about a day". It is the internal time keeping mechanism which is operating for the period of 24 hr. Most organisms possess a circadian clock includes organisms such as bacteria and fungi as well as plants and animals (Doherty & Kay, 2010). This circadian regulation occurs in all species but has been extensively studied in mice, *Drosophila* (Ceriani *et al*., 2002), *Neurospora* (Nowrousian, 2003), *Arabidopsis thaliana* (Salome & McClung, 2004) and rice (Filichkin *et al*., 2010).

Plants undergo endogenous rhythms in the presence or absence of environmental signals in cycle with the 24-hour period. These have been named circadian rhythms (McClung, 2001). The circadian rhythms are the oscillation of metabolic, physiological and behavioral processes (Nakamichi, 2011). The first observation of circadian rhythms was observed by French astronomer De Mairan in 1729. De Mairan noticed leaf movement in heliotrope plants and tested his theory by transferring the plants to dark conditions (McClung, 2006). All circadian rhythms share three basic properties includes they persist even under constant conditions; the system is in continuous interaction with the environment and the system is temperature-compensated.

Circadian system

The circadian system regulates several aspects of plant development such as flowering time, hypocotyl elongation (Schultz & Kay, 2003), seed germination, leaf movement, cellular processes, stomatal opening, photosynthesis, carbon fixation and stress response (Yakir *et al*., 2007). The circadian system contains three conceptual components: the input (entrainment) pathways (light & temperature), the central oscillator (clock), and the output pathways **(**Somers, 1999).

The input pathways include light and temperature. The input pathways then entrain the central oscillator. Light is mediated through plant photoreceptors *phytochromes* (*PHY*) and *cryptochromes* (*CRY*). The central oscillator contains a subset of proteins forming multiple feedback loops, controlling each other and generating a period of approximately 24h. The output pathways contain several overt rhythms such as leaf movement, flowering time, stomatal opening, seed germination, nutrient uptake, and defense against pathogens.

Input pathways: light and temperature

The circadian system contains two input pathways: light and temperature. The clock can be reset by changing of these two variables. The input pathways convey environmental information, which entrains the central oscillator (clock). The plant photoreceptors are classified as phytochromes

(PHY) and cryptochromes (*CRY*). Phytochromes absorb the red and far-red region of the spectrum and cryptochromes absorb blue light (Devlin & Kay, 2001). Temperature is another environmental signal that resets the circadian clock, although the mechanism is less well understood (McClung, 2006).

Central oscillator

The clock (central oscillator) generates a 24-hour rhythm, which regulates certain physiological processes of plants occurring at the optimal phase of the light–dark cycle (Fankhauser & Staiger, 2002). The central oscillator is the core of the circadian system and consists of multiple rhythmic behaviors controlling multiple physiological processes (Más, 2005). The core feedback loop contains three components: two morning-phased Myb-related transcription factors *CCA1* and *LHY*, and the evening-phased and clock-regulated *TOC1* (Harmer, 2009). During the day, in the first loop (the core loop), the *CCA1* and *LHY* proteins bind to the *TOC1* promoter and inhibit the expression of *TOC1*. Thus, *CCA1* and *LHY* function as negative regulators (elements) of *TOC1*. Shortly before the evening, the levels of *CCA1* and *LHY* decrease and *TOC1* expression increases. At the end of the night, *TOC1* induces the expression of *CCA1* and *LHY*. *TOC1* thus functions as a positive regulator (element) of *CCA1* and *LHY* (Alabadí *et al.*, 2001).

Output pathways

Output pathways such as flowering, photosynthesis, cold, salt and drought tolerance, hypocotyl growth and nutrient uptake and metabolism are controlled by the following genes: *CCA1*, *LHY*, *TOC1*, *ELF3/4*, *LUX*, and *GI* (Pruneda-Paz & Kay, 2010).

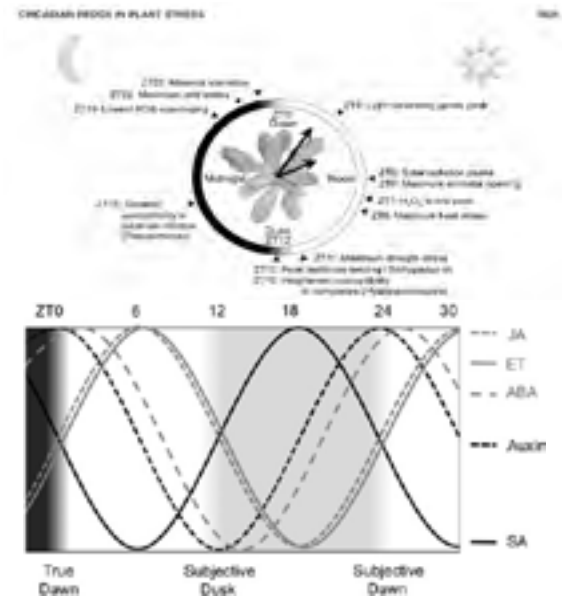
Circadian system of fungus

The central clock proteins Frequency (FRQ) and white collar complex (WCC), which consists of the transcription factors white collar-1 and -2 (WC-1 and -2, respectively), are the classical elements of the interconnected transcriptional/translational feedback loops in *N. crassa* (He *et al.*, 2005).

Plants are continually subjected to biotic and abiotic stress. Incidence of many of these stresses fluctuates over the 24-h cycle. The stress reaction in the plants based on the circadian oscillation as given by Spoel and Ooijen (2014).

Also, the hormone levels are found to oscillate and the effects of hormone stimulus will be more or less pronounced depending on the time of day. For example, circadian regulation of hormone signaling and has been found for auxin (dawn-phased), abscisic acid (ABA, early morning-phased), jasmonates and ethylene (JA and ET, midday-phased) and salicylates (SA, midnight-phased) (Spoel and Ooijen, 2014).

The direct regulation by the circadian clock on stress signaling, enhances the ability of the plant to prepare for severe conditions and to gate appropriate responses in a timely manner, thereby providing an efficient way to maximize metabolic efficiency and to improve plant fitness. Plants anticipate daily fluctuations of ambient biotic and abiotic stresses, which activate molecular and physiological responses at the corresponding time to ensure adaptive fitness.



Conclusion

From this it is understood that, every organism has a unique 24 hr cycle to regulate its normal functions. Any deviations in this cycle lead to suffering in the plant which may be due to the biotic factors (pest & pathogens) and abiotc factors (environmental factors). So, detailed study on this circadian cycle will helps to elevate the plant health by managing the factors with affects the plant health.

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50. Bacterial Bioagents: Safest Strategy of Plant Disease Management

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Introduction

The indiscriminate and extensive use of pesticides in recent years has posed a serious problem of pollution in the eco-system and development of resistance in the pathogens. In this context, biological control strategy of the pest management has been found ecofriendly, less expensive and offer marketable products free of hazardous chemicals. Many genera belonging to fungi, bacteria, actinomycetes and viruses are used as a biocontrol agent to combat several important plant diseases.

Biological Control

The reduction of inoculum density or disease producing activities of a pathogen or parasite in its active or dormant state, by one or more organisms, accomplished naturally or through manipulation of the environment, host or antagonist or by mass introduction of one or more antagonist.

Characteristics of Ideal Biocontrol Agents

It should grow fast. It has un-damaging nutrient and environment requirement. It should be good at primary resource capture to colonize organic, new plants and seedling. Isolation and culturing them should be easy. It should be non-pathogenic to plants, humans and domestic animals. It should be stress tolerant. It should have capacity to parasitize more than one pathogen.

Significance

Enhance seed germination. Better seedling emergence. Improve root system. Increase plant growth and development. Increase plant yield. Reduce plant diseases. Inexpensive. Environmentally safe.

Mode of Action

- Antagonism
- Antagonist
- Antibiosis
- Antibiotic production

Antibiotic produced play a vital role in antagonist and pathogen interaction leading to disease suppression. Certain strain of bacterial antagonist produce diffusible secondary metabolite that inhibit other bacteria and fungi.

BACTERIA	SECONDARY METABOLITE
Pseudomonas fluorescens	2, 4 Diacetylphloroglucinol, Sorbisitin Al & B, Pyrrolnitrin, Pyoluteorin, Oomycin A
Bacilus sp.	Surfactin

Siderophore Production

Bacterial bioagents produces water soluble fluorescent siderophore, which act as high-affinity iron chelators that inhibit the growth of fungi and bacteria through iron deprivation under iron limited condition. As siderophore sequester the limited supply of iron in the rhizosphere, they limit its availability to pathogens and ultimately suppress their growth.

BACTERIA	SECONDARY METABOLITE
Pseudomonas fluorescens	Ferribactin, Ferrichrome, Ferroxamine B, Pseudobactin, Pyochelin
Pseudomonas aeruginosa	Pyoverdine

Limitation of Biological Control

It is slow process as complex interaction involved in control. Lack of funds. Lack of knowledge of factors which determine survival and colonization of the pathogen and antagonist are some of the limitation for quick adoption of the technology.

Bacterial biocontrol products in the market

Biocontrol agent	Target pathogen	Products
Bacillus subtilis	Corticium invisum, C. theae	Biotok
Pseudomonas fluorescens	Numerous fungal diseases	Biocure-B, Bioshield, Plant biocontrol, Agent-2
A. radiobacter strain K84	A. tumefaciens	Diegall, Galltrol, Norbac 84c
Bacillus subtilis Strain GB 03	Pythium ultimum, Rhizoctonia solani	Kodaik, Companion
Streptomyces griseovirdis strain K61	*Sclerotinia sclerotiorum, S. minor, Pythium* spp.	Mycostop

Conclusion

Bacterial bioagents are potential bioagents which act against various fungal, bacterial and nemic diseases. The bacterial bioagents used alone and in combination with fungicides, amendments, fungal bioagents have given better disease control and resulted into better yield. The bacterial bioagents have helped in better germination and plant growth, besides disease suppression. Therefore, bacterial bioagents have been found as primary component in integrated crop management of soil borne and certain other aerial fungal plant pathogens.

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51. Arbuscular Mycorrhizae: A Way Towards Sustainable Plant Disease Management

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Introduction

Sustainable disease management is a modern concept against the evolutionary battels among the host plant and phytopathogens. Biological control method is one of the best alternate routes in place of chemical management to control the pathogens. Most pathogens are soil borne, soil invaders or soil-inhabitants. Use of agro-chemicals to control the soil borne pathogen is the riskiest method in recent days due to its numerous negative effects in our environment. In recent era, use of arbuscular mycorrhiza (AM) is an emerging

concept to control various bacterial, fungal as well as viral diseases. Their symbiotic association with a wide range of plants not only help in plant disease control but also enrich the soil with many nutrients, improve soil health and plant growth etc.

What is VAM?

Symbiotic association of plant root with some fungal species is known as mycorrhiza. It is divided in to two types basing on their branching pattern: Ectomycorrhiza and Endo mycorrhiza.

Endo mycorrhiza normally penetrates the host root and lives there. It is also known as Vesicular-arbuscular mycorrhiza (VAM) due to the presence of vesicles and arbuscules for storing of lipids and penetration inside host root respectively. Ectomycorrhiza stay outside of host cell and produce network of mycelium surrounding the root surface which is termed as Hartig Net. These fungal species increase the nutrient (Mainly phosphorus) uptake by the host plant. Besides this, it also helps in plant growth by secreting growth promoters, improve soil health and increase yield (Figure 1).

FIG 1: The Multifunctional aspect of Arbuscular Mycorrhiza

AM and plant pathogens

AM fungi interact with wide range of rhizosphere pathogens and protect the host plant from their attack. A number of researches has concluded the potential effect of AM fungi in disease control or suppression of bacterial, fungal and viral population. Glomus mosseae can reduce the disease incidence by Pseudomonas syringae in soybean plant by inhibiting their population. In 2014, Maffei and his co-workers reported the mycorrhizal effect against potato virus Y in potato plant where mild symptom and increase in shoot growth is observed after mycorrhizal inoculation. Inoculation of *Glomus* spp has reduced the incidence of Rhizome necrosis and some external diseases in case of micro propagated banana (Xavier and Boyetchko, 2004).

Mechanism of Disease management

Physiological and Biochemical changes in host

The increased phosphorus availability in host root can alter the composition of phospholipids which modify the root cell membrane permeability. These biochemical changes avoid the pathogen to enter inside the root tissue. The entry and colonization of *Alternaria alternata* is reported to decrease in the maize plant which is pre-inoculated with *Glomus mosseae* (Xavier and Boyetchko, 2004).

Competition

The pathogen and the AM fungi compete each other for space and food. This competition may delay the entry of pathogen inside the host. But sometimes no competition is observed between AM fungi and pathogen.

Antibiosis

The antimicrobial substances secreted by the AM fungi has potential effect in suppressing the pathogen population. Antimicrobial material produced from the mycelium of *Glomus intraradices* can affect the conidial germination of *Fusarium oxysporum f.sp. chrysanthemi* (Xavier and Boyetchko, 2004).

Host nutritional factor

The root injury and photosynthate damage by the pathogen can be managed by AM fungi as they take a major role in nutrition availability and plant growth. The senescence of host by pathogen can be delayed as photosynthetic capacity of host increases due to AM fungi. The colonization of AM fungi can alter the root exudate composition which leads to the modification of microbial population and equilibrium near the root zone.

Alteration of Host immune system

High degree of coordination is required by both partners to regulate plant defence system. When phosphate supply increases, the host plant allow the fungi for colonization. After colonization, the plant regulates the fungal growth to prevent carbon drainage and excessive colonization, maintaining a symbiosis relationship. This induce the systemic resistance by friendly micro-organisms against the harmful.

Conclusion and future trend

Arbuscular mycorrhiza has a significant role in plant disease management. This is one of the advanced methods of crop protection in modern agriculture system. This eco-friendly and cost-effective method is very suitable where high dose of chemical fertilizers or fungicides are required in larger area. Many biotic and abiotic factors influence AM fungi like fungal aggressiveness and host plant response. The multi-functional aspects of AM fungi have made it one of the potential agents of Integrated disease management.

In future, more studies are required to explore more potential strains of AM fungi as very few fungal genera are discovered till now. Because of their sensitivity towards various biotic and abiotic stresses, more research is highly needed to study and improve their potential in field condition. The mechanism of action is yet to be discovered in near future to gather more knowledge on plant protection. The antibiotics

should be identified which plays an important role in plant disease management. Another key point is to increase awareness among the farmers to replace the conventional chemicals by this eco-friendly method. In arriving the above goals, the demand and application of AM fungi will surely increase in near future.

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52. Nanopesticides: Next Generation Precision Pesticides for Sustainable Crop Protection

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Introduction

Indian agriculture has come a long way since independence. The country has achieved self-sufficiency in food grain production and is in a position to export various food commodities to other countries. The tremendous growth in agriculture is mainly due to the new production technologies introduced during green revolution in early 1970s. High yielding crop varieties of wheat and rice were introduced for commercial cultivation with intensive application of chemical pesticides and nutrients. As a result, the production and productivity increased by many folds. Intensive agriculture brought some negative effects also as a number of pest and diseases emerged as major problem and caused epidemics in several parts of India. Worldwide insect pests cause an estimated loss of 14% (Pimentel, 2009). The major epidemics of insects such as brown plant hopper, armyworm and stem borer in rice, boll worm in cotton, fall armyworm in maize, fruit and shoot borers in various vegetables are being noticed frequently from several parts of India. Management of insect pests are most important in sustainable crop protection and production. One of the effective strategies of management of pests is the use of chemical pesticides. These are the chemical substances designed to control pests in various crops. Pesticide industry is growing every year and globally six billion pounds of pesticides are applied worldwide. In India alone, pesticides of worth INR 197 Billion was sold in market during 2018. They are being used in agriculture fields by different method of applications. They include, seed treatment, seedling dip, foliar spray, soil or stem injection methods. Based on the type of pests they control, pesticides are grouped as insecticides, herbicides, fungicides, nematicides, rodenticides, antibiotics etc. Large scale and injudicious application of pesticides created several negative problems like they could harm beneficial insects, birds, mammals along with causing environmental pollution. The serious problem created by pesticides raised concern among researchers and people to look for alternate form of pesticides. The pesticides which are precision in their action and non-harmful to environment must be explored. Nano pesticides are the best alternatives to chemical formulations which are gaining attention of researchers to solve the problems associated with chemical pesticides.

Nanopesticides

Nanopesticides are the pesticides incorporated within nanoparticles. Nanoparticles are very small molecules (Billionth of a matter) that are usually made of metals. Being smaller in size, they can cover larger surface areas and very low rate of nano pesticides would require covering a larger area with high precision. They do not break down easily and need not be applied frequently for pest control. Since they are encased in a capsule form, penetration and killing of targeted pests is possible more effectively. They also have lower efficacy on non-targeted pests and could reduce overall pesticide requirement. Nanoparticles with pesticidal action are silver nitrate, gold chromite, zinc oxide and zinc acetate, cadmium sulphide and zinc sulphide and carbon. They can be synthesized from different sources like plant and natural sources (Rai and Ingle, 2012).

Classification of Nano Pesticides

Nanopesticides are classified and described taking the chemical composition of the nanocarrier into account. These nanocarriers occurs in many forms such as

clay based nano-materials, lipid-based formulations, organic polymer-based formulations, nanosized metals and metal oxides, silica nanoparticles and layered double hydroxides.

Various Types of Nano Pesticides and their Advantages

Agrochemicals can be encapsulated with polymer-based nano materials like nano gels, micelles, nano spheres, and nano capsules etc. nanomaterials which are lipid based such as liposomes and also clay-based nanomaterials are available in market (Ohja *et al*, 2018). Essential oil based (EOs) nano formulations are useful in eco-friendly management of post-harvest pests during storage. Numbers of techniques are developed to encapsulate essential oils with different carrier materials for potential control of insect pests in storage. These EO based nanopesticides offer various advantages like uniform distribution on targeted pest, less reactivity with weather conditions, enhances ease in handling, decreases evaporation rate and safe delivery and action. They also do not cause any problem to human health (Urkude, 2019).

Conclusion

Nanotechnology and its application in plant protection are still in the early stages of development. Isolation and characterization of potential nanomaterials for their pesticide properties are being explored. Use of nano pesticides/nano pesticide formulations in agriculture could provide better plant protection when compared to chemical pesticides. Various types of pesticide formulations like microemulsion, nano emulsion, nano dispersion and nanoencapsulation of pesticides enhances the efficacy of pesticides by site specific delivery and action. In conclusion, nano pesticides hold tremendous promise for reducing environmental pollution due to conventional pesticides.

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53. Parasitic Action of Cordyceps on Insect Pest

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INTRODUCTION: *Cordyceps* belongs to the genus of ascomycete fungi (family: Clavicipitaceae, Hypocreales). This fungus plays an essential role in pest management by altering the behavioral patterns of the insects and it acts as entomopathogenic fungi on insects and produce secondary metabolites and antibiotics, which are harmful to insect species. The fungi of cordyceps replace the tissue of insects and sprouting in the insect body and it grown like a slender stem on the outer surface of the host body. These fungi are generally present in several parts of tree. Usually this fungus present in the forest which receives the highest rainfall.

Examples for insects which is infected by cordyceps species:

SI: NO	Species of cordyceps	Target insects
1.	*Cordyceps acridophila*.	Grasshopper
2.	Cordyceps. brongniartii	Anomala cuprea
3.	Cordyceps militaris	Bombyx mori
4.	*Ophiocordyceps*. *Michiganensis*	Scarabaeus sp
5.	Ophiocordyceps. Unilateralis	Camponotus pennsylvanicus

FIG: 1 Ant infected with *O. unilateralis*

FIG: 2 Grasshopper infected with *Cordyceps acridophila*

Mode of infection of cordyceps fungus on insect:

Attachment of fungal spores onto the insect body

The *cordyceps* fungus identified the host and infects through its the spore and formation of appressoria take place and fungal hypha penetrated itself onto the insect exoskeleton using enzymes like chitinase, lipase and protease with mechanical pressure and enter to the host body. Then fungal filaments will switch into yeast like cells, when fungal body reached to the hemocoel of the host and undergo budding and disrupt the host immune system. When the infection process over the death of insects takes place and dead insect become mycosed.

Climbing behavior

When the *cordyceps* fungus enters the insect body, it propagates and fungal cells found in various parts of insect body. Once the fungal spore attains a sufficient size it secretes sphingosine and guanidinobutyric acid (GBA) and hypoxanthine. Which affects the central nervous system of insects by altering of insect motor neuron, neural tissues of the cerebral cortex and brain function leads to neurological disorders in infected insect and finally infected insects climb the vegetation and adhere to the tree trunk.

Death grip

The infected insect is going to bite the underside of a leaf tightly and dies hanging in the tree. It helps the proper growth of the fungus and atrophication of the mandibles of insect due to secretion of fungal body and decreases in leucine concentration affect the muscle regeneration of insect and decrease in mitochondria number and calcium levels affects the energy of host and lack of ATP generation in insect respectively and finally mortality of insects takes place within 4 to10 days.

Factor influencing fungal infection on insect:

The environmental conditions like temperature, humidity and rainfall can influence the development of fungal infection on the insect population. Rate of infection of these fungi are noticed higher in monsoon season. Because higher rainfall at the beginning of season congenial for the development of fungus and influence in increasing rate of infection and it decreases during the hot weather conditions and density of spore, number of infected insects in that location also influences the rate of fungal infection.

Conclusion: *Cordyceps* fungi play an essential role in insect pest management as entomopathogenic fungi and they produce secondary metabolites like Polyketides, Naphthoquinone and antibiotics like patulin and compactin they are immunemodulatory, antitumor, antioxidant, hypoglycemic, hypocholesterolemic in nature, used in curing of various diseases and they are good source of nutrition as food%.

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54. What can Plasticity Contribute to Insect Responses to Climate Change?

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The term plasticity reflects how much the environment modifies phenotypic expression. Plastic responses allow an individual to respond rapidly to new conditions. Evolutionary responses are considered slower because they depend on selection changing the genetic constitution of a population across generation. To counter negative effects of both climate variation and climatic extremes, all organisms rely on the capability to adjust the expression of phenotypic values to environmental needs. All plasticity is physiological, but can manifest as changes in biochemistry, physiology, morphology, behaviour or life history. Expression of plasticity in insects from variable climates involves diapause, cessation of reproduction, suppressed metabolism, changes in the life history of insects, polyphenism, Extension of longevity, changes in the types of eggs or pupae produced by insects across a season. Climate variability can impose large fitness costs on insects showing diapause and other life cycle responses, threatening population persistence. In response to stressful climatic conditions experienced across developmental stages or by prior generations can influence hardening and acclimation (Sgro *et al.*, 2016).

Soil fauna communities are especially vulnerable to rapid climate change because of their limited dispersal ability. It is generally recognized that trans

generational effects can contribute to the expression of phenotypic plasticity. Tested for trans generational effects of heat shock exposure, in the soil arthropod *Orchesella cincta* a springtail species that regularly experiences heat stress conditions in its natural environment. Females were exposed to heat stress, and subsequently investigated the effects of the same stress on the survival of their offspring. Thermal resistance of the progeny from treated and untreated mothers was compared at three life stages: egg, juvenile and adult. Exposure to heat shock induces a life stage-dependent increase in thermal resistance in the subsequent generation. The induced adaptive maternal effect persisted into the adult stage of the progeny (Zizzari *et al.,* 2014). The afrotropical butterfly *Bicyclus anynana* shows striking seasonal plasticity for wing patterns and life history traits. This polyphenism is an adaptation to contrasting patterns of rainfall over wet and dry seasons, and is mainly determined by temperature. The extent of local adaptation of the developmental plasticity response to regional climate, compared with thermal reaction norms for several life history traits of two distant populations from regions with different temperature and rainfall associations was investigated. Results showed little geographic variation for life history traits. Traits that can be further modified by acclimation during the butterfly's adult life span (starvation resistance, resting metabolic rate and egg size) showed little geographic differentiation for their developmental plasticity. (De jong *et al.,* 2010).

Climate change means not only increases of temperature but also sudden decreasing temperature below than normal. A test was conducted to know the plasticity with respect to cold hardiness in the leaf beetle *Ophraella communa*. This beetle was introduced to control the spread of the common ragweed, *Ambrosia artemisiifolia*, in china. Hypothesis of this experiment is that the beetle, to be able to track host-range expansion into colder climates, can phenotypically adapt to cold temperatures across generations and questioned that whether parental experience of colder temperatures increases cold tolerance of the progeny. Specifically, the authors studied the demography, including development, fecundity, survival, as well as physiological traits like supercooling point (SCP) and glycerol content of *O. communa* progeny whose parents were maintained at different temperature regimes. Glycerol contents of both female and male in progeny was significantly higher and supercooling point of the progeny adults being significantly lower when maternal and paternal adults were cold acclimated as compared to other treatments (Zhou *et al.,* 2013)

Plasticity is one of the best mechanisms to cope up with sudden changing of climate. Plasticity may impose a large cost to survival but it can increase the fitness, generate novelty, facilitate evolution and forecasting the thermal safety margin. If the intrageneration plasticity increases the chance of survival within the generation during adverse climate, the trans generation plasticity increases the fitness of survival in the next generation offspring.

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55. Role of Steroid Receptors in Host Plant Selection and Rejection

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Introduction

A steroid is a biologically active organic compound with four rings arranged in a specific molecular configuration. Steroids have two principal biological functions: as important components of cell membranes which alter membrane fluidity and as signaling molecules. Several steroids are found in plants, creatures and growths. All steroids are fabricated in cells (Koolman, 1989). The significant insect's steroid are ecdysteroids, including the most organically dynamic structure 20-hydroxyecdysone (20E). The first ecdysteroid, was isolated by Butenandt and Karlson from silkworm. Today, it is understood that these steroids are available at all phases of bug advancement, controlling numerous biochemical and physiological procedures: in recently laid eggs, during early stage and post-early stage improvement, managing of advancement, transformation, multiplication and diapause.

(A) Plant Natural Products as Insect Steroid Receptor Agonist

1. Phytoecdysteroids agonists
2. Non-steroidal agonists

Phytoecdysteroids

Phytoecdysteroids is a class of synthetic substances that plants blend for safeguard against phytophagous insects. These mixes are emulates of hormones utilized by arthropods in the shedding procedure known as ecdysis. At the point when insects eat the plants with these synthetic substances they may untimely shed, get thinner, other metabolic harm may occur and die. Some plants that produce phytoecdysteroids include Tinospora, Serratula, Cordyceps, Asparagus and so forth.

Mode of Action- In the adult female, ovary is a source of 20-Hydroxyecdysone production. In adult males, fat body is the source of hydroxyecdysone. Its anologues called phytoecdysteroids are produced by various plants where these disrupt the development and reproduction of insect pests. In insects, 20-Hydroxyecdysone acts through the ecdysone receptor. The ecdysone receptor is a nuclear receptor, which controls development and contributes to other processes such as reproduction. The ecdysone receptor is a non-covalent heterodimer of two proteins viz., the EcR protein and ultraspiracle protein (USP). The ecdysteroid-restricting pocket is situated in the EcR subunit, however EcR must be dimerised with a USP for high-liking ligand binding. The authoritative of ecdysone to receptor prompts the initiation of ecdysone responsive qualities and numerous different qualities causing puffing of polytene chromosomes at over a hundred destinations. At last, the actuation course causes physiological changes that bring about ecdysis (shedding).

The ecdysone receptor additionally bind to and is actuated by phytoecdysteroids. Accordingly, phytoecdysteroids can mimic 20-hydroxyecdysteroid of insects, bind to insect ecdysone receptors and can initiate similar reactions. These phytoecdysteroids induced responses at inappropriate time and stage causes feeding deterency, abnormal development, ecdysis and finally death.

Uses of phytoecdysteroids

1. Improvement of silk yields (Ninagi and Maruyama, 1996)
2. Modification of ecdysteroid levels in crop species (Dinan,1998)
3. It is invertebrate pest control agent (Dhadialla et al., 1998).

Non-steroidal agonists are novel compounds that have become attractive candidates not only as pest control agents in agriculture but also as tools for research. Diverse non-steroidal ecdysone receptor agonist like tebufenozide, methoxyfenozide, chromafenozide, and halofenozide are very toxic to insects and safe for mammals.

Mode of action of non-steroidal agonists- Bio-analogues of ecdysones are called non-steroidal ecdysone agonists. After absorption into haemolymph it binds to the ecdysone receptor proteins which initiates moulting process. The normal moulting process is disrupted. Larvae are prevented from shedding of old cuticle and it will die due to dehydration and starvation.

Role of non-steroidal agonists

1. **Antimorphic effect:** Do not allow metamorphosis to take palace there by forcing larva to continue as a larva. Therefore, if the juvenoids are provided exogenously the larvae will undergo an extra larval moult (change in to super larva) or moult in to defective intermediate forms which may suffer from a failure to successfully moult, feed or mate.
2. **Ovicidal effect:** Juvenoids acts as ovicide when applied directly on eggs and indirectly on ovipositing females. They block embryogenic development of blastokinesis stage. When applied before hatching, they show morphogentic effect at the time of metamorphosis.
3. **Larvicidal effect:** They inhibit ecdysone synthesis by effecting prothorasic glands. If applied to the last instar larvae, they could prevent pupa from entering in to diapauses.
4. **Diapause disrupting effect:** They could terminate pupal diapause by activating the inactive PTG of diapausing pupa.

(B) Plant Natural Products as Insect Ecdysteroid Receptor Antagonists

Limonoid:

The first limonoid compound limonin, was isolated from citrus fruits. Limonoids are found in leaves, bark, natural products, seeds, or bits generally all through the Meliaceae and Rutaceae. Liminoid isn't a contact poison. It is systemic in action, mainly affecting the feeding as well as growth and development of insects (Laurence, *et al*., 1999).

Mode of action of limonoids - Limonoid can act as a feeding deterrent against a number of insect pests including beetles. It reduces the level of the insect hormone ecdysone by disrupting the insect's molting process so that the immature larvae cannot develop into adults. Some soft-skinned insect larvae may be killed by direct contact with the spray. Adults are not killed by the growth regulating properties of azadirachtin but mating and sexual communication may be disrupted which results in reduced fecundity.

Role of limonoids-

- They do not kill instantly but wipe out a whole generation of insects by preventing the young ones from maturing and the adults from reproducing.
- It is similar to the insect hormone ecdysone, which is needed for moulting during insect development.
- Limonoids are antifeedent, insect growth regulator and sterilant property.
- Limonoids exert significant antibacterial and antifungal activities
- Limonoids also possess anticancer, antiviral, anti-

inflammatory and other pharmacological activities in humans

Withanolides

The first withanolides, was isolated from Ashwagandha plants. Withanolides are a group of C_{28} steroidal lactones isolated from various solanaceous plants. The withanolides are biological activities anti-microbial, anti-tumour, anti-inflammatory, immuno-modulating, anti-oxidant, anti-stress and insect antifeedant property.

Mode of action of withanolides - Withanolide is a chemical that inhibits feeding but does not kill the insect directly. These are also called as "Feeding deterrents". After treating with withanolides the insect may remain on treated plant material and die of starvation.

Role of Withanolides

- Withanolides affect only the phytophagous insects and are safe for beneficial parasitoids, predators and pollinators.
- Pests are not killed immediately due to anti-feedent (withanolides) action also its parasites and predators continue to feed on pests thrive and keep pest in control.

Conclusion: Phytoecdysteroids are toxic compounds that defend plants against phytophagous insects. These can be used as insecticidal tool in pest management programme, as these are eco-friendly, economic, target-specific and biodegradable. Limonoids are one of the derivatives of azadirachtin which reduces the level of insect hormone ecdysone by disrupting the moulting of larvae. Withanolide are insects antifeedent, withanolide containing plant are rejected by insects, because of antifeedent properties. Withonolide can be commercialized as an effective pest management practice.

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56. Brain Hijacking in Cockroach by its Parasitoid, Jewel Wasp

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Introduction:

Some parasitoids have the ability to precisely and adaptively manipulate the specific behavior of their host and thereby turning their hosts into 'Zombie' and this zombie acts as a safe food for parasitoids offspring's. This overall process is called zombification. Many other organisms including viruses, bacteria, fungi, apicomplexans and diverse worms have evolved to control their host behavior in different ways. In insect, first time identified zombie insect is carpenter ant which was affected by fungus from Amazon rainforest and this was identified by the great British naturalist Alfred Russel Wallace in the year 1859. Apart from this, many insect taxa have themselves evolved parasitic modes of life *viz., Dinocampus coccinellae, Lysibia nana, Gelis agilis, Trichomalopsis Spp.* and *Ampulex compressa.* Among them, the jewel Wasp, *Ampulex compressa* have developed the special type of brain hijacking behavior to manipulate the movement of their host cockroach *periplanata americana* and thereby provides the safe food to their offspring's. Jewel wasp directly manipulates the nervous system and the associated muscular system or indirectly manipulates the immune system and the host's metabolism.

Diversity and Distribution of Jewel Wasp

Ampulex compressa (Fabricius, 1781) is a wasp of the family Ampulicidae, subfamily Ampulicinae and tribe Ampulicini, with 217, 22 and 16 species reported, respectively (Buys, 2007). This insect presents a metallic body colour pattern, usually in blue or green and this colouring is responsible for *A. Compressa* being popularly known as "jewel wasp" or "emerald wasp." Regarding reproductive/ evolutionary aspects, *A. compressa* presents a direct relationship with some specimens of cockroaches like *Periplaneta americana* (Linnaeus, 1758), *Periplaneta*

australasiae (Fabricius, 1775) and *Neostylopiga rhombifolia* (Stoll, 1813). The geographic distribution has been reported originally in Ethiopian and Oriental Regions. In the Americas, this species has been found in Brazil, USA (Hawaii) and Venezuela, where the only reports of its occurrence were in the states of Rio de Janeiro and São Paulo (Amarante, 2002).

Zombification Process of Cockroach by Parasitoid:

Jewel Wasp (*Ampulex compressa* Fabricius) to supply its larvae with live cockroaches (*Periplaneta americana*) as a food supply, this tropical wasp first attacks a cockroach by clamping its mandibles on the pronotum or on the base of the wing and inflicting a sting into the host's thorax especially to first thoracic ganglia since the forelegs are defensive in nature. This thoracic sting temporarily inactivates central motor circuits to block motor output (post synaptic blockage of cholinergic synaptic transmissions) in the cockroach's forelegs for 1–2 min (Fig. 1). Hence, it cannot hold their body weight so cockroach head downs and facilitating a subsequent second and longer sting, through the host's neck into its head especially directly to brain (Moore *et al.*, 2006).

Then, after the head-sting is complete, the wasp leaves for roughly 30 min in search of a nest suitable for the development of its young ones during this time, the stung cockroach shows a peculiar behavioral change instead of escaping the scene, it engages in excessive grooming behavior and thoroughly cleans its entire body with its legs and mandibles because of presence of biogenic monoamines such as dopamine, octopomine and serotonin in the venom of jewel wasp. Among them dopamine is a major component that induces excessive grooming. The main function of venom induced grooming is to easily locate the prey before transporting it to the nest by wasp, reduces the locomotion of host and removes the ectoparasitic fungal infections from the cockroach's cuticle, which may be harmful for the wasp's egg or its developing larva. Once after successful completion of grooming behaviour, the cockroach ceases to initiate normal escape responses and spontaneous locomotion showing Lethargic, depressive-like or even zombie-like behavior is called Hypokinesis. Upon returning to its stung prey the wasp first uses its strong jaws to break the cockroach's antennae close to their base and then sucks up the exuding fresh hemolymph from the stumps. The stung cockroach, nevertheless, neither flees nor fights off the wasp, allowing its parasitoid to grab one of its antennal stumps and escort it in a long walk to the preselected nest. Guided by the wasp, the docile cockroach enters its "tomb" and remains immobile as the wasp lays an egg and glues it onto the mid-leg cuticle (Fouad *et al.*, 1994).

Although not paralyzed, the "zombie" cockroach does not escape the nest as the wasp searches around for small items (leaves, pebbles etc.) with which to seal the entrance, before flying away. Entombed inside the sealed nest, the stung cockroach then serves as living food storage for the developing larva that hatches in a couple of days later and perforates the host's leg cuticle to feed on nutritious hemolymph for the next few days. When ready to pupate, the last larval instar penetrates through the cockroach's cuticle and repeatedly deposits the clear droplets of oral secretion having (R)-(-)-mellein and micromolide to sanitize the host then feeds on its internal organs and pupates inside the abdominal cavity (Gudrun *et al.*, 2012). There, well satiated and safe from predators, the larva metamorphoses and emerges roughly a month later as an adult, ready to restart this unique life cycle.

Conclusion: Different group of organisms have different strategies to provide a secure life and ensure survival of their progenies. *A. compressa* uses this brain hijacking strategy to provide a safe host to its eggs. Though attempts were made to employ this wasp in biocontrol of cockroaches, it turned out to be a failure. Because of territorial behaviour and low fecundity of wasp.

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57. Biotic and Abiotic Factors Influencing the Activity of Entomopathogens

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Introduction

Entomopathogens are microorganisms that are pathogenic to arthropods such as insects, mites and ticks. Several species of naturally occurring bacteria, fungi, nematodes and viruses infect a variety of arthropod pests and play an important role in their management. Using entomopathogens as bio pesticides in pest management is called microbial control, which can be a critical part of IPM against several pests. Understanding the mode of action, ecological adaptations, host range and dynamics of pathogen-arthropod-plant interactions is essential for successful utilization of entomopathogens. But the activity of entomopathogens *i.e.*, their efficiency in managing the insect pests, their virulence is greatly influenced by both biotic and abiotic factors.

Abiotic factors

It is a non-living chemical and physical part of the environment that affects living organisms and the functioning of ecosystems. These affect living organisms in terms of growth, maintenance and reproduction. Abiotic factors include temperature, relative humidity, light, radiation, water and soil etc.,

1. **Temperature:** Entomopathogens require optimal temperature for their growth, development, survival and activity. If the range of the temperature is optimum then it leads to successful growth and development of the entomopathogens. Optimum range lies between 10 and 30 degrees. But the alteration in temperatures reduces their activity. Higher temperatures destroy it and lower temperatures may inactivate this. Optimum temperatures vary for different entomopathogens that are virus, fungi, bacteria, nematodes.
2. **Relative humidity and water:** Relative humidity and moisture availability play a very important role in the activity of entomopathogens. If the moisture content of the soil is more, then it affects the movement of nematodes in the soil. Water acts as a dispersal agent for the entomopathogens. Lack of optimum humidity can limit germination of fungal spores and the infection of some fungi and protozoa.
3. **Solar radiation:** Solar ultraviolet radiation is probably the most detrimental environmental factor affecting the viability of entomopathogens applied for pest control. On exposure to UV light it affects different groups of entomopathogens by deactivating the active compounds present in formulation.
4. **Soil:** In the activity of entomopathogens soil plays an important role. Soil characters such as soil structure and soil texture, amount of organic matter present in the soil, PH of the soil and soil atmosphere influences the activity of entomopathogens by influencing their movement, growth, and survival.
5. **Rainfall:** It adds moisture to soil and plants. Optimum amount of water helps in germination, growth, dispersal etc., but excess amount leads to reduction of efficiency. And also, rainfall after the application of entomopathogens in the field washes off the formulation present on the plant thereby reduces the activity.

Biotic factors

It can be described as any living component that affects another organism. It also includes human influence, pathogens, plants etc. Each biotic factor needs the proper amount of energy and nutrition to function day by day.

1. **Producers:** It includes plants. Plant secretions and some chemicals produced from the plant influences the activity of entomopathogens. Plant roots alter soil structure and soil chemistry by producing some chemical compounds. Plants produce a variety of secondary metabolites to the surroundings for their own benefit. Some of these compounds act as toxins and cause harmful effects to other organisms.
2. **Consumers and pathogens:** Some consumers may reduce the plant surface thereby reducing the spreading portion of entomopathogens. Some organisms like mites' springtails may predate on the entomopathogenic nematodes and protozoa. Some other pathogens may degrade the active compounds present in the entomopathogens. Thereby they influence the activity of entomopathogens.

Conclusion

Using entomopathogens as bio pesticides in pest management is a critical part of Integrated Pest Management (IPM) against several pests. Their eco-friendly and specific nature increases their demand in pest management. But their activity is very much

influenced by different factors. An understanding of their ecological adaptation and the parameters that influence the activity of entomopathogens would help to identify the species best suited to a particular environment and thereby we can improve biological control efficiency.

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58. Insecticide Resistance and their Management

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INTRODUCTION

Insecticide resistance is a rising problem. This problem expanded to all major groups of insecticides. Late in the 1940s, the World Health Organization initiated programs to eradicate malaria around the world with the use of DDT. In consequence the vectors of malaria anopheline mosquitoes, which showed resistant. The species are resistant; 47 resistants to dieldrin, 24 to DDT, 4 to carbamates & 10 to organophosphates. DDT resistance in *Anopheles culcifacies* was found over much of India (Georghiou *et al*., 1986) it was the first case of DDT resistance in 1947, the incidence of resistance has increased annually at an alarming rate.

There were so many factors which influence the development of insecticide resistance these are biological, genetic and operational factors. Biological factors such as production of more off-springs, generation time & migration. Genetic factors responsible like resistance gene, fitness of resistance genotype & number of different resistance alleles.

The development of pesticides resistance also influences the persons who usually spray, whether they do demonstrate in urban pest management, in vector control or to protect agronomic crops. A combined action of political parties of industries, research, and regulatory groups has formed the Insecticide Resistance Action Committee (IRAC) to liquidate the problems related with resistance

Kinds of resistance

- **Multiple Resistances:** resistance to different classes of insecticides by multiple mechanisms.
- **Cross Resistance:** resistance to one insecticide leads to resistance to another yet unused insecticide. Usually the two insecticides belong to the same class and share identical or similar mode of action
- **Negative Cross-Resistance:** resistance to insecticide A leads to susceptibility to B and vice visa

Various factors behind the development of insecticide resistance

Insects develop resistance due to number of factors.

1. Insects have capacity to produce a large number of offspring, and due to this there is increased opportunity of mutations which leads to resistance.
2. Most insects have capacity to detoxify insecticides (chemicals) exposed to environment as they have natural toxins in their respective food sources.
3. When insecticides having same mode of action are applied by applicators it will generates or might increases the selection pressure and finally result in resistance. An example of this development of resistance in an insect is the story of the bedbug. Nowadays the resurgence of bedbugs has grab the headlines in the press. As bedbugs are resistant to the current group of insecticides being used against them. Diazinon belongs to Organophosphate insecticides and Chlorpyrifos are banned to be used in urban pest management and pyrethroids remains as the tools bag. The pyrethroids and DDT are in the same mode of action category (Group 3: Sodium channel modulators), which was majorly used to treat in eradication of bedbugs earlier.

Management strategies of insecticide resistance in insects

The areas which are economically important for food production and currently affected by resistant insect species, in those areas everyone must follow the Integrated pest management strategies including Bio-intensive Integrated Pest Management and Biointensive pest management and Ecologically Based Integrated Pest Management (EBIPM) these all are ecofriendly practices and never induce resistant in insects. These management practices should be followed in order to mitigate existing pest resistance. Some of these strategies include:

It is important to monitor pest populations regularly. Any changes in insect populations that may indicate the presence or development of resistance should be dealt with promptly

- **Avoid selection pressure:** To reduce the selection pressure of the toxic compound on the pest species is a best way to manage resistance or can be said that the complete removal of susceptible pests by the pesticide should be circumvent. To attain this, it is essential to do combined pest management approach, avoid the unnecessary application of pesticides, use physical or biological control methods, and conserve areas free of chemical treatments where susceptible pests survive. However, in those situations where the use of pesticides becomes the only control tool, resistance management requires a rotation of the pesticides
- **Utilize non-chemical control techniques:** Integrated pest management should be done
- Leave untreated population refuges where susceptible pests can survive and insert their genetics into populations like in case of Bt cotton where High dose refuge strategy (EPA, 1996) – High dose: > 25 times the concentration required to kill susceptible individuals – Non-Bt crop refuge size: 20% (spray permitted) or 4% (no insecticide allowed)
- **Alternate insecticides with a different mode of action:** rotation plan for insecticides, considering some of the main classes of insecticides on the market. Some authors support it. For example, to control *Alphitobius diaperinus* in broilers production rotation can be after 2-3 flocks of use. Other option is to apply neonicotinoids during summer season, pyrethroids during summer/fall, spinosyns during fall/winter and organophosphates in winter/spring.

For *e.g.* Both Pyrethroids and organophosphate produce hyper excitation, and sometimes nerve impulse blockage also cause hyper excitation by inhibiting the enzyme acetyl cholinesterase (AChE) (IRAC, 2017).

- Apply insecticides in tank mixes or sequentially that include multiple modes of action
- Utilize host-plant resistance and rotate to different crops
- Improve sanitation: practices like weeding, hoeing and remove crop debris should be done.

Conclusion:

Insecticide resistance will continue to be an issue, because resistance is a never-ending process. As long as growers uses the pesticides injuriously without recommendations the resistance prevail for long time so to overcome this problem, we must aware the farmers through new technologies in the field of entomology and recommend them authorized Insecticide resistance management strategies. Utilizing an integrated resistance management plan allows us to delay and manage resistance

Utilizing an integrated resistance management plan allows us to delay and manage resistance.

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59. Biology of Desert Locust (Schistocerca gregaria), (Orthoptera: Acrididae) and their Management

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Introduction

Desert locust (*Schistocerca gregaria*) is a polyphagous, short-horned, under the family Acrididae. Naturally, it was a great devasting migratory pests around the world and obtained huge quantity of feeds from the several agricultural and horticultural crops during their vegetative to grain filling stages. In global wide, it provides food grain loss in the economic loss of US $ 2.2 billion / year. At worldwide, 32 m. sq. km spaced accumulated by these locusts in earth about 20% of land surface. They consumed feed such as leaves, shoots, pods and fodder are equivalent to their body weight (2 gram / each) at host and non-host plants (Mckenna and Limbe, 2020). A swarm the size of 1 km, with about 40 mn locusts, can eat as much as what 35,000 people can in a day. A swarm the size of Paris eats as much food in a day as half the population of France. As of April 2020, efforts to control the locusts are being hampered by ongoing restrictions in

travel and shipping due to the COVID-19 pandemic, contributing to the global coronavirus food crisis.

Outbreaks of Locusts

Invasion of desert locust's incidence was an unpredicted one and it has been a great disaster in recent years. These outbreaks caused great production loss in food grain and along with spoiled the food supply chain distribution to human and animal husbandry also around the world. These crucial infestations were recorded during cropping and non-cropping regions with prominent move due to ecological imbalance in living organisms and impact of climatic changes.

Life Cycle

This pest has three stages viz., egg, nymph (hopper) and adult. When heavy rains come in to saturate the desert, locusts breed profusely and lays egg in moist soils under suitable conditions and each egg pod containing up to 100 eggs during deposited. On that time the egg pod containing a mucilaginous fluid and adsorbs the moisture for maintained the soil temperature for proper hatching.

Mating

The male locust locates a female locust and inserts his semen into a sperm sac located on the female locust's abdomen. The female then releases eggs that mix with the male's semen and become fertilized.

Eggs

When heavy rains come in to saturate the desert, locusts breed profusely and lays egg in moist soils under suitable conditions and each egg pod containing up to 100 eggs during deposited. On that time the egg pod containing a mucilaginous fluid and adsorbs the moisture for maintained the soil temperature for proper hatching.

Hoppers

The locust eggs generally hatch about two weeks after they were laid. These baby locusts are referred to as "hoppers" or "nymphs." Over the next month to two months after hatching, the nymph locusts go through five moulting stages called "instars." After the fifth instar, the locust's wings are fully developed.

Fledglings

After the fifth moult, the locusts are called "fledglings." The fledglings cannot fly yet. Their bodies take approximately seven days to harden and become capable of flight. During this early stage of adult life, the locust must continually feed on vegetation in order to store up the energy necessary for reproduction and flying.

Adults

It takes approximately two weeks for the fledgling locust to reach sexual maturity. When matured, they were swarmed and created a big group due to secretion of pheromone. It moved the distance on flow of wind direction 100-200 km / day. A single swarm consists 50-100 billion locusts / group and approximately 1-2 m. tonnes of weight covered an area of 1200 sq. km. Adult locusts typically live about 10 weeks. During that time, they mate and the females lay eggs.

Ecology and Climatic Changes

Naturally, locusts were bred during high humidity with wind and erratic rainfall distribution. In India, the western disturbances (WD) low pressure rain distributing winds originated from Mediterranean or Midwest Atlantic Ocean and it move towards India and reached during December to April. During these months, 4-6 (WD) reached to India every year. Current year it has been reached more numbers. These climatic changes great impact in biology of locusts bred and swarming rapid move in our country.

Nature of damage

Locusts do harm by eating the clears out, blooms, natural products, seeds, bark and growing-points, additionally by breaking down trees since of their weight when they settle in masses, and now and then indeed by ruining plants with them excrete. They do not, as far as we know, carry any disease but some laboratory workers have developed an allergy to them.

Management of Desert Locusts

- Select the climatic resistant crop varieties and maintenance the field should be free from weeds or crop residues by burning. Deep summer plough and use recommended irrigation schedule.
- If oviposition holes are found in the uncultivated fields first dust any insecticide (Quinalphos 1.5 % DP or chlorpyriphos 1.5 %DP or methyl parathion 2 5 DP @ 25kg/ha) and then plough the field to kill the eggs and emerging nymphs.
- If hatching of eggs started and nymphs observed, spray bio pesticides *Metarhizium anisopliae var. acridum* @ 75 gram /15 lit. water or dust any insecticides: Quinalphos 1.5 % DP or chlorpyriphos 1.5 %DP or methyl parathion 2 5 DP @ 25kg/ha to kill the emerging nymphs.
- If hopper band is formed and observed marching, ignite dry grass or any trash in front of the marching hopper band to kill the nymphs.
- Dig a trench 2 feet deep and 2 feet wide in front of marching hopper band and apply above insecticides in the trench or if water is available, pour water in the trench.
- Spray neem-based formulation (0.15% EC) @45ml/ litre water of standing crop as feeding deterrent.
- Dust the crop with quinalphos 1.5 % or chlorpyriphos 1.5 % DP or methyl parathion 2 %DP 2 25 kg/ha on standing crop
- Farmers should go to their crop field and make loud sound by beating empty tins/metal plates drum or radio or through other electronic sound system to prevent locust swarm landing in the crop
- If the locust swarm is spotted settled in non-scheduled cropped or non-cropped area, the state Agriculture department should arrange aerial spraying of ULV formulation of insecticides like

malathion 965 ULV @1.0 lit./ha or fenitrothion 96% 0.5 lit./ ha with the help of ULV nozzles on a Helicopter.

- Using entomopathogenic fungi (*Metarhizium acridum*) (or) bio-inhibiting of pheromones (Guaiacol – especially for synthesis to attracting locusts and forming swarm) through application of Pantoea agglomerans (Zhang et al., 2019). Government of India announcing the locust infestations relief packages under Pradhan Mantri Fasal Bima Yojana (PMFBY) in Rajasthan, Punjab and Gujrat.

Conclusion

This desert locusts (*Schistocerca gregaria*) invasion and upsurge is due to climatic changes and association of imbalance status of food chain (lack of natural enemies. In favourable conditions the population densities of locusts bred, swarm and upsurge were occurred from one region to other regions So various condition we recommended to farmers like follow the climatic oriented cultivation with climatic resilient varieties and crop rotation, maintained field free from stubbles, using crop protection measures through base of chemicals (Malathion and methyl parathion) and eco-friendly (biocontrol) approaches. In future, we save the nature by doing eco-friendly management

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60. Borer Insect Pests of Apple and their Management

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Borer insect pests damaging apple trees have mainly been categorised into three main categories viz., root borer, stem borer and shot hole borer. All the three types of borers are normally present in all the apple growing areas of North-western Himalayas. Root borer infestation is more pronounced in sandy and loamy soils experiencing scanty rainfalls whereas stem borer and shot hole borer attack is more in unmanaged and or neglected orchards.

1. **Apple Root Borer:** Infestation of root borer is found in almost all the apple growing areas. The adult beetles of this insect are deep reddish brown in colour measuring about 5 cm in length. These beetles start emerging from the soil on the onset of pre-monsoon rains. They are attracted towards light sources and can be easily identified by their large bodies and long antennae. The grubs of the insect are pale yellow/creamish white in colour and found in the roots of the plants. The maximum length of these grubs may be up to 10cms. Farmers often get confused between white grubs and root borer larvae but they are much different from one another. White grubs have six distinct legs and remain in C shape when taken out whereas root borer larva have no such visible legs and they remain straight. Infested trees have small leaves and fruits as compared to normal plants. Such trees show wilting symptoms in the summer afternoons and have shaky appearance and can be blown away by strong winds. The bark of stem or main branches show characteristic splitting in oval shape which are 2-15 cm. long.

   Management: Since most of the adult emergence take place during last week of June - July and incubation period of eggs is about 20-24 days, so drenching with chlorpyriphos (Durmet/ Dursban 20 EC) @ 5ml per litre of water during mid of July is more effective treatment for its suppression. Put about 10-30 litres of solution in the tree basin depending on the age of the plant. Alternatively, dust forms of insecticides may be used as they are more convenient to apply. Even some biopesticide formulations such as *Metarhhizium anisopliae* and *Bauveria bassiana* @ 5ml/L are effective against the pest. Install light traps at the tree canopy height in the orchards during monsoon period which helps in trapping of the adult beetles. In case of severely affected trees farmers can plant 2-3 seedlings around the infested trees during February-March and graft them into the main stem during April-May. This will provide an additional rooting support to the affected plants and increase their life.

2. **Stem Borer:** These insects make tunnels in the stem or branches and feed inside them, thereby weakening the trees. Active infestation or holes can be identified from the faecal matter pellets being thrown out by the larvae.

   Management: Remove dry and infested branches during the pruning of trees and burn them. Clean the holes/galleries with a flexible wire and put kerosene oil/petroleum oil/ insecticide solution-soaked cotton swabs inside the hole and plug from outside with clay soil so

that the larva inside gets killed by the fumes of the chemical. Inspect the holes after one week and treat the live holes same way.

3. **Shot Hole borer:** This insect pest infests only drying/weak / neglected plants. This also infests other fruit trees like plum, apricot and pomegranate etc. Small pin head size holes on the branches/stem are the visible symptoms. After removing the bark, one can find a cross network of tunnels /galleries packed with frass underneath the bark of infested branches. Adult beetles are dark brown/black in colour measuring about 3-6 mm in length and larvae are 2-3 mm and white in colour.

Management: Keep the vigour of the trees high through proper nutrition and irrigation. Remove the infested branches and burn them. Swab/spray infested stem/branches with 0.04 % chlorpyriphos solution.

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61. Species Diversity of Insect Defoliator Pests in Drumstick Ecosystem

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Drumstick tree, *Moringa oleifera*, is referred to as "*Brahmavriksham*" that means "God identified this tree to save people" may be because it is packed with nutrients. It is native to the foothills of north-western India and is now cultivated around the world as valuable, drought-resistant, multi-purpose crop. As a vegetable, the plant possesses various edible parts (leaves, tender pods and flowers, etc.) with high nutritional and medicinal values. They are rich in proteins, minerals (*e.g.*, Al, Ca, K and Na) and vitamins (A, C, B, etc.). The leaves are the most nutritious parts which contain high levels of important vitamins and all the essential amino acids. Important secondary metabolites such as tannins, saponins and alkaloids are also found, which seem to contribute to its medicinal properties (Gupta and Barat, 1989 and Kawo *et al.*, 2009). Therefore, the area under *Moringa* cultivation is continuously expanding in many other countries during recent years. Regarding problems of *Moringa* production in the world, some insect pests are being placed among the main limiting factors of the crop. They include; budworm, *Noorda moringae* Team, hairy caterpillar, *Eupterote mollifera* Wlk., pod fly, *Gitona distigma*, bark caterpillar, *Indarbela quadrinotata* Wlk., and stem borer, *Indarbela tetraonis* (Moore) (Abdalla *et al.*, 2013).

The insects found feeding on the foliage of drumstick starting from the early stage of the crop till the pod formation was recorded.

Leaf eating caterpillar, *Noorda blitealis* Walker (Crambidae: Lepidoptera)

Early instars of leaf eating caterpillars fed on the leaves by scrapping the chlorophyll content resulting in papery appearance of leaves and later instars fed on entire leaves leaving only veins behind. In severe infestation, the trees were almost without leaves resulting in 100 per cent defoliation. The incidence was seen throughout the year. The early instars preferred the tender leaves and later stages fed on matured leaves.

Hairy caterpillar, *Eupterote mollifera* Walker (Eupterotidae: Lepidoptera)

The caterpillar fed on the foliage of drumstick and soft bark. The larvae tend to aggregate on the bark of the trees in the night and feed on the foliage during day time. The incidence of this species was recorded during July to December.

Tiger moth, *Amata passalis* Fabricius (Erebidae: Lepidoptera)

All the stages of the caterpillars were found to feed on leaves and act as defoliators on drumstick. The pest was noticed during August to November.

Pierid caterpillar, *Catopsilia pyranthe* Linnaeus (Pieridae: Lepidoptera)

The caterpillars of the pierid butterfly fed on the foliage of the drumstick. They were solitary in nature and observed during July to September.

Grass hoppers, *Atractomorpha crenulata crenulata* Fabricius and *Pyrgomorpha bispinsoa bispinosa* Walker (Pyrgomorphidae: Orthoptera)

Two species of grass hoppers were observed to feed on the foliage of drumstick plant, viz., (a) *Atractomorpha crenulata crenulata Fabricius* and (b) *Pyrgomorpha bispinosa bispinosa* Walker. Both adults and nymphs of the two grasshoppers were found to feed on leaves irregularly and also cut the tender shoots often. These grass hoppers were recorded both during vegetative and flowering stage. Infestation was noticed from July to November.

Ash weevils, *Myllocerus viridanus* Fabricius and *Myllocerus discolor* Boheman (Curculionidae: Coleoptera)

Two species of Ash weevils, (a) *Myllocerus viridanus* Fabricius and (b) *Myllocerus discolor* Boheman were observed on drumstick ecosystem. Incidence was observed throughout the year. *M. discolor* is larger than the *M. viridanus*. The activity was noticed during second fortnight of July to second fortnight of November and during February to July. The weevils made semicircular notches on the margin of leaves in 'U' shaped manner.

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62. A Call for Help!!

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Introduction

Owing to their sedentary form and inability to beat a retreat from attacks, plants have developed exceptionally advanced defence techniques to protect themselves from pest attacks. This evolution has been going on for past 400 million years of co-evolution between plants and herbivores. Physical barriers like lignin, antibiotic production, interaction with organisms which aid in defence, anti-nutritional factors like tannin, lectins etc., constitute these sophisticated plant evolved methods and also act as natural enemies to herbivores. Varied expression is seen in defenses *viz*., constitutive expression in induced resistance, priorly existing components like phytoanticipins and defense triggered due to elicitors present in saliva of pests attacked. Plants are known to emit volatiles, but when the same plants are subjected to herbivore attack, they tend to produce more volatiles termed as herbivore induced plant volatiles (HIPVs). The devouring insect is also known to emit volatiles or pheromones to attract their fellow community which is comparatively less than the HIPVs released by plant. Successful defense is achieved when these HIPVs function as signals or prompts to specific predators and parasitoids helping them locate to their prey *i.e*., attacking herbivore. Direct defenses reduce the suitability of plants to herbivores. In contrast, this three tiers interaction of plant, pest and predators or parasitoids (natural enemies) is called indirect defense. Precisely as tritrophic interactions. As a part of tritrophic interaction, plants give a "call for help" to natural enemies which will be discussed in this article.

Need For Help

In natural ecosystems, the land races and wild plants are prone to natural selection in improving their ability to protect themselves from pest, while domesticated crops have been under greater artificial selection added to their monocropping. This artificial selection pressure makes them more prone to insect attack which gradually turn into devastating pest. This calls for a need to evolve tritrophic interactions and various traits to attract natural enemies.

Call for Help

Back ground-A group of scientists from International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya studied tritrophic interactions in maize plants. They observed plants giving a call for help on attack and oviposition by maize stem borer. Maize is the chief staple crop in world, pronouncingly in sub-Saharan Africa feeding millions of people. But its production is drastically reduced due to pest damage mainly lepidopteron stem borers which account to 80% yield reduction of staple maize at different phonological stages of crop. Many trial and error methods were followed for conventional breeding of host plant resistance, using various genetic lines of maize. Recent commercial maize breeding was also implemented involving several maize potential pests. But very less attention was given to the plant pest beneficial interactions.

Experiment- A hypothesis was built by scientists that locally adapted land races which were used by small farmers who were not able to afford expensive pesticides and hybrids had better indirect defense compared to commercial hybrids and genotypes. Study involved a group of miscellaneous 146 genotypes, constituting 9 landraces, 21 hybrids and 116 inbred lines. Tritrophic interaction in maize ecosystem included maize crop, maize stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) and *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae) parasitoid wasps, which are potential natural enemies of the stemborer. Their hypothesis was proved true when three farmer selected landraces were reported to emit HIPVs in response to stem borer whereas two commercial varieties did not. These plants were screened for presence/ absence of egg-induced parasitoid attraction trait which was found existing in some African maize landraces. The HIPVs released by plants were of South American origin. Further larger genome wide association study (GWAS) of 146 genotypes reported the trait which is the ability to "CRY FOR HELP" by releasing HIPVs. HIPVs in turn allure *C. sesamiae* parasitic wasp acting as body guards when *C. partellus* oviposits on maize leaves. GWAS was used to identify the genomic regions and molecular markers related to them.

Volatiles from plants with eggs and without eggs were collected and studied using gas chromatography. Olfactometer bioassay was conducted by adding volatiles from plants with eggs and without eggs and mean of two solvents to the arms of olfactometer, providing them the mean time spent by wasps in specific volatile added parts of arms. Wasps spent significantly more time in the "with eggs" zone compared to "without eggs" zone.

They discovered the absence of egg induced indirect defence trait in improved hybrids and reported that certain plants responded very quickly in their young age to *C. partellus* egg laying emitting powerful volatiles. These studied were statistically proved using ANOVA with genotypes emitting HIPVs.

Principle

When multi-trophic interactions are built, plants

alter the profile of their volatile releases to become more attractive to respective natural enemies. These natural enemies respond to "call for help" signalling or "indirect defense" and become "body guards" protecting their host from herbivores. Thus, plant indirectly but efficiently increases the herbivore mortality.

Hypothesis suggested

A sequence of reactions in oviposition sensitive maize genotypes was hypothetically quoted as follows

- **First response-***C. partellus* egg elicitors are identified by plant through a molecular recognition process
- **Second response-** Jasmonic Acid pathway is triggered
- **Third response-** HIPVs release is initiated in association with JA pathway

As a result, the oviposition sensitive maize plants trigger a line of defence including both direct and indirect defence to protect themselves against caterpillars hatching out from the eggs laid.

Other factors

In addition to the above mentioned points, other defence traits like primary and secondary metabolites and their chemistry play crucial role in determining the extent of compatibility between plant resistance and biocontrol in IPM as proven by Owain, E and Karam, B. Singh (2006).

Effect of temperature and elevated CO2 (eCO2), on tritrophic interactions of cowpea (*Vigna unguiculata* subsp. *unguiculata* L.), legume aphid *Aphis craccivora* Koch and coccinellid predator *Menochilus sexmaculatus* Fab indirectly and directly was studied at each trophic level. At varied temperatures, increased aphid incidence and its predator along with host mediated effects was observed. But positive predator-prey relationships were found to uphold the ecological processes. Nevertheless, predator (Coccinellids) and pest potential was determined by their adaptation capabilities to abiotic factors like rainfall, eCO2. (Srinivas *et. al.*, 2018)

Insect response to plant defence

After going through a part of how plants retreat the herbivorous pest attack, it must also be known how insects overcome this plant defense and resistance strategies. Insect pest also simultaneously evolved techniques to overcome lectins production, primary and secondary metabolites, protease inhibitors etc. It can be well studied in legume ecosystem where particularly *Helicoverpa armigera*, gram pod borer and *Callosobruchus maculatus*, pulse beetle were found to inhibit protease inhibitors. Detoxification enzymes are present in insects such as glutathione S-transferases, and cytochrome P450s that detoxify secondary metabolites from the plant. They are known to enhance certain detoxification enzymes to fight plant defense. *Helicoverpa zea*, maize cobworm, was reported to use same signaling pathways *viz.*, Shikimic acid and Jasmonic acid pathway to trigger Cytochrome P450 genes which detoxify plant emitted toxic substances according to Owain, E and Karam, B. Singh (2006).

Advantages

1. The study on identifying call for help trait in plants provides us with pest reducing germplasm.
2. Such plants are not only found more resilient to herbivore attack but also makes resistance development strenuous.
3. Less dependence on chemicals for pest management aiding eco -friendly IPM.
4. Ecological balance can be maintained by increasing the natural enemy presence in the field.
5. Equal priority is given to top down control of herbivores by natural enemies and bottom-up control by plants

Future thrust

1. More such studies can fill the lacunae between entomology, chemical ecology and plant genomics
2. The genetic basis for variation among domestic and indigenous races in their indirect defense expression must be discovered
3. Markers must be developed to identify these specific pest repelling gene areas
4. Insight regarding key candidate genes underpinning the indirect defense during tritrophic interactions can be discovered.
5. Improved varieties with incorporated indirect defence triggering genes can be bred to reduce the insecticide load
6. Biocontrol using natural enemies would emerge as a promising element in IPM through marker assisted selection (MAS)
7. Innovative strategies can be developed if insect defense mechanisms against plant defense is studied at molecular level such that particular insect resistance can be destroyed.

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63. Potential Biopesticides Made by Uncultivated Plants (Weeds)

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Introduction

Nature are surrounded by so many plants some are useful and some are not, grown by itself, placed in separate category called weeds. Weeds are not more important as economical plants but most traditional farmers and scientists knows its importance as many plants contain a wide range of chemical compounds and these compounds show excellent biological activities such as repelling or altering insect feeding behaviour, antifeedant, mortality, growth inhibition, suppression of reproductive behavior, reduction of fertility. and nowadays it grab the headlines in the papers that it has so many important properties such as potential use in biopesticide to eradicate pest which cause economical damage to the crops. There are so many examples of weeds which are used in making pesticides The commonly used alternatives as plant extracts and formulations of, Parthenium hysterophorus, Ambrosia polystachya, *Ageratumm conyzoides*, *Lantana camera*, *Eupatorium* spp. *Euphorbia heterophylla*, *Sida rhombifolia* and *Sida spinos*a are some promising against insects.

Diversity of chemicals compounds found in weeds

Weeds have a large diversity of chemical compounds which works as against insects as use for, fungicidal, bactericidal insecticidal action & acaricidal, which have been used by botanical extracts as commercial products or as a source of molecules for the synthesis of pesticide by industries. Some weeds can have complex mixtures of different secondary metabolites derived from various plant tissues (leaves, flowers, seeds, rhizomes, bark), among which we highlight terpenoids that may have biological functions, such as allelopathy, that are essential for survival and adaptation of the plant to the environment

Biopesticides

A biopesticides can be prepared by using large numbers of weeds and the very important thing is that it has a widespread application on varieties of insects like used for bugs, sap suckings as well as biting types insects like caterpillers, termites and mosquitoes. The challenge for entomologist is that to recognize which types of weeds are useful to control particular types of insects and what combination of management strategies will be most effective and how other parts of the ecosystem respond. They could be used for reducing crop production cost. To prepare biopesticide, does not involve any expensive solvent; rather it just requires cow urine as the solvent, which is readily available to the farmers

Homemade biopesticides from weeds

The criteria of selection of plant species, having a bioactive compound was based on literature. Desired plants at the peak of its vegetative growth stage were collected from various locations.

TABLE 1: Selection and collection of plant species for the preparation of extracts

S.No	Common name	Scientific name	Family	Plant part used
1.	Neem	Azadirachta indica	Meliaceae	Leaves
2.	Wild sage	Lantana camara	Verbenaceae	Leaves and stem
3.	Kaner	Nerium indicum	Apocynaceae	Leaves
4.	Bakain	Melia azedarach	Meliaceae	Leaves
5.	Bhang	Cannabis sativa	Cannabinaceae	Leaves
6.	Datura	Datura stramonium	Solanaceae	Leaves
7.	Gajar Ghass	Parthenium hysterophorus	Asteraceae	Leaves and flowers
8.	Crofton weed	Eupatorium adenophorum	Asteraceae	Leaves
9	Sharifa	*Annona* spp.	Annoneace	Leaves

Preparation of plant extracts:

The test plants parts were collected from different location, whereas, Cow urine was collected from desi breed cow. The plants collected from various families were brought to the laboratory, washed with dechlorinated water, shade dried under room temperature for 7-9 days and then the plant materials were powdered individually using an electric blender. 10gm of each powdered plant material weight separately by using a top separately balance and dissolve in 90 ml of cow urine to get 1:9 w/v **Rani *et al.* (2009)** were sieved using a kitchen strainer. The prepared solution were kept for fermentation for 15 days then the extracts filtered by using muslin

cloth after that it was kept in refrigerator at 4^0 C and working solutions of the desired concentrations were prepared afresh prior to application. To prepare 2 and 5 per cent concentrations of plant extracts in cow urine separately, For 2 per cent dissolve 2 ml of stock solution (Plant extract +Cow urine 1:9w/v) in 98 ml of water. For 5 per cent dissolve 5 ml of stock solution (Plant extract +Cow urine 1:9w/v) in 95 ml of water.

FIG 1: Homemade biopesticides from different weeds

Conclusion

The plants which are available everywhere without searching would be most preferable for making biopesticides. Not harmful to environment, and natural enemies since biopesticides prepared is all plant based so it is easily decomposable and no chance of residue left in field. It is also taken into account that a considerable amount of pesticide can be extracted without the use of sophisticated equipment and complex methodology. Very easy practices for farmers because when they use synthetic pesticides they were much confused about recommended dose even don't know how to applied in plants so in this case biopesticides should be used, not required any scientific methodology to apply and any recommended doses are also not required.

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64. Resistance against Novel Insecticide: Sulfoxaflor

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Introduction

Sulfoxaflor, a novel sulfoximine insecticide, is a breakthrough in sucking pest management developed by Dow AgroSciences. It is reported to interrupt with nervous coordination by acting on nicotinic acetylcholine receptors (nAChRs). Other groups acting on nAChRs are neonicotinoids viz., imidacloprid, acetamiprid and thiacloprid, spinosyns, nereistoxin and nicotine analogues. Sulfoxaflor differs from other neonicotinoids in unique manner of interacting with nAChRs. Sap feeding insects which are efficiently managed by sulfoxaflor, on par with other neonicotinoids, are prime resistance developing group among insects. Nearly 1350 resistance records in 80 species of heteroptera and homoptera are reported at an online database maintained at Michigan State University. The first record of neonicotinoid resistance was reported in 2007 but it took 6 years to develop resistance against all neonicotinoids. Though the process was slow, the number of different species exhibiting resistance has been increasing. This article puts forth resistance developing against the distinct sulfoximine insecticide, sulfoxalor.

Chemical Nature of Sulfoxaflor

Sulfoximines are chemically notable being first to integrate a sulfoximine functional group. They have a small hydrophilic core, a hydrogen bond acceptor and in certain cases a hydrogen bond donor. They are also amenable to synthetic modifications because they possess unlike the closely related sulfone, a third point of diversity at the imine nitrogen. These chemical characteristics made the sulfoximine functionality an appealing structural scaffold for further exploration.

Sulfoxaflor is first commercially used sulfoximine insecticide for sucking pest control. (Longhurst et al., 2012). The discovery of sulfoxaflor [N-[methyloxido[1-[6-(trifluoromethyl)-3-pyridinyl] ethyl]-λ6-sulfanylidene] cyanamide] resulted from an investigation of the sulfoximine functional group as a novel bioactive scaffold for insecticidal activity and a subsequent extensive structure-activity relationship study

Distinct Features of Sulfoxaflor

The presence of sp3 nitrogen in association with a conjugated electron withdrawing group that led to the definition of "neonicotinoid", which is absent in the sulfoxaflor. In addition to lacking a sp3 nitrogen, other contrasts in the sulfoximine include the marked improvement in insecticidal activity associated with the presence of a 6-CF3 substituent on the pyridine ring. The sulfoximine is likely to be unaffected by the monooxygenases involved in these neonicotinoid-resistant strains. (Sparks et al., 2013)

Resistance Development

Sulfoxaflor was found to be most effective to manage sucking pest accounting to inability of insects to develop resistance to it. No cross resistance to sulfoxaflor was reported in insects resistant to neonicotinoids. Insects develop resistance to neonicotinoids due to increased metabolism and monooxygenases activity on insecticides. Sufoxaflor are found unaffected by these two mechanisms being the reason for lack of resistance and also cross-resistance. But modest level of cross-resistance to sulfoxaflor was reported in strain-FRC-R of Green Peach Aphid found only on peaches in France, Italy and Spain due to increased metabolic rate added with a mutation in nAChR target site. FRC-R strain expressed 2300-fold resistance to sulfoximines and neonicotinoids. (T. C. Sparks et al.,2013) Though mutation was main reason for enhanced efficacy for sulfoxaflor, it was reported to be less significant than neonicotinoids due to distinct action of former at nAChRs which reduces the metabolic effect of FRC-R strain on sulfoxaflor. Studies on neonicotinoid resistant Drosophila melanogaster revealed minimal or negligible cross-resistance against sulfoxaflor. Even the target site based resistance comprising of two nAChR subunits viz., Da1 and Da2 could not affect sulfoxaflor's potential insects managing efficiency. (T. C. Sparks et al.,2013)

Inherited Resistance

Resistance genes in insect account for efficacy of chemical control and resistance expression. Sulfoxaflor resistance is inherited as autosomal and incompletely recessive trait in *Nilaparvata lugens*, Brown plant hopper. Greater risk of increasing resistance to sulfoxaflor is seen in BPH and aphids. Recessive gene control in the case of sulfoxaflor, accounts to its insecticidal efficacy on sap-feeding insects. It develops at a very slow rate compared to dominant gene-controlled resistance because in latter heterozygotes also exhibit resistance. Based on study on BPH, it was reported that sulfoxaflor resistance is controlled by more than one allele. In homozygous recessive resistance, fitness cost plays important role. Compared to laboratory population of BPH, field population developed inferior degree of resistance. (Xun et al., 2019)

Fitness cost of insects leads to slow resistance keeping the insecticide efficient for a longer period. Both field and laboratory strains had greater fitness costs to sulfoxaflor *viz*., reduced adult longevity, reduced fecundity, short life cycle. Similar behavior was seen in *Myzus persicae*.

In *Bemisia tabaci*, sulfoxaflor expressed lower resistance ratios (RR) while they gave 1000 fold RR to imidacloprid in addition to cross resiatnce to other neonicotinoids. Similar lack of cross resistance was observed in *Trialeuroides vaporariorum*. (Longhurst et al, 2012).

Enzyme activity analysis of Aphis gossypii resistant and susceptible strains showed that Sulfoxaflor resistant strains had higher P450 activity *i.e.*, 6.30 fold) due to over expression of CYP6CY19 and CYP6CY13. Laboratory sulfoxaflor resistant BPH strains exhibited over expression of eight genes (CYP4DE1, CYP15G1, CYP6CS1, CYP6CW1, CYP6ER1, CYP4C62, CYP417A1 and CYP419A1). (Ma et al., 2019)

Why is Sulfoxaflor Resistance Rapid in Field than Laboratory?

Based on the experiment conducted by Wang and his coworkers in 2018, resistance development in M. persicae is rapid in field compared to laboratory. 199.4 fold resistance was reported in lab after selection for 45 generations. Single clone is taken for resistance study which has less recombination and less genetic diversity whereas great genetic diversity, heterocious and holocyclic phases with sexual reproduction resulting in allelic recombination exists in field.

Measures to Manage Resistance

- Inspite of low resistance against sulfoxaflor among neonicotinoids, rational use is suggested as slow increases of resistance can't be ruled out.
- Any insecticide is at risk if not used judiciously. Hence, sulfoxaflor must also be used following the label and directions.
- It must be rotated with other mode of action insecticides if applied more than twice sequentially. If no effective non-neonicotinoids are available, rotation with neonicotinoids is also recommended.
- In case of allelic resistance, transcript level of gene suppression can significantly bring up sulfoxaflor susceptible population.

Advantages of Sulfoxaflor

- Sulfoxaflor has less resistance problem compared to other neonicotinoids and other insecticide classes due to fitness cost of insects and multigenic resistance.
- Its distinct way of acting on nAChRs includes it into efficient sucking pest managing insecticide group.
- Rotational measures with sulfoxaflor helps in long term usage and less resistance problem.
- It also increases the susceptible insect population generation to generation.
- Lack of standard resistance in many experiments conducted with sucking pest viz., whiteflies, BPH, aphids, Sulfoxaflor is an immoderate tool in IPM and IRM based management programme.

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65. Entomotourism

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Introduction

While it is widely known that insects play important roles as pollinators, decomposers, predators, and prey in ecosystems and food webs, their intrinsic value as subjects of their own lives are often ignored. Invertebrates like insects show higher extinction rates than vertebrates as they are deeply impacted by destruction of habitat, pesticides, and pollution. Negative perceptions of insects also contribute to the inadequacy of their conservation. People generally view insects, with disgust, focusing them to be dangerous, poisonous or carriers of disease. Therefore inclusion of insects in ecotourism activities can be seen as a viable tool for raising awareness about insect conservation among people.

What is Entomotourism?

Entomotourism encompasses insects as a part of nature-based tourism that uses encounters with insects in controlled settings, such as butterfly pavilions and insectariums, or in natural settings such as national parks. Much like other famous wildlife tourism opportunities, entomotourism is an estimated multi-million industry possibly employing thousands of people and attracting millions of visitors around the world.

The main components of entomotourism are visibility, proximity, predictability, activity, and safety. Api-tourism is a popular type of entomotourism solely pertaining to honey bees (Apis), and so is meli-tourism (Melipona: stingless bee). Millions of people visit butterfly pavilions and insectariums around the world annually, while thousands of visitors travel to Mexico to see the aggregations of monarch butterflies and the fireflies of Asia. Up to 700,000 devotees visit the glow worm caves in Australia and New Zealand. Other entomotourism activities include festivals, viewing opportunities and interpretive programs provided by state and national parks. Insects are used in regional tourism promotions, science programs, entomophagy (eating insects), and sports like beetle-wrestling and racing. In India, ICAR-NBAIR National Insect Museum, Asia's largest live insect repository holds 1.7 lakh insect specimens of agricultural importance.

Conservation Goals

The inclusion of insects in ecotourism services and products would enhance the quality of both conservation measure and tourism industry. Entomotourism can be a cost-effective and efficient means of raising awareness of insects which will result in support for their conservation significantly, by leading to the establishment of protected areas and the creation of pollinator parks, insectariums, bee gardens, and dragonfly ponds.

Entomotourism thus holds promise, particularly in the educational and research sectors, by helping the public to gain a better understanding of insects, improving human-insect relations, and contributing to their conservation. It is believed that the growing awareness of the decline of insects through entomotourism will result into increased interest in the public and in researchers.

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66. An Account of Bizarre Insects Reported in and around Hyderabad, India

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Introduction:

Insects are ubiquitous globally. The Indian subcontinent is well known for its high biodiversity, diverse climate and ecosystems, and fascinating geological past. In this article, I am going to discuss about amazing beautiful insects, which are occasional that I had encountered during my M.Sc.(ag) days around my university campus. Daily I use to roam here and there in student farm of PJTSAU, Hyderabad especially in the evening time. Surprisingly, one day I found a tiny caterpillar with bulged head, which looks like helmet on head. I took him to lab for further investigation, finally I came to know that his name is *Carea angulata* (nbair.res.in). Likewise, I got many beautiful caterpillars such as *Pachliopta aristolochiae*, *Thiacidas postica* and *Parasa lepida*. All these caterpillars I taken into lab for rearing and studied different life stages of these beauties. I had a little bit conversation with them and briefly explained below.

Observation:

On 13.x.2017, caterpillar of *Carea angulata* (Fabricius) (Nolidae: lepidoptera) was observed on a jamun (*Syzygium cumini*) tree in Hyderabad (Fig. a). Caterpillar was looking awesome that having helmet like structure on head. Actually Helmet is a bulged portion prothorax, which looks like unripen berry, because of this, caterpillars can escape from predatory birds. Heavy infestation of these caterpillars at flowering and fruiting stage may cause considerable yield damage to jamun. Caterpillars devour the leaves, thereby greatly reducing photosynthetic rate and the number of fruits that are set. In the natural stands and plantations it feed on 3 different plant species but it was generally recorded on *Syzygium cumini* (nbair.res.in).

On 31.viii.2017, larvae of caterpillar of *Pachliopta aristolochiae,* the common rose, is a swallowtail butterfly was observed on a weed plant in fields of student farm, Rajendranagar, Hyderabad (Fig. b). *Pachliopta aristolochiae* belong in to a family, papilionidae: Order, Lepidoptera and the larvae feed on creepers and climbers of the genus *Aristolochia*, family Aristolochiaceae (Kamini and Jolanta, 2007) and they sequester toxins such as aristolochic acid in their bodies. This makes the adults toxic to vertebrate predators such as birds and reptiles.

FIG. 1: (a) Carea angulate, (b) Pachliopta aristolochiae (c) Thiacidas postica (d) Parasa lepida

On 31.x.2017, grey hairy caterpillars were observed (Fig. c), which were feeding on ber (*Ziziphus mauritiana*; Family: Rhamnaceae). Grey hairy Caterpillars (*Thiacidas postica* Walker, 1855, Noctuidae; Lepidoptera) are common pest of ber (nbair.res.in), occasionally serious. Caterpillars feed on the young leaves and fruits. The older caterpillars spread in all directions and devour leaves and fruits and sometimes even tender shoots. They start eating new foliage as it grows after pruning and this is continued by overlapping generations.

Mango (*Mangifera indica* L.) is the most popular and widely cultivated fruit crop in India. Beautiful Slug caterpillar *(Parasa lepida)* was observed (On 31.xi.2017) (Fig. d), which were feeding on mango leaves. The caterpillar belongs to the family Limacodidae. Often after the monsoon we can observe many clusters of large ovals, egg like structures on the bark of mango trees. The egglike structures are cocoons that are concealed in the pupa and formed by "slug caterpillars. All the bright bushy hair that you see in the picture is urinating. This implies that each of them holds a small droplet of an irritant. The droplet is inserted into the skin when you touch the larvae and can cause quite intense pain. Actually this pain I have experienced while handling the slug caterpillar.

Conclusion: Information on important taxonomic characters of the larvae and adult is limited. Careful monitoring and timely reporting is necessary to avoid any future outbreak.

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NEMATOLOGY

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67. Caenorhabditis elegans as Biological Model for Studying Various Life Processes of Organisms

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Sydney Brenner identified and introduced *C. elegans* as a model organism for doing research in developmental biology and neurology

Characters

- Small about 1mm in length
- Lives in transplate soil environments
- Feeds on bacteria, transparent
- Easy to multiply in large numbers
- Easy for manipulation and observation
- Short life cycle, rasy to mutate
- Have 1090 somatic cells
- Genomeis completely sequenced (about 100mbp size)
- An excellent in vivo model for biology studies
- Can be stored for image time

Why *C. elegans* used in research

- Organism has simple growth conditions and reproduces rapidly with a life spash of approximately 2 -3 weeks
- The cell lineage of the organism is known and does not vary
- It can be easily genetically engineered for research purposes
- Research began on C. elegans because of interest in nervous and developmental systems as they are very similar to humans

Life Cycle of *C. elegans*

- Normally grows as a self-fertilizing hermaphrodite, laying about 300 eggs
- Hacing larva feeds, grown and moults through four larval stages, maturing as the egg laying adults
- Generation time is 3 days

C. elegans is applied studying

- cellular diffraction
- Nervous systems
- Embryo development
- Cell cycle
- Meiosis
- Fertilization
- Cleavage
- Fat metabolism
- RNA interference
- Memory
- Gerantology (Aging)
- Apoptosis
- Toxicology
- Pharamacology
- Developmental Biology
- Genetics
- Evolutionary biology

Aging in *C. elegans*

- Normal infespan of *C. elegans* is 14 days
- Genetic mutants / experimental treatments either extend or shorterm life span
- Lifestyle can therefore be rapidly assessed than in other animal models
- Caloric restriction extends life spam
- Loss of superoxidae dismutase does not shorten life span
- Manipulation of DAF -2 / DAF – 16 insulin – like pathway can strongly affected life cycle

To Study Alzheimer Disease

C. elegans has a single gene related to amyloid processor protein apl – 1 both loss of function and over expression have deleterious consequences. Triplet repeat disease Transgenic expressin of GFP fused to polyglutavine repeats results a formation of toxic aggregates in the worm in apoly or – length dependant manner.

Mutation

- *C. elegans* mutants are required for genetic study
- Some genetically determined trabs, such as motivity mutants are easy to observe
- Powerful genetic experiments can be conducted using simple microscopes to observe the inheritance of traits in *C. elegans* mutants
- When a mutant is found it can be crossed with

worms having a known genetic backround and further one can learn where this mutated gene may be located and define its function.

Apoptosis Regulation

Much of the mammalian apoptosis is cearned from studying PCD during embryonic development in a nematode worm called c. elegans

In zoom Nobel prize awarded to Sydney Brenner, Bob Horvitz and Jonathan Sulston for their discoreries about the ced family of genes and their involvement in apoptesis regulation.

Cell collapses and disappears, soon after being born.

Pharmacology Studies:

- Drug dosage and time can be controlled
- These studies lead to therapeutics for normal aging or age relatal diseases
- Interpretation of pharmacological experiments with *C. elegans* to ensure that compounds are not toxic to organism so it is valid for mammalian toxicity
- Measurement of life span is straight forward (alive or dead)
- Pre adult development and adult maturation of functional period is declined, leads to measure specific physiological functions (reproduction) body movement and pharyngeal pumping

RNA Interference (RNAi)

- To disrupt the function to of specific genes by RNA interference (RNAi)
- The nematode can either be soaked in or injected with a solution of double stranded RNA, the sequence of which is supplementary to the sequence of the gene the researcher wished to disable
- Alternatively, worms can be fed genetically transformed bacteria that espress the double – stranded RNA of interest

Toxicology Studies

- Species vary in sensitivity to toxicants, various developmental stages
- The developmental stage between J4 & adult – genotoxicity indicator
- Mortality to sublethal effects but sub lethal more sensitive and accurate
- Morphological changes
- After the reproductive capacity and mortality
- To act as teratogens and cause abnormalities in development metabolic function
- Neuromuscular function

Effection – Ovulation Fertilization Hatching Ombryomic and Post Embryomic Space Travel Research

- *C. elgegans* made news when it was discovered that specimens had survived the space shuttee colomiba disaster in february 2003
- In January 2009 it was announced that live samples of *C. elegans* from the university of Nottingham would spend two weeks on the international space station to explore the effects of zero gravity on muscle development and its physiology
- The emphasis of the research was to be on the genetic basin of muscle atrophy this has relevance to space travel.

Further Noble Prizes or *C. elegans* Physiology a Mediane 2006

Andrew fire, Craig mello, Chemistry Martin cnalfie

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68. Nematodes of Household Pests and EPN for the Control of Plant Parasitic Nematodes Mechanisms

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Nematodes of Household Pests

Entomopathogenic nematodes for the control of plant parasitic nematodes mechanisms

1. Cockroaches – *Steinernema carpocapsae oxyuris diesingi*
   - *a) Periplaneta Americana – Hammerschmidtella bareillyi*
   - *b) Blaterlla germanica – Oxyuris blatta orientalis*
   - *c) Blatta orientalis – Leidynema* sp. *Thelastoma appendiculata*
2. Housefly – *Steinernema carpocapsae*
   - *a) Musca domestica – Heterorhabditis bacteriophora*
3. Face fly
   - *a) Musca autmnalis – Heterotylenchus autmnalis Paraiotonchinm muscadomesticae*
4. Mole cricket
   - *a) Gryllotalpa* sp. *Steinernema scapterisci*
5. Ants

a) *Cephalotus minutes – Agamomermis cephalati*
b) *Lasus flavus – Pheromermis vilosa*
c) *Ectatomma ruidum – Meximermis bctatommi*

6. EPNS
   a) *Camponotus* sp. – *S. carpocapsae*
   b) *Myrmica* sp. - *S. carpocapsae*
   c) *Solenopsis* spp. – *S. carpocapsae*
   d) *Solenopsis nichteri – S. carpocapsae*
   e) *Solenopsis nichteri – H. bacteriophora*

Commercial formulations of EPN used

1. Algienate gel – *S. carposae S. foltiae*
2. Flowable gel – *S. carpocapsae*
3. Attapulginite chips – *H. bacteriphora S. feltiae*
4. Water dispersible granules - *S. carpocapsae, S. feltiae*

Nematodes for Weed Control

1. Compositae *Artemisia asiatica subanguina moxae*
2. Solanaceae *Solanum elaegnifolium – orrina phyllobia*
3. *Achyranthus aspera*
   a) *Chenopodium album- Meloidogyne incognita*
4. *Solanum nigrum*
   a) *Tifdwarf bermudagrass - Hoplolaimus galeatus*
5. Russian knapweed
   a) Acroptilon repens Subanguina picridis

Entomopathogenic nematodes for the control of plant parasitic nematodes mechanisms

Proposed to explain the suppression of PPNs by EPNS

1. Crowding of EPNs along the plant roots forces PPNS away
2. Massive doses of EPNs lead to the buildup of nematode antagonistic organisms in the soil resulting in nematode suppression
3. Allelochemicals like ammonium and indole produced by EPNs and / or their bacteria (Xenorhabdus / photorhabdus) inhibit egg hatching and repel or intoxicate PPNs

Attraction and Migration of EPN Towards Root Zone

- Co2 released by roots
- Constitute and induced plant volatiles attract both EPN and PPN. Some plants may release attractants constitutively or in other case, it may be pest induced response.
- Eg. Root weevil (Diaprepes abbreviates) feeding on roots of swingle injured root releases C12 terplnes.
- C12 terplnes acts as a nematode attractant both for EPNs and PPNs

Interaction between EPN and PPNs in the Rhizosphere

- There is no direct interaction between EPNs and PPNs
- Development of antagonists
  - Accumulation of EPN leds to development of general antagonists against nematodes which may reduce the number of PPNs

Allelochemicals

- Complex of allelochemicals produced by insect cadavers, various life stages of nematodes inside cadover and symbiotic bacteria which may drive PPNs
- Eg. EPN infected cadavers releases ammonia which is toxic to many organisms
- Secondary metabolite 3,5 fihydroxy didydroxy – 4-isppropulstilbene infected cadavers inhibited egg hatch of *M. incognita*
- Xenorhabdus and photorhabdus produce several agents with nematicidal and antimicrobial activity, which helps to maintain deceased insects for the development of EPNS antimicrobial agents include non-protein idoles, stillbene derivatives, xenorhabdins, denocowmacins, protenaceous chtinase and bacteriocins.

SERICULTURE

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69. Mulching in Mulberry

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Mulching is one of the agronomic practices which have influence on the plant growth and yield. The main purpose of mulching is to discourage weeds. Mulches have several advantages when they are applied on soil surface. Mulches not only conserve soil moisture through runoff control, increase infiltration, decrease evaporation and help in weed control but affect the soil temperature through radiation shielding, heat conduction and trapping and evaporation cooling. They also increase the soil nutrients through organic

matter addition, nitrification and mineral solubility, improve soil structure and increase microbial and soil fauna. Mulches which absorbs the impact of falling raindrops and reduce dispersion and sealing.

Mono-cropping, wider spacing and regular applications of manures and fertilizers to mulberry garden under irrigated conditions encourage the growth of number of weeds which affect the leaf yield. Nowadays, the greatest threat is availability of water for irrigation as the water table is going down year after year because of failure of monsoon and poor rain fall due to climate change. Hence, water management is also important for sustainable silk production. A major portion of irrigated water in mulberry garden gets evaporated from the soil surface as well as consumed by the competitive weeds.

Advantages of mulching

- Reduces weed growth by keeping light from reaching the soil surface.
- Reduces water loss from the soil surface, which helps maintain soil moisture.
- Moderates of soil temperatures, keeping it warmer on cold nights and cooler on hot days
- In winter, soil under mulch will be warmer than unprotected soil. This protect plants from the cycle of freezing and thawing.
- Reduces soil erosion and often reduces soil compaction.
- Prevents crusting of the soil surface. Water moves more readily into soil covered with mulch instead of running off.
- Keeps soil from splashing onto leaves; keeping soil off leaves reduces plant diseases.
- Breaks down and feeds the soil (if organic mulch).
- Improves the structure of clay soils and the moisture-holding capacity of sandy soils.
- Slowly increases soil fertility (if organic) and may make micronutrients already in the soil more available.
- Improves plant health and growth

Disadvantages of mulching

- Over-mulching (more than 3 inches) can bury and suffocate plants; water and oxygen can't reach the roots.
- Mulch near plant stems is the perfect place for slugs, snails, tunneling rodents, and more pests. Sprinkle wood ashes or diatomaceous earth around the base of plants
- Mulch can bake plants with excess heat in midsummer if not done properly.
- Light colored, wood-based mulches, like sawdust or fresh wood chips, can steal nitrogen from the soil as they break down. Counter this effect by adding a nitrogen-rich fertilizer, such as soybean meal, alfalfa, or cottonseed meal, to the mulch.

Types of mulching

Organic mulching

Organic mulches are natural products from leaves, trees, grass, and other plant material, often from your own yard**.** Organic mulching can enhance the yield of mulberry plants and which reduce the water loss from the field. **Compost mulching** is readily available and breaks down rapidly to improve soil. Leguminous cover crop adapted to tropical or subtropical area that generates much biomass. Sunhemp (*Crotalaria juncea* L.), Gliricidia are the best leguminous plants for mulching in mulberry field, which gives higher leaf yield both in winter and rainy seasons. Pruned mulberry twigs are also used as mulch, which not only improves the leaf yield but also to reduce the labour cost. Pruned mulberry twigs mulch is beneficial to the environment and does not create a problem of unnecessary waste being sent to the landfill. Straw and hay are a very popular mulch material which keeps the soil and soil-borne diseases from splashing up on lower plant leaves. Decomposition rate of straw is very slow and it lasts throughout the entire growing season. It also makes a nice shelter for spiders and other beneficial insects. Shredded mulberry leaves are also work as mulch naturally. It increases the earthworms in soil. Under water stress condition, combined application of sun hemp, organics and biofertilizers (*Azotobacter chroococcum*) can regulate the soil moisture and major nutrients, and to enhance the production and quality of mulberry leaves. With most organic mulches, a layer of 2 to 3 inches is plenty. The finer the material, the thinner the layer needed.

Inorganic mulching

Black polythene mulching is one of the important mulching practices in mulberry garden, which is highly effective on weed infestation, soil moisture conservation, growth of plants and leaf yield comparable to conventional hand weeding practice. Adoption of black polythene mulching in mulberry garden could help for sustainable production of cocoon by overcoming the problems of scarce of agriculture labours for weeding and limited availability of water for irrigation due to poor showers in the tropical zones.

Conclusion

Both organic and inorganic mulch are highly effective in mulberry field, mulches improves mulberry leaf yield, quality of mulberry leaves, reduce weed infestation and improves the soil properties with the use of proper mulching practices.

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AGROCHEMICALS

20767

70. Pesticide Cycle

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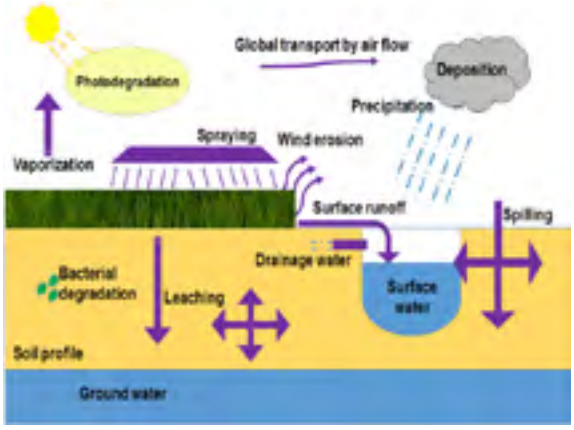
- The environmental dynamics of pesticides are predisposed largely by the several factors functioning in the environment and the physicochemical and biological properties of pesticides.
- The environment consists of atmosphere (air), hydrosphere (water), lithosphere (soil), and biosphere (biota), each component contains its own physical and chemical and/or biological properties.
- The living and nonliving elements in each component influence the dynamics of pesticides. The movement of pesticides in environment are further influenced by the physicochemical factors of pesticides.
- Properties of pesticides such as hydrophilicity or lipophilicity, partition coefficients, adsorption, vapor pressure, and volatility determine the ultimate fate of pesticides in the living and nonliving portions of the systems.



Entry into soil

- Pesticides enter the soil via spray drift during application, wash-off from treated leaves, release from granules or from coated seeds in soil.
- The movement, perseverance or break down of pesticides in soil depend on their chemical properties as well as physical, chemical and biological properties of the soil.
  - All these factors affect sorption/ desorption, volatilisation, degradation, uptake by plants, run-off, and leaching of pesticides.
  - Addition of organic raw material (biofertilizers) to soil can increase sorption and reduce risk to water pollution.
  - Change in soil pH or addition of nitrate fertilizers can induced a release of this residues. *e.g.* **plants and earthworms, can absorb and remobilise residues situated between pores**.

Entry to plant

Starts from foliage/root – various routes for penetration such as epidermal cells, walls of root hairs, stomata, cuticular cells, spongy mesophyll cells, lenticels or cracks, plasmodesmata. After penetration gets translocated in plants through phloem vessels and finally stored/metabolized sent out as transpiration loss.

Points considered while translocation of pesticides in the plants

- Systemic nature of chemical (mode of absorption)
- Lipophilic compounds get entered through root or wax cells and sometimes may found on pericarp of fruits.
- Absorption will be decided by solubility of pesticides and directly correlated with temperature.
- Wind velocity
- Seed dressers may enter through seeds.

Pesticides detected in water bodies are Pronofos, Dimethoate, Chlordane, Diuron, Prometryn and Fluometuron.

ORGANIC FARMING

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71. Liquid Bio Fertilizer and its Use in Crop Production

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Introduction:

Increases in human population raise a big threat to the food security of each people as the land for agriculture is limited and even getting reduced with time (Conway 2012). It is estimated that by 2020, to achieve the target production of 321 Mt of food grain to feed 8 billion populations globally, the requirement of nutrients will be 28.8 Mt while the availability will be only 21.6 Mt, creating a deficit of approximately 7.2 Mt of required nutrients (Arun 2007). Imbalanced used agrochemicals to meet the growing demand for food supply has undoubtedly led to contamination and severely damaged microbial habitats as well as beneficial insects. Nonetheless, the outcome of using excess chemical inputs has made the crops more prone to diseases and reduced soil fertility (Aktar 2009). LBFs are natural materials which are microbial inoculants they augment the availability of plant nutrients and enhance the growth of plants by increasing the supply of nutrients to the host plant. These are applied to seed, plants, and soil. LBFs are special liquid materials containing not only microorganism and their nutrient but also cell protectants and tolerance to adverse conditions. These liquid materials are also developed for potential applications in modern agriculture such as soilless farming systems.

Need for liquid biofertilizers:

Liquid biofertilizers are the natural form of fertilizer, required to restore the fertility of the soil. Continuous application of chemical fertilizer and other chemicals such as pesticide, herbicides decrease the crop yield and soil fertility. Liquid biofertilizers are supplement materials, increase the WHC of soil, and plant nutrients such as nitrogen, proteins and vitamins of the soil.

Application method of liquid biofertilizer:

Seed treatment: Seed treatment is effective and economic. liquid biofertilizer mixed with a 10% solution of jaggery. These materials and seed both are properly mixed and spread in shade on a cemented floor at overnight and then they should be used dry seed. Rhizobium, Azotobacter, Azospirillum with PSM can be used on seed treatment.

Root dipping: Root dipping is very effective on paddy or transplanted / vegetable crops. In this method, the seedling required for one acre is inoculated using 2.0-2.5 liter Azospirillum / PSM has to mix with water. The roots of seedlings have to dip for a minimum of half-an-hour before transplantation. (BIOFIT)

Soil application: This mixture is used for soil application during the leveling of soil. 200 ml LBFs mixed with (400-600 kg) compost along with 25 kg of rock phosphate. These mixtures kept on any tree or in the shade overnight and moisture should be maintained. Next day mixture fully prepared on the application of planting of fruit trees.

Self-inoculation: This method uses only tuber crop. 50 liter of water for 4-to-5 kg BF and mixed properly (tuber crop) planting after drying the materials in the shade.

Precaution of liquid biofertilizer application

- Liquid biofertilizer packets should be put away in a cool and dry spot away from direct daylight and warmth since biofertilizers are live items and require care in their storage. (BIOFIT)
- Right mixes of liquid biofertilizers must be utilized and different chemical substances should not be mixed with the liquid biofertilizers. (BIOFIT)
- The biofertilizer should be used for specific crop before the expiry date as mentioned on packet. (BIOFIT)
- When purchasing, one should ensure that each packet is provided with all necessary information like name of the product, name of the crop for which it is intended, full address of maker with name, making, and expiry date. (BIOFIT)

Advantages of liquid biofertilizers:

- Liquid biofertilizers have the potential to increase soil health and productivity and also reduce the use of agrochemicals.
- They are tolerant of high temperatures and ultraviolet radiation as compared to biofertilizers.
- The liquid formation is easy to handle and apply no loss of properties due to storage.
- They act as antagonists and suppress the incidence, as a bio-control, liquid biofertilizers are cost-effective relative to agrochemicals.
- They can add 20-to-200 kg N/ha under optimum soil condition and thereby increase the crop yield (15-25%).

Quality control measure of liquid biofertilizer:

These are some quality standards of liquid biofertilizer.

- The inoculant should contain a minimum of 108 viable cells of bioinoculant/g of the carrier on a dry weight basis when it is stored at 25–30°C.
- The inoculant should have at least 6 months shelf life from the manufacturing date in case of carrier-based and 9 months in case of liquid-based.
- The pH of the inoculant should be between 6.0 and 7.5.
- Inoculant should show effective nodulation/ nitrogen fixed on a particular crop before the expiry date.

Effect of liquid biofe6rtilizer on cereals crop

Crop	BF/chemical fertilizer	Results	References
Triticum aestivum L.	Azotobacter + PSB	Enhance growth, yield and nutrient uptake	Khandare2019
	Trichoderma harzianum BHU 51, varied N doses (100%, 75%, 50% and 25% RDN)	Significantly higher leaf area, root infection, grain yield was recorded with combined application of trichoderma with chemical N fertilization	Meena 2017
Zea maize L.	Liquid bio fertilizer + carrier based culture	Maximum yield attributes, grain & biological yields obtained as compared to others.	Gautam 2017

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CLIMATE CHANGE

20796

72. Climate Smart Agriculture: Need of the Hour

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Abstract

Moving towards 'Climate-smart Agriculture' (CSA) is currently promoted by key international organizations as a mandatory task to secure food supply by 2050. Since first promoting the term in 2009, the World Bank has ascended to become the chief voice in the CSA choir. CSA's approach to simultaneously addressing multifold sustainability and development challenges has gained significant attention at global forums, when it was presented by the Food and Agriculture Organization of the UN (FAO) at a Conference on Agriculture, Food Security and Climate Change (Rosenstock *et al.*, 2016). Powered by its intuitive call for change, CSA has rapidly become a leading organizing concept for international organizations working at the nexus of climate change, agriculture and development. There are scale of technologies that have potential to increase food production and adaptive capacity of food production system as well as reduce emission or magnify carbon storage in agricultural soils.

Introduction

Climate Change: climate change refers to the variation in the earth's global climate or in regional climates over time. It could show up as a change in climate normal's for a given place and time of year, from one decade to the next.

Why the Climate Change?

- **Natural causes:** continental drift, volcanoes, the earth's tilt, ocean currents
- **Manmade causes:** the industrial pollution, burning of fossil fuels, deforestation

Climate and Agriculture

- Considerably dependent on changes in weather.
- Contribution of agriculture to GDP is decreasing, yet large population dependent on this for livelihood.
- Need to understand the impacts of increasing climate risks and possible adaptations.

Climate Smart

- Developing countries must undergo a significant transformation in order to meet the related challenges of achieving food security and responding to climate change.
- Population growth and food consumption pattern indicate that agricultural production will need to increase by at least 70% to meets demands by 2050.

What is Climate Smart Agriculture?

- Sustainably increases productivity
- Resilience
- Reduce/remove greenhouse gases
- Enhance achievement of national food security

'Climate-smart agriculture' (CSA)—agriculture and food systems that sustainably increase food production, improve resilience (or adaptive capacity) of farming systems, and mitigate climate change when possible—has quickly been integrated into the global development agenda. The opening pages of almost any recent institutional publication unfold the future of agriculture and a common scenario.

Concept

It is an integrated approach to developing technical, policies and investment conditions to achieve sustainable agricultural development for food security under climate change It is this 'triple win' approach– the incorporation of intensification, adaptation and mitigation goals into a single rubric-that defines CSA. The overall aim of CSA is to support efforts from the local to global levels for sustainably using agricultural systems to achieve food and nutrition security for all people at all times, integrating necessary adaptation and capturing potential mitigation. Climate change is already hampering agricultural growth. According to the Intergovernmental Panel on Climate Change (IPCC), climate change affects crop production in several regions of the world, with negative effects more common than positive, and developing countries highly vulnerable to further negative impacts (McCarthy *et al.*, 2011). Average and seasonal maximum temperatures are projected to continue rising, with higher average rainfall overall. These effects will not, however, be evenly distributed.

The most critical issues of global warming could be managed by successful adaptation, which would probably be less than the cost of effects that would occur without development. CSA is comparatively a new approach which helps to increase agricultural production and income of the poor households through ensuring better practices in agriculture as well as reducing green-house gases emission. It has emerged as a framework to capture the concept that agricultural systems can be developed and implemented simultaneously to improve food security and rural livelihoods, facilitate climate change adaptation and provide additional benefits. However, the concept of CSA is still evolving and there is limited research that explores the linkages of CSA and sustainable agriculture and how the practices of CSA can be promoted to achieve food security and development goals. Despite potentiality of attaining sustainable agricultural development goal by implementing CSA properly, there is a poor connection among the components of CSA at the field level. More importantly, the concept is sometimes poorly understood by various levels of stakeholders (Braimoh and Osaki, 2010).

Objectives

1. Sustainably increasing agricultural productivity to support equitable increases in incomes, food security and development.
2. Adapting and building resilience to climate change from the farm to national levels.
3. Developing opportunities to reduce GHG emissions from agriculture compared with past trend.

What is needed for effective implementation of CSA?

Urgent action from public, private and civil society stakeholders at the international to local levels is required in four areas:

1. Building evidence and assessment tools.
2. Strengthening national and local institutions
3. Developing coordinated and evidence-based policies
4. Increasing financing and its effectiveness.

Technologies implied in smart agriculture

- **Satellite:** for crop classification, crop condition, land use and land cover
- **Drone:** for codastral survey, digital elevation and farm survey
- **Mobile app:** farmer registration, information sharing, data collection
- **Users:** farmers, authorities, government, related industries.

Climate smart practices

- **Crop management:** intercropping with legumes Crop rotation new crop varieties improved storage and processing techniques greater crop diversity.
- **Livestock management:** improved feeding strategies, rotational grazing, fodder crops, manure treatment, improve livestock health, animal husbandry improvement.
- **Soil and water management:** conservation agriculture (minimum tillage), contour planting, water storage, improved irrigation.
- **Agroforestry:** Boundary trees and hedgerows, nitrogen fixing trees on farms, multipurpose trees, fruit orchards.
- **Integrated food energy systems:** biogas, production of energy plants, improved stoves.

Solution summary:

1. **Planning:** better crop selection.
2. **Input management:** timely delivery of quality inputs.

3. **Crop insurance:** increase coverage of crop insurance and timely payouts.
4. **Extension services:** improve efficiency of better outreach and making farmers informed about best available.
5. **Farm management**: drive towards precision agriculture covering entire crop lifecycle management.
6. **Disaster management:** early season warnings for draught, flood, cyclone to ensure prevention action.
7. **Beneficiary schemes:** better linkage to output and inputs and timely and transparent access to schemes.

Role of institutions:

1. Enabling policy environment
2. Production and dissemination of information
3. Dissemination mechanism farmers field schools
4. Support financing and insurance need
5. Climate data and information gap
6. FAO's contribution to Climate smart Agriculture
   a) FAO's Fisheries and Agriculture Climate Change Programme
   b) Partnership and Sourcebook on Climate Smart Agriculture
   c) Economics and Policies Innovations for Climate Smart Agriculture (EPIC)
   d) FAO Framework Programme: Disaster risk reduction for Food and Nutrition Security
   e) FAO EX-ACT (EX-Ante Carbon Balance Tool)

Climate smart Agriculture in India

Climate Smart Villages (CSV's): CVS is a model of local actions for climate risk management in farming communities that:

- Promote adaptation
- Built resilience of climate stresses
- Enhance food security
- Capacity strengthening and technology targeting
- Integrated farmers participatory approach

NICRA- National Innovations on Climate Resilience Agriculture:

- To enhance resilience of Indian agriculture to climate variability and climate change
- To demonstrate site specific technology packages on farmer's field to cope with current climate variability
- To enhance the capacity of scientist, farmers and other stakeholders in climate resilient agricultural research and awareness of impact

Conclusion

Fast adoption of the CSA concept into the global betterment lexicon places a premium on understanding what is really known about CSA practices and technologies, the synergies and tradeoffs among its three pillars, and the socio-ecological niches where CSA works. Without such information, at best CSA will be a passing fad and at worst a large of influx of resources– both time and money–will be wasted. An unified, evidence based and transformative approach to addressing food and climate security at all levels requires coordinated actions from the global to local levels, from research to policies and investments, and across private, public and civil society sectors to achieve the scale and rate of change required. With the right practices, policies and investments, the agriculture sector can move onto CSA pathways, resulting in decreased food insecurity and poverty in the short term while contributing to abate climate change as a risk to food security over the longer term.

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WATER MANAGEMENT

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73. Integrated Water Management: A Paradigm Shift for Higher Productivity in Agriculture

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Water is a critical resource in terms of utilization and management for achieving better crop production. Greater pressure on water resources and stronger interconnectivity between sectors sharing these resources, demand for a novel approach *i.e.* integrated water management.

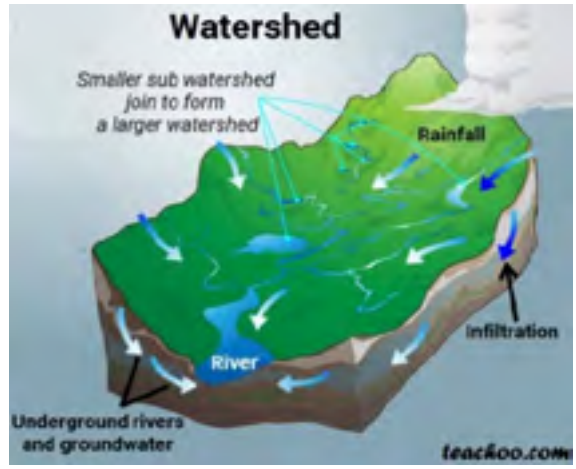
Integrated water management (IWM)

Effectiveness in saving of water, equity in water sharing and delivery efficiency are essential for the sustainable use of available water resources. There would be an integrated policy for appropriate use of ground, rain, river, sea, sewage and other water resources. For accomplishing these objectives integrated water management is the exact approach. It includes micro-irrigation, rainwater harvesting and watershed management for attaining above distinct goals.

1. **Micro-irrigation:** It is a method of irrigation in which water is applied to the root zone of the crop at slow speed, under low pressure and a measured rate. It helps in fertigation and chemigation. Micro-irrigation includes drip, sprinkler, trickle and micro spray. Micro-irrigation systems not only promote water conservation but also create specific micro environment. It is proved to be an efficient method in saving water and increasing water use efficiency as compared to the conventional surface method of irrigation, where water use efficiency is only about 35-40%.
2. **Rainwater harvesting:** Rainwater is a prime and vital source of freshwater on the earth. The distribution of annual rainfall varies from less than 50 mm to more than 2000 mm in low to high rainfall areas. Water harvesting indicates a paradigm shift from the present reliance on river and groundwater to meet the domestic, industrial and irrigational requirements of water.
3. **Watershed management:** Watershed management is a holistic approach where it aims at optimizing use of land, water and vegetation in an area to alleviate drought, moderate floods, prevent soil erosion, improve water availability and increase food, fuel, fodder and agricultural production on sustainable basis.

Micro irrigation

Rainwater harvesting



Watershed management

Conclusion

To make water resources sustainable, there is need for an integrated water management system which

should include policy and management actions like.

- Improved water conservation and storage measures.
- Incentives for selection of draught tolerant crop varieties.
- Efficient irrigation systems.
- Crop that reduce water loss

Agricultural growth and development will become sustainable only if we judiciously use our valuable and limited water resources with the help of modern technologies and traditional wisdom. If we follow all the integrated water management approaches as we said above that will pave a way for a paradigm shift for higher productivity in agriculture

CROP PHYSIOLOGY

20742

74. Next-Generation Phenotyping for Crop Improvement

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Introduction

In the future, the world population is expected to increase by up to 9 billion by the end of 2050. To feed the increasing population, crop yields have to be improved at an annual rate of 2.4%. Such an escalating population creates critical demand for food, energy, and water which becomes a daunting task for scientists and policymakers in recent decades. Besides, as a consequence of global climate change, the crops are more frequently exposed to extreme weather conditions like drought, flooding, high temperature, etc., On the other hand, limited availability of arable land and water and nutrient resources also creates great impact Therefore, improved and climate-resilient varieties of crop plant are required to address these challenges by connecting genotypes with phenotypes so that the fullest potential of a genotype can be gained in given environments. Whereas progress in breeding depends on the ability to design crosses with complementary traits, and then perform effective selection among offspring. This requires precise and cost-effective methods to evaluate large numbers of plants across relevant environments and stresses.

The traditional method of plant phenotyping is now a bottleneck in accelerating the breeding program because it deals with either one or a few specific plant characteristics at a given time and does not allow a thorough functional analysis of constituent traits linking genotype with the phenotype. Furthermore, it is an invasive, labor- dependent and time-intensive for measuring many traits in segregating generations, thereby, delaying selection to later generation and decreasing the breeding efficiency and genetic improvement. To adapt to modern breeding programs, plant phenotyping needs to generate high-quality quantitative data on the dynamic response of a genotype to the environment. Recently, plant phenomics has offered and integrated a suite of new technologies that have increased accuracy, precision, and throughput at all levels with reducing costs and minimizing labor through automation, remote sensing, data integration, and experimental design, which is the trend in modern plant phenotyping.

High throughput phenotyping

Many next-generation and high throughput plant phenotyping platforms (HTPPs) were developed to measure trait values accurately and assess variation among individuals. This is based on various imaging techniques to record plant structure, estimate biomass, and analyze phenology, plant health, tissue water relations, transpiration, photosynthetic activity, and others. The phenotyping systems can operate in a field setting or a controlled environment. It is a low-cost, automated method for data acquisition on various physiological and morphological data with high precision. This helps to screen a large number of populations at a considerable time with a better understanding of the whole phenome of the plant under a wide range of environmental and growth stages. In HTPP, a variety of imaging methodologies are being used to collect data for quantitative studies of complex traits related to the growth, yield, and adaptation to biotic or abiotic stress (disease, insects, drought, and salinity). These imaging techniques include visible imaging (machine vision), imaging spectroscopy (multispectral and hyperspectral remote sensing), thermal infrared imaging, fluorescence imaging, 3D imaging, and tomographic imaging (MRT, PET, and CT).

Visible imaging

A visible image is similar to perception as the human eye. It is also known as RGB imaging because its camera array has red, green, and blue sensors. It uses the visible range of the electromagnetic spectrum (400–700 nm) to capture the image of plants from different angles. It provides imaging in two dimensions, those images are processed in specific algorithms to find the pixel of the image which is later used to analyze the data of numerous morphological phenotypic characteristics like the biomass, plant growth, leaf area, leaf number, leaf senescence, seed germination, seedling vigor, yield traits, and root

architecture. This technique can be efficiently used in a controlled environment than the field or open environment as it influences light, shadow and less difference between the crop and background was observed because of color and brightness effect.

Near-Infrared Imaging (NIR)

NIR imaging is longer than the limit of visible imaging (~700 nm to 1700 nm). Infrared light interacts with the plant tissue and reflects the spectrum based on plant health where healthy plants emit a higher portion of NIR and weak plants emit more red lights. Since water has a strong absorption band at five regions like 970nm, 1200nm, 1450nm, 1930nm, and 2500nm out of which 3 regions were captured by NIR sensors. It is used to detect the vegetation indices like green biomass, pigment, senescence, and water status of the plants under varied environmental conditions. In most of the studies, visible and NIR are combinably used to detect the vegetative indices. Visible and NIR assesses the plant health status in response to various environmental stresses. It gives the precise and large volume of the information under changing environmental conditions in the field of a large population. It can also be mounted to unmanned aerial platforms to screen the tolerant line over a large population on drought, salinity, or high temperature. It is not only used in the abiotic stress screening process but also biotic stress.

Hyperspectral Imaging

Hyperspectral imaging functions in the infrared region that uses hundreds of narrow bands to derive the reflectance from each pixel of the image thus generates larger data for each image. Captured data will be processed in specific databases and algorithms. Based on the spectral reflectance physiological state of the plant can be determined. It is mainly used to detect the plant water status, the severity of damage caused by an insect, plant architecture, plant stress level, relative water content, sugar level, nitrogen distribution on plants and pigments. Besides various micronutrients and protein content can also be measured as it can scan at a higher resolution. The major limitations in hyperspectral imaging are high cost, larger data sets, and complex to interpret the data.

Fluorescence imaging

Fluorescence imaging is used to measure the stress level of the plant-based on the chlorophyll emission. In this method, plant samples were illuminated with visible or ultraviolet wavelength using pulsed lasers or sunlight, and absorbed light will be reemitted by the chlorophyll that is probed by a charge-coupled device camera. The re-emission of fluorescence signals varies based on plant health. Fluorescence imaging is used to screen the plants based on photosynthetic performance. It is also used to quantify the non-photochemical quenching, photo-assimilation, photosystem II status of the plant sample. The major limitation of fluorescence imaging is deep canopy structure, varied illumination, and wind under field condition.

Thermal imaging

Thermal imaging is used to visualize the surface temperature of the canopy or leaf surface. The spectral range of the camera is more than 3000 nm. It is used to measure the leaf temperature in correlation with stomatal conductance and transpiration rate to examine the plant water relation. Thermal imaging can be implemented both in controlled and field conditions to screen large populations for water stress, salinity stress, and biotic stress. It provides rapid and precise measurements under uniform environmental conditions over a large area in a short time. The major limitations while visualizing in filed condition are external factors like wind, transient cloudiness, soil temperature therefore it requires extensive calibration and rigorous protocol.

Conclusion

It is a recently established technique on plant phenotyping which gives precise information on various physiological traits in interaction with their dynamic environment. It requires prerequisite knowledge of software, plant phenotyping, image processing, and data extraction to access the high throughput phenotyping (HTP). It is used to understand the complex interaction of various phenotypic responses to different climatic conditions, soil type, and different management practices. It helps to screen large populations like the mutant population, mapping the population in reliable time. This approach facilitates speeding up the breeding program to develop resilient or improved varieties to feed the growing population.

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20765

75. Effect of Melatonin on Seed Physiological Quality under Abiotic Stress

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Melatonin is a hormone and biosynthesised from tryptophan, which is chemically called as N-acetyl-5-methoxytryptamine. It was first segregated from cow-like pineal organs (creatures), which is associated with numerous physiological cycles including circadian rhythms. This compound is also naturally been detected in the seeds, roots, fruits, and leaves of plants. Its antioxidant activity seems to function *via* a number of mean as a direct free radical scavenger by stimulating antioxidant enzymes, its ability to augment the activities of other antioxidants by protecting them from oxidative damage and increases the efficiency of mitochondrial electron transport chain there by lowering electron leakage and thus reducing of free radical generation.

Exogenous melatonin treatment to seeds, roots and can ease biotic and abiotic stresses, for example, outrageous temperature, overabundance copper, saltiness, dry spell, senescence and microbe assault by directing physiological cycles in plants including seed germination, growth promotion, photoperiodic responses, flower development, root system architecture and senescence delay (Murch and Saxena, 2002). A highly appealing property of this molecule, which distinguishes it from most antioxidant is that, its metabolites also have the ability to scavenge reactive oxygen species (ROS) and reactive nitrogen species (RNS), even at low concentrations and highly effective in protecting seeds and plans from oxidative stress.

Posmyk *et al.* (2008) resulted in red cabbage (*Brassica oleracea rubrum*) that pre-sowing treatments with HM (Hydro priming melatonin) 1 (1 µM) and HM 10 (10 µM) was most effective in protecting against toxic copper ion concentrations than HM 100 (100 µM) which leads membrane peroxidation and DNA endo-replication blockage in seedlings.

Wei Wei *et al.* (2015) showed the effect of 100 µM melatonin seed coating in soybean (*Glycine max* (L.) *Merr.*) showed tolerances to abiotic stresses salt and dry spell) and saw in yield and its unsaturated fat substance. Transcriptome examination uncovered that salt pressure repressed articulations of qualities identified with official, oxido-reductase movement/ cycle and auxiliary metabolic cycles was up-managed by melatonin treatment eased quality number.

Mervat Sh. Sadak (2016) reported that 500 µM melatonin by priming treatment in wheat (*Triticum aestivum* L.) seeds showed pronounced and effective mitigation for adverse salinity stress in field conditions.

Kataryzan *et al.* (2016) monitored the stability of the photosynthetic pigments (chlorophylls a, b and carotenoids) and higher water content in the tissue under paraquat induced oxidative stress conditions in pea (*Pisum sativum* L.) growing seedlings by hydro priming with 50 µM melatonin indicated beneficial effect.

Qiao *et al.* (2017) researched the conceivable mediatory function of melatonin in development, photosynthesis and the reaction to cold worry in rice (Oryza sativa L. cv. DM You 6188) with treatment techniques for seed drenching and root inundation of 100 µM melatonin were more successful in improving cold obstruction than the showering strategy following six days of cold pressure.

Conclusion

Melatonin has both lipophilic and hydrophilic nature has a capacity to cross morphological and physiological obstructions and quickly shipped to cells of seeds through preparing prompts increments in plant development yield and shield from abiotic worries in plants, conceivably through improvement of photosynthesis, sugar digestion and antioxidative activities, gives a stage to future examination.

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76. Impact of Salinity Stress on Growth Traits in Sorghum

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Introduction

Among the cereals, sorghum (*Sorghum bicolor* L.) is the fifth most important crop after wheat, rice, maize and barley. Sorghum crop mainly cultivated under high temperature areas with relatively low rainfall patterns. It is considered to be the principal source of energy, vitamins, proteins and minerals especially for those in semi-arid condition. Plant growth has been affected by many of the environmental factors out of which salinity stress on crop development is considered as one of the most important abiotic stress on crop plants. Osmotic effects, nutrition disorders and specific ion deficiency or toxicity are some of the major constraints that are caused due to the salinity stress especially in semi-arid and arid regions. Its effects may depend on the crop characteristics like species, genotype, crop stage, salinity solution composition, ionic strength and causes a series of physiological and biochemical changes including reduction in plant water content, degradation of chlorophyll and also results in morphological changes. Therefore, salinity stress retards the crop growth and development and eventually results in reduction of yield. Sorghum is often grown under poor irrigated conditions with partial saline soil condition. Thus, it is expected to have some physiological and biochemical mechanisms partially to overcome the salinity stress.

Effect on germination percent

Sorghum germination was significantly influenced by different factors that resulted in increasing salinity stress. Salt stress given by irrigation water to sorghum at three different levels @ 100mM, 200 mM and 300 mM of NaCl and germination percent was recorded by Mbinda *et al.* (2019). Germination of the crop was highly influenced by salinity stress due to irrigated water. Reduction of germination ranges from 14.47 to 84.51 % differs based on the cultivars. Serena cultivar recorded higher reduction of germination than the cultivars Gadam and ScSila. Mbinda *et al.* (2019) concluded that the salinity stress had also delayed the germination by decreasing osmotic potential of soil solution which delays seed water imbibition, affecting protein synthesis and makes embryo toxicity to sodium and chloride ions.

Effect on shoot and root length

Salt stress not only delayed the germination rate but also caused reduction in seedling vigour. Mbinda *et al.* (2019) and (Ali and Idris, 2015) had concluded that the increase in salt concentration crop establishment was reduced and resulted in decreased root length ranges from 6.08% upto about 93.30% and shoot length about 15.11% to 94.32% which depends on the type of cultivars and varieties. Root length was highly reduced even at low salinity concentration due to accumulation of excess of toxic ions which resulted in reduced water intake due to increased osmotic pressure of the soil (Ouji *et al*., 2015; Majid *et al*., 2013). Hence, causing wide alteration in physiological mechanisms correspondingly would have been recorded lower growth of sorghum crop. This result was in accordance with the findings of Chai *et al.* (2010).

Length of root and shoot was significantly affected due to salt imposition artificially at early growth stages. Roy *et al.* (2018) given that the seedling establishment was poor due to accumulation of salts in the germination area of the crop which causes hypocotyl mortality thus it obviously resulted in reduction of shoot and root length. Growth gets inhibited due to the ethylene accumulation around the roots due to salinity causing retarded root and shoot length (Sagar, 2017).

Effect on leaf blade and sheath length

Seedling under salinity conditions with less vigour correspondingly leads to the poor establishment and growth of the crop. Roy *et al.* (2018) resulted with reduced growth rate with lesser leaf blade length. Salinity stress also has a significant effect on shoot and internodal length of sorghum. The reason behind this reduction in shoot length might be the initiation and expansion of leaf suppression, reduction in internodal growth and by accelerating the abscission of leaf resulting in leaf blade and sheath length reduction (Qu *et al.*, 2012; Sagar, 2017).

Effect on plant height

Interaction of salinity and plant height resulted in a decreasing plant height with increase in salt concentration (Haghighat *et al.*, 2012). Plant height was found to be sensitive to salt stress that it got greatly affected. Joardar *et al.* (2018) recorded lower plant height in high salinity condition than the normal growth conditions. Plant height recorded 27.09% lower than the control condition under the irrigated water with the salt concentration 14.04 dSm^{-1} whereas irrigation water with 4.19 dSm^{-1} recorded 3.98% lower plant height than the control treatment. This was due to the reduced water uptake and toxic level of sodium ions in the growth media causing physical damage to roots resulted in reduced nutrient and water absorption which ultimately retards the plant growth and development (Iqbal *et al*., 2000).

Effect on leaf number, length and width

Number of leaves produced in sorghum plants recorded lesser effect due to salinity stress. Whereas, leaf length and width were significantly reduced due to salt stress thus leaf length and width decreased with increase in salt concentration. Joardar *et al.* (2018) reported that salt concentration at 14.04 dSm^{-1} resulted in reduced leaf length and leaf width to about 16.63% and 30.79% respectively when compared to control. This might be owing to changes in biochemical and physiological mechanisms which causes toxic ion accumulation, increased osmotic potential of plant cells leads to decreased cell size and growth and causing deficiency of minerals would adversely affect the leaf size of the crop plants.

Effect on plant biomass production

Crop undergoes characteristic changes in growth processes in growth stages which leads to decreased growth rate and dry matter production. Niu *et al.* (2012) reported that stalk dry weight reduced in EC of 8 dSm^{-1} about 79.41% in the cultivar KS585 and in the cultivar SS305 to about 39.39%. They also concluded that shoot dry weight reduced in the cultivars SS305 and KS585 to about 51.17% and 76.925% respectively. Chai *et al.* (2010) result shows that the fresh and dry weight of root and shoot get reduced under salt stress. Observation during the initial crop growth stage had higher effect on biomass production than during the later stages. Bavei *et al.* (2011) also reported that the reduction of fresh weight due to higher salt concentration. This reduction in production of plant biomass mainly due to changes in physiological and morphological changes (Hasegawa *et al*., 2000; Munns, 2002). Reduction in biomass was due to the reduction in chlorophyll content and relative water content (Acosta-Motos *et al.*, 2017). Salinity stress also has resulted in reduction of cell division and cell elongation which ultimately causes decreased plant biomass production. Thus, salt stress resulted in lesser plant growth rate with reduced dry matter production then ultimately resulted in lower productivity of crop.

Conclusion

Extent of salt stress on crop plants depends on the type of cultivars and salt concentration of the growth media. Response to salinity stress on physiological, biochemical and morphological processes based on the cultivars and varieties. Some of the cultivars reported to be sensitive and some are partially tolerant to salinity. However, salt stress accordingly resulted in reduced growth and development of crops with decreased productivity. Its effects include decreased germination percent, plant height, plant dry matter production and economic product. Thus, salinity was major abiotic stress to the crop plants and identification of salt tolerant variety to overcome this lesser productivity.

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77. Exploitation of Biofertilizer in Ornamental Bulbous Crops

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INTRODUCTION

Floriculture is considered as the sunrise industry and now a day it is gaining popularity throughout the world. The word bulb is mostly used in commercial horticulture technology. It is generally used to describe the specialized modified underground stem structures with tunicate (Tulip) or without tunicate (Lilium). To improve the floral and vegetative characters, vase life and for higher productivity of flowers, a good nutrient management is essential. Biofertilizers are the new cost effective renewable source of plant nutrients to supplement chemical fertilizers. Now a days using the biofertilizers as a partial substitute for chemical fertilizers.

Biofertilizers are defined as industrial outcomes based on culturable microorganisms that were isolated from the soil. Which are able to modify or improve the plant development through different mode of actions and the culturable microorganisms are present in soil only 1%. After different in vitro tests the numerous researchers results that microorganism as a biofertilizer and its activity should be proven in soil and field conditions, because the plant microbe interaction must function in the presence of the high diversity of other microorganisms living in soil.

Bulbous ornamentals?

Those ornamental plants which have specialized modified underground stem structures to overcome the unfavorable environmental conditions are known as ornamental bulbous plants. They are flowering or non-flowering bulbs. Ex. Tuberose, Narcissus, Dahlia, Tulip

What is Bio fertilizer..??

Bio fertilizers are a large population of culturable, specific and beneficial microorganisms for increase the productivity of soils either by fixing atmospheric nitrogen (or) by solubilizing soil phosphorous (or) by stimulating plant growth through synthesis of plant growth promoting substances.

How biofertilizer function

Bio fertilizers fix atmospheric nitrogen in the soil at plant root zone and make it available to plant. They are solubilizing the insoluble form of phosphates such as tricalcium, iron and aluminum phosphate into available forms and also they are scavenging phosphate from deeper soil layers to make it available to ornamental bulbous plants. Biofertilizers are producing hormones, anti-metabolites and decompose organic matter which promotes root growth and help in mineralization process in soil.

Types of biofertilizers

Rhizobium

The most recent studies communicate the N-fixing symbiosis between G^{-ve} bacteria generally called rhizobia and plants including various important ornamental bulbous crops. The chemical molecules involved in the signal exchange between the bacteria and the ornamental plant which determines the development of the infection and nodule formation in the root have been described in various model plants. One of the best models is flavonoids or isoflavnoids molecules released by the plants which induce bacteria genes and consequently the synthesis of the lipo chitin oligosaccharides (LCO) which in turn control infection and nodule development in the root. Recently by using the new technologies researchers are improved a new generation of rhizobium inoculants based on crop specific, including the addition of those signals involved in the early interactions between the bacteria and the plant. Generally rhizobium fixes 10-30 Kg of nitrogen per hectare, leaves residual nitrogen, increase yield by 10-30% and maintains soil fertility.

Azospirillium

Various strains of Azospirillum were initially characterized as free living diazotrophs which were able to fix nitrogen in aerobic conditions. Nitrogen balance measurements and *in situ* determination of acetylene reduction activity have shown that nitrogen fixation was not only the main reason for the plant growth mediated by Azospirillum, but an effect on root development and structure looks to be the main reason for the stimulatory effect of plant growth (Bashan *et al* 2004). With application of Azospirillium 20-40 kg of nitrogen fix in soil and increase mineral, water uptake, root development, vegetative growth and crop yield.

Azotobacter

Azotobacter is a free living bacteria mostly found in neutral to alkaline soils. It can fix the atmospheric N_2 by converting into NH_4. It also solubilizes insoluble phosphate into soluble form of phosphate for crop plants.

Benefit to the plants

Azotobacter supplies 20-40 mg nitrogen per gram of carbon source and promotion of growth substances such as vit. B group, indole acetic acid and gibberellic acid. It increases the yield 10-15%, maintains soil fertility and biological control of diseases by suppressing the pathogens. Improve germination percentage, increase number and length of shoot & root, reduce 25-30% nitrogenous fertilizer requirement.

Blue Green Algae and Azolla

Blue green algae are both free living as well as symbiotic cyanobacteria. Azolla is an extremely reduced in form and specialized, looking like typical ferns and it is important factor in using azolla as biofertilizer for crops is its quick decomposition in the soil and efficient availability of its nitrogen to the plant and also production of plant growth substances like IAA and GA_3

Phosphate solubilizing inoculants (PSI) and Vesicular arbuscular mycorrhizeae (VAM)

Phosphate solubilizing microorganisms are bacteria (or) fungi, which can dissolve bounds of phosphate in soil and make it available to plants *e.g. Pseudomonas*, *Bacillus*, etc.

Mycorrhizeae are obligate and sporophytic in nature requires a living host for their survival and they improve the uptake of Zn, Cu and Water.

Method of Applications

Seed treatment

The biofertilizer is mixed with 200 ml of jaggery solution. Then after mixed the slurry so as have to uniform coating of inoculant on seeds and then dried for 30 mints. Soon after drying the inoculant coated seed are broadcasted. The treated seeds should be used within 24 hours.

Dip method

In this method one kilogram of inoculant is mixed with 5L of water in a bucket and mixed thoroughly. The roots of seedling dipped in the inoculant suspension for about 1/2hr and transplanting into field.

Soil application

In this method taken the 4-5 kg desired strain and mixed with 100 kg of well decomposed farm yard manure then after apply the mixer to the soil; cover

the soil soon after application to avoid direct sunlight exposure.

Use of biofertilizer in ornamental bulbous crops

Biofertilizers provide some of the plant nutrients are available to the roots through the different actions of biofertilizers. Bacteria are among the predominant organisms that solubilize mineral phosphorus into soils. The biofertilizers discharge plant growth substances which are favor for bulb germination, root growth and increase absorption of nutrients from soil. It can reduce 50 % of the loss due to denitrification and leaching of fertilizers. Application of biofertilizer in bulbous ornamental plants increased plant height, spike length, flower diameters, etc. the biofertilizer treated corms earliness in days to spike and days to flowering.

Recommendation of biofertilizers for different ornamental bulbous crops

Gladiolus: Application of Azotobacter and Azospirillium @ 4 kg/ha each, improves growth and development of plants.

Tuberose: Application of Azotobacter and Phosphate solubilizing bacteria @ 2.5 g /Kg improve growth, quality and productivity.

Dahlia: Application of Phosphate solubilizing bacteria 25 g pot1 with Vermicompost 500g increase growth and quality attributes.

Narcissus: Inoculation of biofertilizers to improve growth and quality characters.

Biofertilizer	Recommended Crops
Rhizobium	Gladiolus, Tuberose etc.,
Azospirillum	Gladiolus, Tuberose, Dahlia, Daylily, Alstroemeria, etc.,
Azotobactor	Tuberose, Dahlia, Helianthus, Gladiolus etc.,
Blue Green algae	Daylily, caladium, etc.,
Azolla	Narcissus, Daylily, Alstroemeria etc.,
Phosphate solubilizing bacteria	All ornamental crops

Requirement biofertilizers in India

Bio fertilizers	Estimated requirements (tons)
Rhizobium	34999
Azotobacter	145953
Azospirillum	74342
Blue green algae	251378
Phosphate solubilizer	25534

Source: Agriculture Today

Precautions

To use only crop specified inoculants just before sowing of the crop. Biofertilizers are stored in room temperature (25°C) at cool and dry place and do not put culture in warm (or) hot water. In high acidic (or) alkali-saline soil use the soil amendments with biofertilizers.

Tulips

Narcissus

Azolla

Rhizobium

Conclusion

From the foregoing discussion it can be concluded that the use of biofertilizer inoculants not only increase yield parameters but also improves soil physical properties by increasing the activity of microorganism which eventually increases the sustainability of soil. By use of biofertilizers reduces 25-30% of nitrogenous and phosphatic chemical fertilizers.

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78. Biostimulants: Role and Categories of Biostimulants in Agriculture

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A plant biostimulant is any substance or microorganism applied to plants with the aim to enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrients content. By extension, plant biostimulants also designate commercial products containing mixtures of such substances and/or microorganisms. Bio stimulants are referred to as positive plant growth regulators or metabolic enhancers which when applied in small quantities enhance the growth and overall development of plants (Srivastava *et al.*, 2010). Bio stimulants can act directly on the plant physiology and metabolism or by improving the soil conditions. Bio stimulants in soils affect the micro flora and may have positive influence on plant growth. These products are usually applied in addition to recommended fertilizer to improve the nutrient use efficiency and crop quality. These bio stimulants serve to be very effective in plant growth and enhancing crop yield, but since soil acts as an ultimate sink for all the chemicals applied on it, therefore even slightly higher concentrations of any chemical can harm the next crop in rotation or may also leach down to contaminate ground water resources. The aim of modern agriculture is to reduce inputs without reducing the yield and quality. This can be achieved through breeding programs but it would be species specific and time consuming. Any improvement in agricultural system that results in higher production should reduce the negative environmental impact of agriculture and enhance the sustainability of the system. One such approach is the use of bio stimulants, which can enhance the effectiveness of conventional mineral fertilizers and enhances growth and overall development of plants.

Benefits of Bio Stimulants

1) Supplement and enhance existing agricultural practices and crop inputs. 2) Faster plant growth and development throughout the crop life cycle from seed germination to plant maturity. 3) Improve efficiency of the plant's metabolism to induce yield increase & enhanced crop quality. 4) Increase plant tolerance and recovery from abiotic stresses. 5) Facilitate nutrient assimilation, translocation & use. 6) Enhance quality attributes of produce *viz*. sugar content, colour, fruit seeding, *etc*. 7) Render water use more efficient. 8) Enhance soil fertility.

Categories of Plant Biostimulants

On the basis of source and content bio stimulants categorized into:

1. Humic substances (Humic acid and Fulvic acid)
2. Amino acid products.
3. Seaweed and Plant extracts
4. PGPRs
5. Chitosan and biopolymers
6. Inorganic compounds

Humic Substances (Humic acid, Fulvic acid)

Prolonged use of chemical fertilizers alone in intensive cropping systems leads to unfavourable soil nutrient status, harmful effects on soil physico-chemical and biological properties and thus defies the concept of sustainable crop production. Humic substances are heterogeneous organic molecules in the soil as byproducts of microbial metabolism of organic matter which is extracted from naturally humified organic matter. Natural organic substances such as humic and fulvic acids play an essential role in ensuring soil fertility and plant nutrition. Addition of such molecules either to the soil or through foliar spray along with adequate amount of conventional fertilizers improves the efficiency of applied fertilizers apart from promoting the conversion of unavailable form of nutrients to available forms. The organic compounds prepared from humic and fulvic substances have chelating, plant growth stimulating effects and positive effect on the growth of various groups of microorganisms. The presence of humic acids was found to increase the content and total amount of nitrogen in plant. Humic acids also promote antioxidant production in plants which in turn reduce free radicals, which result from stress (drought, heat and ultraviolet light). There radicals are damaging because they are strong oxidizing agents which damage lipids, proteins and DNA within plants cells. Antioxidants are metabolites and enzymes which

seek out free radical molecules and protect plants from damage. They include lipid soluble substances like vitamin E, beta-carotene and water-soluble materials such as vitamin C and various enzymes. Savitha *et al*. (2018) reported that soil application of humic substances (humic and fulvic acid) @ 5 kg ha^{-1} at sowing + foliar application of humic substances (humic and fulvic acid) extracted from vermicompost (0.2%) at 40 DAS resulted in better uptake of nutrient by the crop and higher yield in soybean (1.74 t ha^{-1}).

Amino Acid Products

Commercially available amino acid bio stimulants are mixtures of different amino acid and short peptides, called protein hydrolysates (PHs). PHs are mainly produced by chemical (with strong acids or alkalis) and/or enzymatic hydrolysis of proteins contained in agro-industrial by-products from animal (*i.e.*, leather, viscera, feathers, blood) or plant origin (*i.e.*, vegetable by-products) and in biomass of dedicated legume crops (*i.e.*, seeds, hay). PHs have been identified to improve the performance of several horticultural crops, including increased shoot, and root biomass and productivity. Application of PHs to plant leaves and roots has been shown to increase Fe and N metabolism, nutrient uptake, and water and nutrient use efficiencies for both macro and microelements (Cerdán *et al*., 2009; Ertani *et al*., 2009; Halpern *et al*., 2015). The higher nutrient uptake in PH-treated plants has been attributed to (1) an increase in soil microbial activity and soil enzymatic activities, (2) improvement of micronutrient mobility and solubility, in particular Fe, Zn, Mn and Cu, (3) modifications in the root architecture of plants, in particular root length, density and number of lateral roots and, (4) an increase in nitrate reductase, glutamine synthetase and Fe(III)-chelate reductase activities. Colla and his cowerker in 2013 conducted experiment to study the effectiveness of a plant-derived protein hydrolysate to improve crop performances under different growing condition.

Seaweed and Plant Extracts

In recent years natural seaweeds are being used as substitute of synthetic fertilizer fertilizers. Seaweed extracts are marketed as liquid fertilizers and bio-stimulants because they contain multiple growth regulators such as cytokinins, auxins, gibberellins and various macro and micronutrients necessary for plant growth and development. Moreover, it helps in promoting the growth of beneficial soil microorganisms developing tolerance to environmental stress and increasing nutrient uptake from soil and enhancing antioxidant properties. Different formulations of sea weed such as LSF (Liquid Seaweed Fertilizer), granular and powder are available in market. Foliar spray of 10 per cent seaweed sap extracts of *Kappaphycus alvarezii* and *Gracilaria spp*. with 100 per cent RDF could improve nutrient content in cane and nutrient uptake by sugarcane. Mahajan *et al*. (2017) revealed that foliar application of *Gracilaria sap* along with recommended dose of fertilizer (RDF) resulted higher macro nutrients uptake *i.e.* nitrogen, 54.47 and 27.59, 7.46 and 4.49 kg ha^{-1} phosphorus and 14.34 and 17.56 kg ha^{-1} potassium in grain and straw and highest uptake of micronutrients (Cu, Fe, Mn and Zn) and also noted increment of protein yield of blackgram (31.67%) as compared to the control.

PGPRs

Plant growth promoting rhizobacteria (PGPRs) are multifunctional and influence all aspects of plant life: nutrition and growth, morphogenesis and development, response to biotic and abiotic stress, interactions with other organ-isms in the agroecosystems

Inorgani Compounds

Chemical elements that promote plant growth and may be essential to particular taxa but are not required by all plants are called beneficial elements. The five main beneficial elements are Al, Co, Na, Se and Si, present in soils and in plants as different inorganic salts and as insoluble forms like amorphous silica ($SiO_2.nH_2O$) in graminaceaous species. These beneficial functions can be constitutive, like the strengthening of cell walls by silica deposits, or expressed in defined environmental conditions like pathogen attack for selenium and osmotic stress for sodium. Their function as bio stimulant of plant growth, acting on nutrition efficiency and abiotic stress tolerance, hence distinct from their fungicidal action and from their fertiliser function as sources of nutrients, deserves more attention.

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WEED SCIENCE

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79. Allelopathy in Weed Management: A Way Forward to Weed Management in Organic Agriculture

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Introduction:

Weeds are the serious threat in crop production compared to pest and disease problem. It causes more than 33% of yield loss in crop production. As the manual weeding is costlier and increasing the demand for agricultural labours due to urbanisation, farmers are forced to choose chemical weed management. But it causes environmental pollution and also contaminate the water bodies. Now a days due to increasing awareness towards organic food, the demand towards its food production has increased. But weed management through herbicide is strictly prohibited in organic agriculture. So, if the farmers wish to cultivate crop in organic way, they need to depend on manual weeding. It increases the cost of production, instead to that plant derived allelopathic compounds can be used to control weeds in organic agricultural field. Most of the study results revealed that the parthenium, eucalyptus, etc., derived allelopathic components produced effective weed control in agricultural fields.

There are two types of allelopathy:

True allelopathy: The direct or indirect harmful effect on the other plants through the release of toxic substance as such from the plant. *E.g.* Eucalyptus

Functional allelopathy: When precursor is released which is converted into active substances by some microorganisms is categorized under functional allelopathy. *E.g.* Brassica sp.

Allelopthatic weed management strategy:

Applying extracted of allelochemicals or applying the alleo chemicals producing residues as mulch on the soil surface

Spraying of fresh leaf extract of Parthenium effectively controlled grassy weeds in blackgram, but eucalyptus leaf extract applied at durum wheat field affected the seedling growth of wheat. Decaying Polygonum leaf extract are toxic to germination of hypocotyls weeds like Amaranthus.

Allelochemical releasing crop residues are applied on the soil or incorporated into the soil, during decomposition that releases allelochemicals, which inhibit the germinating weeds. During 1979, Lockerman and Putnam conceptualized the idea of using allelopathic crop residues as mulch. After that several researches were conducted to evaluate the potential use of allelopathic crop residues to suppress the weeds in field crops. Eucalyptus leaves applied as a surface mulch effectively controlled weed in blackgram. Most of the studies were conducted with sorghum crop. Sorghum mulch applied on the soil surface of maize field effectively controlled weeds about 26–37%, whereas it was 23-65% in cotton field. Surface applied sorghum mulch reduced the purple nut sedge density by 40–45% and also it suppressed the germination and growth of broad-leaved dock, little seed canary grass. Likewise, sunflower mulching suppressed the weed seed germination and seedling growth of several weeds. Rye mulch application controlled the common lambsquarters, amaranthus, and common ragweed (*Ambrosia artemisiifolia* L.) population upto 90% in tobacco, sunflower, and soybean under no-till condition. Rice straw applied as a mulch, controlled the several weed species of wheat. In maize legume intercropping, use of wheat residues as surface mulch effectively reduced the dry weight and density of several weeds. It also effectively controlled the horse purslane (*Trianthema portulacastrum* L.). *Tagetes minuta* L. leaves soil incorporation suppressed the growth purple nutsedge and barnyard grass, these are the two most important problematic weeds in rice and

Compared to sole application of allelopathic mulch, joint application of more than one allelopathic mulch has produced more effective weed management. Mulching of sunflower, sorghum and Brassica residues suppressed the density and growth of horse purslane and purple nutsedge; whereas, better weed control was obtained when these residues were applied together compared to sole application of these crop residues. Weed seed are suppressed effectively when sole application of sunflower mulch on soil surface or in mixture with legume and buckwheat.

Growing of allelochemical producing crop:

Commercial crop cultivation mainly aims on high productivity. Now a day's farmers in may part of the world preferring not only high yielding crop varieties but also it should have capability to suppress the weeds. The weed suppressing ability of the crop cultivars mainly due to the allelopathic potential. So, they are preferably reducing the weed density compared to non-allelopathic cultivars without investing any additional cost, ultimately it can also improve the efficacy of inputs and the method of weed control. Most of the study results revealed that

sowing of allelopathic cultivars reduces the weed pressure. Mahajan and Chauhan (2013) emphasized the importance of cultivars for weed management in aerobic rice by using allelopathic potential of the crop. In Korea, Ahn et al. (2005) found 78 local rice cultivars produced the allelopathic activity against the most notorious rice weed *Echinochloa crusgalli*. Chung et al. (2006) also observed the allelopathic potential of 99 rice cultivars under field condition, among that five cultivars of rice hindered the weed germination and its growth by more than 50%, which produced allelolochemicals like momilactone A and momilactone B that ultimately reduces the growth and germination of weeds. DIBOA in rye is responsible for allelopathic effect of rye. In future, allelopathic effect can be produced in crop by using breeding program. Root exudation of maize inhibits the growth of chenopodium album. The cold-water extract of wheat straw when applied to weed reduce germination and growth of abutilon sp. Intercropping is mainly done to increases the net yield and economic benefits. It also can improve the resource use efficiency. Further it helps to suppress weeds in environment friendly manner and also it acts as an economical weed control method. Maize and cowpea intercropping grown in alternate ridges helped to reduce weed density of *Dactyloctenium aegyptium*, Portulaca oleracea, *Chorchorus olitorius*, *Echinochloa colona* by ~50%. Intercrop in wheat with red clover not only suppress the weed, but also reduced the following crop's weed density. Berseem intercropping suppress the weed growth of *Orobanche* sp. Sorghum and sunflower intercropping in sorghum reduce the weed density by 60 to 62%.

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ENGINEERING AND TECHNOLOGY

20390

80. Method of Fibre Extraction and Retting of Flax (Linum usitatissimum L.) Crop

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Introduction

Flax is a fibre of plant origin. The fibre is obtained from the plant called flax or linseed (*Linum usitatissimum L.*). Flax fibre is mostly utilized in textile industry besides other numerous uses due to its good qualities. Fine and regular long flax fibres are spun into yarns for linen textiles and more than 70% of linen goes to clothing manufacture. Flax is a versatile crop that is grown throughout the world and in a variety of climates and has high employment generation potential during post-harvest handling and processing. Unlike cotton, fibre from flax plant is not obtained during the harvest of the crop. The retting of plant followed by fibre extraction process is the most important operations to get best yield and quality fibre.

Flax Fibre Extraction Process

Harvest

The flax plant generally shoots up straight up to 0. 45 to 1.16 m height without or with little branches (Fig.1).

FIG. 1: Flax crop

At the time of harvest the plants have a grayish green colour with diameter of 1.0 to 3.0 mm. The plants are harvested at the crop age between 60 to 100 days, preferably at the yellow ripe stage of stem. The harvesting is done by pulling the plants manually from the ground instead of being cut to avoid deterioration and loss of fibre at the point of cut especially where the crop is short one. Harvested plants / straw are left

on the ground to dry for one or two days and then stooped to complete the drying which may take about 5- 10 days depending upon the geographic location. After drying, the seed pods are detached by beating and separating the straw. After removal of seed, the dried straw is sorted and bundles are made according to quality and length of straw. The straw bundles are carried to the water pool or tank for retting.

Post-harvest Operations

After harvesting the flax crop, the following operations are carried out in sequence to obtain the marketable raw fibre.

1. Drying of straw,
2. Rippling or deseeding,
3. Sorting and bundling of straw,
4. Transport of straw bundles to retting pool,
5. Steeping of straw bundles in water for retting,
6. Drying of retted straw,
7. Scutching of retted & dried straw to extract fibre,
8. Hackling operation to clean the fibre.

Retting

The purpose of retting (rotting) is to separate the various layers, preferably by first dissolving the less resistant semi-ligneous layer that connects the woody core to the bast which has the fibre strands. Retting is the most important operation in production of flax fibre and has to be carried out with much care in order to obtain good quality fibre. Improper retting of plant leads to breakage of fibre during extraction process and deterioration of quality. Good judgement and considerable experience on the part of the retter are required, if the best results are to be obtained.

Flax straw bundles are steeped in water for retting, which is completed in between 3 to 5 days according to the prevailing weather conditions. Sometimes, the better-quality flax is retted twice if the best results are to be obtained. The second ret will normally last for about 1 to 2 days only. The straw is considered retted when it readily breaks without bending and the fibre loosens easily from the central woody core. The retted stems are dried in the open by standing up the sheaves in the field so that they resemble a cone, with the lower part spread out in order to thorough circulation of air. After about two day this is turned inside out, so that the inside can be dried. Drying may take three to four days, or longer, according to the weather conditions at the time. Sometimes, drying is done by spreading the straw on the ground and turning it frequently. Completely dried straw are ready for scutching operation.

Fibre Extraction (Scutching)

The aim of the scutching operation is to separate the flax fibre from the straw and to clean them and open them up. This is done by simply beating or scutching the straw to break the internal pith (or boon), and to free it from the fibres with as little damage to them as possible. During the scutching process, care must be taken that the fibres are not injured when the boon is broken; the more the boon is broken, the higher will be the yield of fibre and the better its quality. The scutching is done manually or with the help of machine followed by shaking and finally hackling to obtain marketable fibre. Hackling is an operation to lay the fibres parallel and to comb out the tow and short ends. The scutched fibre strands are drawn manually through a bed of metal teeth or spikes (hackle) in a combing action.

Manual Scutching

Manual scutching is done by beating the retted and dried straw with a wooden mallet to break up the boon or internal pith followed by shaking and hackling. A person could deal in a day about 5 kg straw and extracts about 1 kg long fibre. The manual scutching method is uneconomical as well as not feasible.

Mechanical Scutching (CRIJAF Flax Fibre Extractor)

The machine is operated by 1 hp motor and portable (Fig. 2). Two men are needed for fibre extraction, one for machine operation and other to assist the operator. Retted and sundried stalks/plants are fed manually into the machine and scutched fibre is collected. The machine consists three sets of fluted nylon rollers through which straw passes for scutching action in vertical direction. The machine can deal 140 kg of retted and dried straw in a day and produce 30-35 kg fibre. Capacity of machine is about 5-6 kg dry fibre per hour. To extract fibre of a hectare area it needs about 22 working days *i.e.* 44 man-days for its operation. The overall dimensions of the machine are 840 × 730 × 1120 mm (L x W x H) & weight is 158 kg. The unit price of the machine is Rs. 40,900/-. The use of machine for fibre extraction not only improves the fibre quality, but also reduces time, drudgery and labour requirement for fibre extraction.

FIG.2: Flax fibre extractor

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81. Occupational Exposure to Vibration of Walk behind Type Tractor: Its Hazard Management

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Introduction

Power tillers are also termed as hand tractor, walk behind type tractors, walking type tractor which are extensively used for rotary cultivation like roto-tilling and roto-puddling. The main reason for widespread use of power tillers is that, the use of tractors for the above operations is uneconomical for the small and marginal farmers in India. Their demand is immense in various agricultural operations due to their adaptability and due to availability of large variety of matching equipments. The use of hand tractor is about 42 % more economical for ploughing, 49 % for sowing and 50 % for transportation as compared to bullock power (Gupta and Kumar, 2001). Even though the power tillers are not much popular amongst the farmers as expected. The current population of walking type tractors in India is around 16000.

One of the main reasons for less popularity of hand tractors is the drudgery involved in the operation. Since, the operators are exposed to the severe environmental conditions like temperature, humidity, noise and vibration. The important shortcoming in the field operation of hand tractor was excessive vibration. The vibration from power tiller handle will be transmitted to different body parts like hands, arms and shoulders. Vibration is defined as the to and fro movement of object from rest position and it depends on the size of oscillation, frequency of oscillation, type of oscillation and time duration which the oscillation occurs. Increased vibration increases accidents and injuries, reduced mental fatigue results in less amount of time that a worker can intend to work in such an environment. The magnitude of vibration depends on the manner in which the machine is used and varies along the length of the tool handle.

Hazards

The operators of the walk behind type tractors are exposed to a high level of vibration. The detrimental effects of the hand–arm vibration on the operators have been known for a long time. The development of hand arm vibration is the gradual progressive process which involves long term exposure to vibration. Hand arm vibration is the chronic disorder with a latency period of few months to several years. Treatment is ineffective for the advanced stages of hand arm vibration, and the disorder can progress to loss of effective hand function and necrosis of the fingers.

Relationships considered in different diagnosis for hand-arm vibration by NIOSH (1983).

Medical condition	Signs or symptoms
Primary Reynaud's phenomenon	Constitutional white finger
Trauma direct to extremities	Injuries or fractures, frostbite and immersion syndrome
Nerve compression	Carpel tunnel syndrome
Trauma to proximal vessel compression	Thoracic outlet syndrome
Occlusive vascular disease	Thromboangiitis obliterans, arteriosclerosis, thrombosis, burger's disease
Dysglobulinemia	Cold heamagglutination syndrome, cryoglobulinemia, macroglobulinemia
Intoxication	Acroosteolysis
Neurogenic dysfunction	Poliomyelitis, syringomyelia, hemiplegia, polyneuropathy
Secondary connective tissue disease	Scleroderma, Systemic lupus, mixed connective tissue disease etc.

Management of hazards

Engineering and work practise controls shall be used to reduce hand –arm vibration exposure to lowest feasible level

Engineering controls

A. Vibration acceleration level shall be controlled by reducing the vibration energy produced by the vibrating tool to the lowest level.
B. The power and weight of the tool shall be optimized.
C. The tool manufacturers shall furnish data on the vibration acceleration and frequency characteristics of the tools
D. Work Practises

In addition to all possible engineering controls, work shall be modified to minimize vibration exposure

A. Number of working hours a worker uses a vibrating tool during a workday should be reduced
B. Number of working days per week should be reduced
C. Designing the work task and workplace to incorporate ergonomic principles to minimize vibration stress.

D. Reducing the grip force on the tool handle and the force applied at the tool interface. Etc.

Protective clothing and equipment

Protective clothing and equipment shall be used where feasible to reduce the level of the vibration energy transmitted to the hand and arm.

A. Incorporating vibration-damping material into the palms and fingers of gloves
B. Incorporating vibration-damping material into or on the tool handle or areas where the worker tool coupling occurs.
C. Wearing adequate cold weather clothing to maintain body core temperature and prevent cold-induced peripheral vascoconstriction
D. Ensuring that the antivibration equipment, clothing, and hand gear are ergonomically appropriate.

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COMPUTER ADDED TECHNOLOGY

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82. Information and Communication Technology (ICT) in Agriculture: Recent Trends and Challenges

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Introduction

Information and Communication Technology (ICT) helps to disseminate information with the help of technology which incorporates all modes of transmission like electronic devices, networks, mobile services and applications which helps small land holders, marginalized and poor farmers in exchange their opinions, experiences, ideas and also helps in marketing, precision farming and improves the profits of farmers.

Many people around the world don't get proper food on regular basis. In this context, the use of ICT offers enormous benefits to agriculture and rural development sector for the need of solutions. Information technology helps the rural people to make decision for their farming activities. ICT plays a key role to bridge the information gap in agriculture. To manage the risk of crop, pest and animal diseases ICT tools are used, which helps to maximize the farming income of farmers.

Modern developments and emerging trends

The ICT development in agriculture is given below.

Usage of Mobile technology for agriculture:

There is an increase in the use of Mobile technology for past ten years, which led to numerous mobile applications for agricultural development. The mobile platform helps the farmers to share the information (internet, newspaper, radio and extension agents). The mobile application not only caters the needs of the farmers, but the integration of agriculture and ICT also helps for the development of farming activities. ICT tools such as SMS, Interactive Voice Response (IVR), smart phone applications and integration with social media are being used for the benefit of farming community.

ICTs in agriculture risk management:

Innovation in ICT helps to improve the agricultural production and value chain in local and international markets. ICT is also used for risk management in the field of food industries. ICT has major role especially for information on market prices, disease surveillance and pest tracking. ICT solutions in agricultural value chain which includes post-harvest, transport, storage is also common during recent days.

ICTs in Financial services in agriculture:

Financial services related to payment facilities and insurance are very much essential to farmers to achieve their economic goals. ICT delivers more financial products to large number of clients

Online learning in agriculture:

Online learning courses increased the flow of new information and learning to small farmers. Online courses are the combination of educational and scientific contents, followed widely around the world.

Use of big data collection for agriculture:

Governance of data, information, skills and development of technologies with innovative

applications for farm management and decision support systems.

Current and future challenges

Following are challenges in making ICTs available and accessible for rural communities

Content and Technologies

Success of e-agriculture initiatives depends on appropriate content and trusted intermediaries for flow information. If, the nature of information does not match farmers' needs, dissemination of information may be constrained. Locally adapted content needs to be given sufficient attention.

Capacity Building

Illiteracy in using complex devices, pricing of broadband and mobile services for youth, women and aged farmers and people living in most remote areas to effectively receiving and using information delivered through ICTs. The individual, organizational and institutional levels capacities need to be strengthened for improving access to agricultural information to rural population and to achieve the desired reduction of the rural digital divide.

Gender and Access

Despite the growing number of internet users, digital divide between men and women is increasing. The cost of ICT hinders the access for youth, women, older farmers and farmers living in remote areas.

Public-private partnerships

Sustainable business models at the community level can be achieved through Public-private partnerships. Local producer organizations and community-based NGOs provide information to the farmers.

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BIOTECHNOLOGY

20724

83. Artificial Transcription Factors for Regulation of Gene Expression

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Introduction

Synthetic transcription factor or artificial transcription factor play an important role for modulation of gene expression in living organism. Till now there is plenty of DNA binding molecule has been developed that DNA binding molecule used as ATF. From that Zinc finger protein (ZFP) mostly used because having its modular DNA binding nature it's up and down regulates gene expression level and gene activity will be change. (Takashi *et al.*, 2009)

After ZFP TALE protein was discovered in 2009 this also used as ATF because having molecular DNA binding domain it performs better function than ZFP, specificity binding level to target is better than ZFP. TALE domain is used to modulate mammalian gene expression by binding specific target gene region (Moscou *et al.*, 2009).

In 2012 CRISPR/cas9 system developed to bind target region of gene this system not based on DNA-Protein interaction it's based on the DNA-RNA interaction, other two approach ZFP and TALE protein both are based on DNA-Protein interaction. This approach is very effective, easier, and faster for regulation of gene expression than other ZFP and TALEN. (Mali *et. al.*, 2013)

Transcription factors

Are the proteins coded by the transcription factor coding genes They recognize some specific sequences at the promoter regions of a target gene Generally they have three domains, and many are modular.

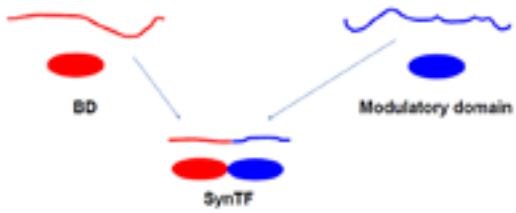
- DNA binding domain (BD): Binds to specific sequence
- Modulating domain (MD): Activates or represses
- Interaction domain (ID): Helps to interact with other regulating proteins

Transcription factors play a main role in modulating gene expression now it is possible to modulate any gene of interest because several BD, MD and ID have been studied and characterized. This also allows construction of novel transcription factors artificially to tailor-make our requirement of regulating any gene such tailor-made transcription factors are called synthetic transcription factors or artificial transcription factors

Artificial transcription factor (ATF) or Synthetic transcription factor (synTF)

Is a chimeral protein expressed from a DNA molecule

synthesized by combining regions coding for DNA-binding domain and modulatory domain.



Artificial TF-mediated regulation of gene expression, it would be better to employ the term "gene control region" rather than "promoter". This control region is usually defined as the portion of a eukaryotic gene containing the core promoter as well as any other regulatory sequences that control or influence transcription of that gene.

Artificial TFs: those based on Zinc fingers, TALEs, and on CRISPR/Cas9 technology

Zinc fingers TF

ZFP protein used as ATF because its having modular structure so its specifically bind to target gene by using zinc finger domain we can alter phenotypic character of organism. By linking multiple zinc-finger domains together, more than 100,000 zinc-finger proteins with diverse DNA-binding specificities were constructed and fused each of them to either a transcription activation or repression domain. The resulting transcriptional regulatory proteins were expressed individually in yeast and mammalian cells. The transfected cells were screened for various phenotypic changes, such as drug resistance, thermo tolerance or osmotolerance in yeast, and differentiation in mammalian cells. Genes associated with the selected phenotypes were also identified.

TALE TF

The TALE DNA-binding domain consists of multiple repeats of 34 amino acids where variability in positions 12 and 13, referred to as the repeat-variable di-residues (RVDs), confer binding specificity for one specific DNA base. The array of TALE domains is then fused to an effector domain to induce a specific action at a user- determined genomic locus. Fusion of TALEs to transcriptional activator, or repressor domains, such as VP16 or KRAB could generate TALE-TFs that can target selected promoter regions and modulate expression of corresponding genes. TALE repressors have been used to successfully suppress multiple endogenous genes in human cells, model organism and plant (Cong *et. al.,* 2012) TALE-repressors have not yet been widely used, which may be in part due to their recent development. One example is activation of the Oct4 locus. Targeting the human Oct4 proximal promoter with a single TALE activator led to modest changes in gene expression.

CRISPR/Cas9 TF

Similar to ZFP- and TALE-based activators, the CRISPR/Cas9 system has been successfully engineered to activate endogenous gene expression in both Escherichia coli and human cells transcriptional activators/ repressors fused to a mutated Cas9 protein lacking endonuclease activity (dCas9–TF) could also be guided to desired DNA by sgRNAs, thus establishing a new platform for modulating gene expression In this approach, transcriptional activators are created by fusing dCas9 with modular activation domains, including the omega subunit of RNAP, p65 VP64. (Gilbert *et al.*, 2013)

Construction of ATFs

Step involved in construction of ATF

1. Firstly, determination of target DNA
2. Then Design the Modulatory domain
3. Then Assembly of Domain will be done
4. Then Validation of ZFP, dCas9, TALEN
5. Fusion of other function
6. Finally, Validation of ATF in living organisms.

Application Artificial transcription factors

1. Down-regulating the expression of a gene using ATF
2. Quantitative study of synthetic Hox transcription factor-DNA interactions in live cells
3. Versatile Nanoparticle-Based Synthetic Transcription Factor for Innovative Gene Manipulation
4. A peptide-based synthetic transcription factor selectively down-regulates the proto-oncogene CFOS in tumour cells and inhibits proliferation
5. Synthetic transcription factor used for verify gene function and gene discovery
6. In molecular therapeutics ATF help to regulate disease gene and regulate viral protein
7. ATF having broad application in produced active metabolite, modify phenotype of an organism.

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84. A Cardinal Role of Ankyrin Proteins in Plants

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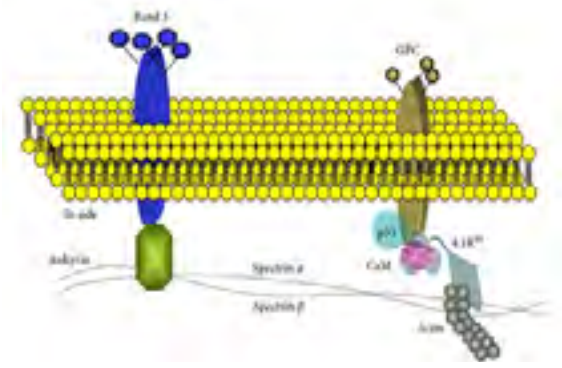
Ankyrin proteins

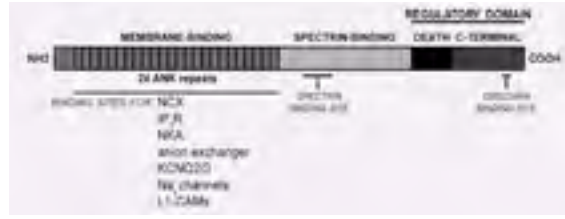
Among different super families of proteins like 4.1 proteins, Ezrin-Radixin-Moesin family proteins, Ankyrins too are adaptor protein super families which constitute ankyrin (ANK) repeat domains. The first ankyrin was characterized as an adaptor protein which tethered the anion exchanger to spectrin in red blood cells. Initially ANK repeats were discovered in the Swi6 and Cdc10 yeast cell cycle regulators and in the *Drosophila* signaling protein Notch (Breeden and Nasmyth 1987). Ankyrin proteins are conserved across different organisms like bacteria, archeae, virus genomes, eukaryotes and largest known protein super families in plants.



Ankyrins are adaptor proteins that link membrane proteins to underlying cytoskeliton. They are involved in many different complex metabolic and physiological functions like, membrane biogenesis and the formation of diffusion barriers, ion channels and transporters, cell adhesion molecules, signaling proteins, cytoskeletal elements, membrane trafficking and establishing subcellular polarity in animal cells. They also have role in cell cycle regulation, mitochondrial enzymes, cytoskeleton interaction, signal transduction and toxins. In ion channel and transporters, they act as Cl/HCO_3 anion exchanger, Na/Ca exchanger, Na/K ATPase, IP3 receptor, Ryanodine receptor and voltage-gated Na channels.

Functional domains of Ankyrin

As all proteins have different domains Ankyrin proteins too have domains which act as binding sites. N terminal fuses with 24 ANK repeats arranged in super helical solenoid which forms membrane binding domain (MBD) and does not have enzymatic activity, continued by spectrin binding domain (SBD) which helps in binding to spectrin with critical conserved sites ANK-G (DAR 976) and ANK-B (DAR 999). The C terminal follows regulatory domain constituting Death domain and obscurin binding site. C-terminal domain (CTD) governs the specificity of ankyrin function and its subcellular localization. Many missense mutations have been localized to C-terminal domain.



Ankyrin proteins have different isoforms discovered in vertebrates having broad spectrum functions Ankyrin R, Ankyrin B and Ankyrin G encoded by *ANK1*, *ANK2* and *ANK3* genes respectively.

Ankyrin R

- Encoded by *ANK1 gene*
- Erythrocyte ankyrin (Identified in Erythrocyte)
- Link membrane skeleton to Cl/HCO_3 anion exchanger

Ankyrin B

- Encoded by *ANK2 gene*
- Involved in polarized distribution of many membrane proteins
- Na^+/K^+ ATPase, Na^+ channel, Na^+/Ca^+ exchanger

Ankyrin G

- Encoded by *ANK1 gene*
- Epithelial cells and neurons
- Involved in palmitolyation

Ankyrin proteins in plants

In accordance with isoforms in the vertebrates, recently in plants ankyrins have been discovered with isoforms and their function. They are subdivided into 13 subgroups based on diverse domains.

- **ANK-M**: Only with ankyrin (ANK) repeats
- **ANK-TM**: Transmembrane protein
- **ANK-TPR**: Tetratricopeptide repeats
- **ANK-RF**: Ring finger domain
- **ANK-ZF**: Zinc finger domain
- **ANK-BTB**: BTB domain
- **ANK-IQ**: Calmodulin binding protein
- **ANK-PK**: Kinase activity
- **ANK-BPA**: ARF GTPase activating domain

- **ANK-IT**: K^+ channel protein
- **ANK-GPCR**: GPCR chaperone 1 domain
- **ANK-MS**: Motile sperm domain
- **ANK-O**: Other domains

The first *ANK gene* in plants encodes an ANK protein whose loss may lead to a chlorotic phenotype. The ANK domain in plants contributes to different cellular functions via protein-protein interaction *i.e.*, they have role in the defense response, transcriptional regulation ability by binding to DNA or RNA, support specific proteolysis functions, interactor protein, stress response, plant growth, development and hormone signaling, nuclear translocation and localization, post-translational regulation and modification, pathogen associated molecular pattern (PAMP)-mediated immunity, regulation of anti-oxidation metabolism, organellogenesis- chloroplast biogenesis, cytosolic mediator for the sorting and targeting of proteins, function in signal transduction, partake in plant-microorganism interactions, cell motility, flower development, pollen germination and tube growth.

ANK BTB

ANK BTB is an important ankyrin protein domain that mostly involved in biotic and abiotic stress signaling pathways wherein it interacts with TGA transcription factors localized at nuclear and cytosol to regulate SAR and ISR, receptor for salicylic acid and jasmonic acid mediated resistance. Also plays important role in leaf morphogenesis and inflorescence architecture.

ANK RF

A ring finger domain ankyrin next most important to BTB domain involving in morphological characterization in plants like flower development, pollen germination and tube formation, lateral root initiation, ethylene production and also involves in development of resistance against biotic stress for example, Xa21 mediated resistance and late blight resistance. Also supports specific proteolysis functions by E3 ligase.

ANK M

ANK M interacts with different protein partner moieties and help in plastid differentiation, embryo formation and LHC III molecule trimerization in chloroplast. It also plays an important role in modulating plasmodesmatal size, anthocyanin biosynthesis, regulation of antioxidant biosynthesis and in male and female gamete recognition in plants.

ANK TM

Transmembrane ankyrin protein regulating ABA and auxin mediated signal transductions. Important plant ankyrin protein in nitrogen fixation, carbohydrate metabolism and salt tolerance. These proteins also take part in plant microorganism interactions.

ANK ZF

They largely play role in gene regulation at transcriptional and post transcription levels. Zinc finger domain ank protein interacts with MPK3 and MPK6 and initiates the full PAMP triggered immune response. Acts as the negative modulator of salt stress responsive genes.

All other ankyrin proteins contribute to wide and vital functions in plants forming an important part of protein interactions and pivotal role in normal metabolism, development and growth of plants, even in all other organisms.

Conclusion

Versatility accounts for ankyrin's multifunctional capabilities in diverse cellular backgrounds. ANK proteins and the repetas can be used to develop transgenic plants resistance to biotic and abiotic stress. They have more important role in Human disease studies and mostly in therapeutic treatment of AIDS and Cancer. Therefore, Ankyrins are pivotal choreographers in the formation of protein complexes.

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85. Role of Biotechnology in the Management of Escalating Pest Population

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Among the various key components of integrated pest management, biological control using natural enemies, entomopathogens, insect hormones and plant-derived insecticides; are emerging as an alternative to chemical pesticides. The profound usage of chemical insecticides has turned out to form a dangerous threat to human health and even environmental surroundings. These factors increased the dependence on biological pest management strategies with the advantages of ecological sustainability and reliability. Biotechnology has emerged as a promising area in developing pest management strategies, providing cleaner strategies thus reducing the environmental impact caused by the use of chemicals in pest management. Some of the promising strategies are:

1. Insect natural enemies
2. Entomopathogens

a) Bacillus thuringiensis and transgenic insect resistant plants
b) Entomopathogenic nematode
c) Baculoviruses
3. Botanical Insecticide
4. Pheromone

1. Insect natural enemies

Mass rearing of insect natural enemies for field release is practiced but have many limitations associated with the rearing of these insects. The changes in genetic factors by inbreeding, genetic drift, founder effects and accidental selection turned the maintenance of laboratory insects difficult.

New DNA-based methods for monitoring genetic variations are of potential value for identification monitoring and culturing of specific biotypes of insect natural enemies. Transgenic techniques provide the opportunity to introduce and express foreign genes and or disrupt existing genes so that the desirable characteristics may be inherited by subsequent generations.

2. Entomopathogens

Insect resistance to applied synthetic pesticides and the consequences associated with the use of these, made people recognize the significance of biological insecticide with a major focus on entomopathogens.

2.1Bacillus thuringiensis

Bacillus thuringiensis (Bt), a ubiquitous, rod-shaped, spore-forming, Gram-positive bacterium, produces one or more proteins. They crystallize intracellularly during sporulation stage. These Cry proteins are found toxic to insect larvae belonging to the order Coleoptera, Diptera, and Lepidoptera. The cry genes encoding the insecticidal proteins have been classified into different groups by sequences of proteins encoded by the genes. The cost effectiveness and efficacy of Bt as an effective biopesticide lies in the effective genetic manipulation of cry genes in Bt. Bt products have been used almost exclusively as direct spray for the control of foliar-feeding lepidopteran insects. Poor persistence under field condition and the dissemination of large amount of spores are two limitations of Bt for spray application.

Crop	Gene	Target pest
Cotton	cry1Ab/cry1Ac	Bollworm
Corn	cry1Ab	European corn borer
Potato	Cry3a	Colorado potato beetle
Rice	cry1Ab/cry1Ac	Stem borer and leaf folder
Tomato	cry1Ac	Fruit borer
Brinjal	cry1Ab/cry1B	Shoot and fruit borer
Canola	cry1Ac	Diamondback moth
Soybean	cry1Ac	Soybean looper
Corn	cry1Ab/cry1A	European corn borer
Potato	cry1Ab	Tuber moth

2.2Entomopathogenic nematode

They are second in terms of commercially important microbial insecticides. Commercially available species of nematode as bioinsecticide belongs to Rhabditidae, Steinernematidae, and Heterorhabditidae families. The cuticle and other natural opening in the host serves as entry points for the nematodes. The symbiotic bacterium which is released upon entry of the nematode into the host aids in insect death. Nematodes are cultured in large-scale bioreactors similar to those used for the production of antibiotics and can be genetically manipulated for incorporating resistance against extreme temperatures, environmental stress, desiccation, solar radiation, resistance to fungicides and insecticide.

2.3Baculoviruses

Baculoviruses, mainly the nucleopolyhedroviruses (NPVs) were utilised for the development as microbial insecticides particularly for the management of lepidopteran insects on field and vegetable crops. NPVs are formulated for application as sprays in the same fashion as chemical insecticide. The current efforts are to increase speed of action and incorporate insecticidal protein genes by manipulating NPVs genetic makeup such that field persistence is increased and genes triggering prolonged survival in host is deleted.

3. Botanical Insecticide

Neem, garlic, sweet flag, pyretrum, latana, black pepper, onion and ginger are some promising plant species with pest control properties. Botanical insecticides may be in the form of powder or dust of crude preparations from plant parts, either concentrated or diluted, either extracts of organic solvent or water-soluble extracts. The processed forms are purified insecticidal components from plant materials by a series of extraction and distillations. These are expensive in comparison with synthetic insecticides as the availability is often limited.

4. Pheromone

Pheromones are chemical signaling compounds used by insects to communicate. They are used for mating disruption and mass trapping. All the pheromones which are presently available in the market are chemically synthesized. The use of enzyme technology will allow the effective biochemical variant among the two stereo-isomeric variants of pheromone and boost its production than the other. Also increased stability and longevity, and more uniform release rate following field exposure, can enhance the performance of pheromones and can be achieved through biotechnological methods.

Conclusion

Unlike chemical pesticides, bio-pesticides can be produced at an appropriate scale with technologies that are well within reach of most developing countries. Utilizing these affordable technologies along with knowledge in biotechnology, entomology and molecular biology, for the development of bio-

pesticides targeting local pests can create a large impact in reducing the pest population, cost of production, and the negative impact on nature and natural resource, helping farmers to supply good quality produce with no chemical residues.

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86. Epigenetic Regulation of Gene during Stress

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INTRODUCTION

Epigenetic regulation refers to the modifications in DNA structure and histone tails by modifying covalent bonds present between them, without involving any change in DNA sequences. Moreover, these changes are heritable in nature. Gene expressions in eukaryotic cells are greatly influenced by any change occurring in chromatin environment. Plants when exposed to stress result in change in their chromatin environment (Luo and He, 2020). This altered chromatin status of the genes provides an opportunity for epigenetic mechanism to participate in regulating stress-responsive genes at transcriptional and posttranscriptional levels for developing tolerance against adverse conditions (Chang et al., 2020) Further, profound role of epigenetic regulation in creating and inheriting the stress memory among stress treated plants is reported (Friedrich et al., 2019). The effect of epigenetic regulation over gene expression does not entirely depend on the types of epigenetic process occurring but also the on position of the genes over which it is undergoing (Chang et al., 2020).

Epigenetic regulations mainly involve process such as, DNA methylation, histone tail modifications including acetylation, methylation, ubiquitination, sumoylation, phosphorylation, ADP-ribosylation and glycosylation which can easily influence chromatin environment and thereby causing change in the biological function of the chromatin (Duan et al. 2018).

DNA Methylation

DNA Methylation is one of the common DNA modifications occurring in plants, and refers to the addition of methyl group at C5 position of cytosine with the help of DNA methyl transferase (Yaari et al., 2019). In plants it is identified in the context of CG, CHG, and CHH (where H is any nucleotide except G) in which CG is the most common (Law & Jacobsen, 2010).

Histone Covalent Modification

Histone tails can be covalently modified into different amino acids in different ways, such as phosphorylation, acetylation, carbonylation, mono/di/trimethylation, sumoylation, ubiquitination, glycosylation, ADP ribosylation and biotinylation (Ueda & Seki, 2020). In plants, histone methylation and acetylation have been well characterized and are now recognized crucial and ubiquitous epigenetic marks in gene expression against different stress (Xu et al., 2017).

Histone Variants

Apart from conventional histones present in cell, presence of non-allelic histone variants is reported in all eukaryotes. These variants get incorporated into nucleosomes in DNA replication-independent manner during the entire cell cycle. Such variants have ability to alter the properties of the nucleosomes they occupy and play crucial roles in maintaining genome stability, activation and repression of transcription (Kamakaka and Biggins, 2005).

Conclusion

Overall, the roles of histone modifications in response to different stress are largely obscure and need to be further explored. Moreover, a good understanding over this mechanism can explain the reason behind plant tolerance against different stress conditions, which open up ample of opportunity for crop improvement.

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87. Artificial Seeds for Plant Propagation

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In-vitro produced somatic embryos encapsulated in a nutritive protective coating as seed coat having capabilities to grow in young plantlets are termed as artificial seeds. This artificial seed technology has great potential towards rapid, cost-effective mass propagation of commercial/elite plant accessions/ varieties. They also provide a new channel for the plant lines that are being produced by harvesting new in-vitro biotechnological advances that can be directly delivered to the glasshouse, greenhouse, and in the field conditions without the hardening process. The artificial seed production technology can be defined as a rapid, in-vitro cost-effective mass propagation method that can maintain the genetic fidelity of the plants.

Introduction

There are many plants and newly produced synthetic varieties which cannot be directly propagated by seeds. To solve this problem, the shoots, shot apical meristem, somatic embryos generated through micropropagation can be harvested for artificial seed production. The greenhouse vegetative propagation through stem cuttings is another way but it is labour-intensive, less in numbers with the limitation of multiplication factor due to the size of the mother/ donor plant. These limitations may be shorted out using artificial seed technology which utilizes somatic embryos through the in-vitro somatic embryogenesis process which was first reported in 1958 for rapid multiplication of thousands of embryos having the potential to form a plant.

What are Artificial Seeds?

They are defined as artificially generated seed-like living regenerative structure, by utilizing a tissue culture technique in which somatic embryos, shoot tips meristematic tissue or axillary meristem bud having ability to generate into a young whole plant under in vitro and field conditions are utilized for encapsulation (Capuano *et al*., 1998). Functionally, they can be defined as the meristematic somatic embryos/shoot buds encapsulated into an artificial gelatinous covering for commercial plant production (Ara *et al*., 2000).

Historical Aspects of Artificial Seed Production

In the year 1958, F. C. Steward (USA) and J. Reinert (Germany) simultaneously discovered somatic embryogenesis in carrot. Then in 1977, Toshio Murashige formally presented his ideas on artificial seeds for horticultural purposes in a conference hosted in Belgium. The first use of somatic embryos for plant propagation was reported by Murashige (1978). Later, somatic embryos conversion into artificial seeds were initiated by Kitto and Janick (1985), Redenbaugh (1986) and Gray (1987) etc. Drew in 1979 proposed the active methods for commercial propagation of crops using somatic embryos. It was also found that shoot bud based artificial seeds may also be used for plant propagation.

Concept of Artificial Seeds

Artificial seeds mimic the structure of conventional zygotic seeds as these are comprised of both, regenerative explants (Somatic embryo) and a chemical coating behaving as a seed coat. The chemical coating is composed of a gelling agent along with some added nutrients, growth regulators, antipathogenic substances, bio controller agents, etc. (Fig.1) resembles the endosperm of the natural seed imitation of the zygotic embryo.

FIG.1: Diagrammatic representation of components of an Artificial Seed

Types of Artificial Seeds

The available literature reveals the development of two types of artificial seeds:

1. Desiccated.
2. Hydrated artificial seeds (Bhojwani and Razdan, 2006).

The desiccated artificial seeds were produced from somatic embryos, which were either naked or encapsulated with polyethylene glycol for their desiccation (Corrie and Tondon, 1993). These desiccated artificial seeds are only produced for plants that have desiccation-tolerant somatic embryos production capacity. The desiccation tolerance in somatic embryos can be induced/ altered using a variety of nutrient mediums with high osmotic potential. It utilizes high gel strength along with the addition of permeating osmoticants like glycerol, mannitol, sucrose, etc.

On the other hand, hydrated artificial seeds are produced by hydrated somatic embryos that are non-quiescent therefore must be germinated immediately after production or stored under moist conditions for only very short periods. They are fragile and sometimes require careful handling that increases the cost per artificial seed. To avoid this, they are sometimes germinated in vitro under well-controlled conditions and transferred manually through various hardening-off procedures before transplantation to the greenhouse.

Preparation of Good Quality Artificial Seeds

The artificial seeds can be prepared by the establishment of callus culture, induction of somatic embryogenesis, synchronous production of somatic embryo followed by its maturation, and encapsulation (Fig.2).

Synthetic Seeds as Tool for Germplasm Conservation

The artificial seeds are the germplasm having information related to a species' genetic makeup, and can have a valuable technology for conservation of natural resource to preserve plant biodiversity in-vitro. The genetic information, contained in plant parts like meristematic tissues, embryos are genetically alike due to somatic in nature and devoid of sexual reproduction process. Therefore, this technology can also be harvested for production of clones *i.e.* genetically alike plants.

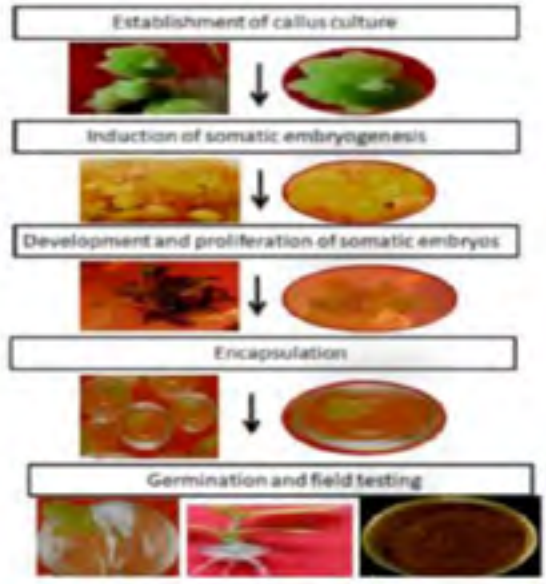

FIG.2: Diagrammatic representation of generation of artificial seed and its germination

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MICROBIOLOGY

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88. Surviving the Inevitable: Implications of Antibiotic Resistance in Phytopathogenic Bacteria

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Introduction

Bacteria are one of the most important pathogens responsible for causing severe diseases in plants all over the world. The diseases caused by plant pathogenic bacteria are difficult to manage due to fast multiplication rates under favorable environmental conditions, unavailability of effective bactericides and survival strategies of bacteria on crop debris and alternate hosts. Moreover, due to very few sources of absolute genetic resistance in host plants and unavailability of effective bactericides, antibiotics serve as an effective alternative of managing bacterial diseases in plants. The term antibiotic, as defined by Waksman in 1973, stands for "a compound produced by a microbe with killing or growth-inhibiting activity against other microbes". During the 1950s, several antibiotics were tested for efficacy in managing plant diseases, however, only streptomycin and oxytetracycline were deployed for use on a large scale. Some other antibiotics used in the management of plant diseases throughout the world include gentamycin, oxolinic acid and kasugamycin. Due to prolonged dependence on specific antibiotics in many disease pathosystems, a major concern has evolved in the form of resistance of phytopathogenic bacteria to antibiotics. Antibiotic resistance is the condition in which a chemical is no longer able to inhibit the growth of a bacterial population and it continues to multiply at the dose of antibiotic which was earlier enough to check its growth. The evolution of resistance to antibiotics in bacteria has become a major limitation in the use of antibiotics in agriculture.

Origin of antibiotic resistance in phytopathogenic bacteria

The factor which governs the presence of antibiotic resistance in a bacterial species is known as a resistance determinant. These resistance determinants are nothing but genes known as antibiotic resistance genes (ARGs), which are acquired by the bacteria through the process of horizontal gene transfer. The antibiotics used in agriculture are most often derived from soil actinomycetes. Such antibiotic producing micro-organisms harbor the antibiotic resistance genes as a self-protection mechanism. *Streptomyces rimosus*, the producer of oxytetracycline and some other tetracycline, carries otrA, otrB and otrC, which are well known tetracycline resistance determinant genes. The ARGs present in the antibiotic producing organisms could reach the pathogenic bacteria by horizontal gene transfer or the pathogenic bacteria could acquire such genes from the environment. In some cases, mutation in the target site of the antibiotic in pathogenic organism, also leads to development of antibiotic resistance in the bacteria.

Mechanisms of resistance to antibiotics in bacteria

The bacteria have devised several exceptional mechanisms of escaping or resisting the harmful effects of antibiotics. These mechanisms have been categorized as follows:

1. **Modification of the structure of antibiotic molecule:** The modification of antibiotic molecule is brought about by the enzymatic action of N-acetyl transferases, phosphotransferases and adenytransferses which catalyze the addition of acetyl, phosphate or adenyl groups to the aminoglycoside antibiotic molecule. This kind of resistance mechanism has been reported in *Streptomyces griseues*, the producer of streptomycin, *Erwinia amylovora*, *Pantoea* spp, *Pseudomonas syringae*, *Xanthomonas axonopodis*, *Xanthomns citri* and *Xanthomonas oryzae*. The two most common resistance determinant genes for streptomycin are *strAb* gene pair and *aadA* gene. These genes are responsible for coding enzymes which catalyze the modification process of aminoglycoside antibiotic molecule.
2. **Degradation of antibiotic molecule:** β-lactamses, which are responsible for degradation of β-lactam antibiotic *i.e.* Penicillin, presents an example of degradation mechanism. This kind of resistance mechanism is mostly found in clinical bacteria.
3. **Reduction of uptake through efflux pump:** The efflux pumps reduce the active transport of antibiotic molecules across the cell membrane as well as remove the molecules of antibiotic from the cell using energy from hydrolysis of ATP. Efflux is the major mechanism responsible for resistance to tetracycline in bacteria. About 28 classes of efflux proteins have been discovered from around a thousand bacterial species. Phytopathogenic bacteria such as *Ralstonia*

solanacearum, *Erwinia* sp, *Xanthomonas* spp and *Pseudomonas* spp, have been found to harbor determinant genes for efflux mechanism of resistance to tetracycline.

4. **Protection of the target site:** This kind of resistance mechanism is associated with tetracycline resistance. It is brought about by the action of ribosomal protection proteins which function to hydrolyze GTP and dislocate tetracycline from its target position on the ribosome, thus, conferring resistance in bacteria. Two most commonly reported determinants for ribosomal protection are TetO and TetM.
5. **Mutation:** Modification in the structure of target site brought about by mutations in the 16S ribosomal RNA, have been found to confer tetracycline resistance in bacteria. Spontaneous mutations have also been found to be responsible for streptomycin resistance in *Erwinia amylovora*.

Conclusion and future prospects

The use of higher doses of antibiotics in orchards and crop fields also raises the concern of selection of resistance genes by the gut microbiota of non-target organisms such as insects, herbivores and aquatic organisms, which are unintentionally exposed to the excess antibiotic in the environment through drift, feeding or runoff to water bodies. Such ARGs when added to the environment could be picked up by the pathogenic bacteria by horizontal gene transfer. Although, it is difficult to manage the problem of resistance, it could be lowered up to some extent by reducing the dose of antibiotics. This is possible by using the antibiotics in combination with other compatible bactericide chemicals. Another important approach is forecasting of diseases through weather-based prediction models, which could help in limiting the frequency of antibiotic sprays. The research efforts should be focused on formulating methods of suppressing the resistance mechanisms of bacterial plant pathogens for their effective management and continued safe use of antibiotics in agriculture.

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HUMAN HEALTH

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89. Seaweeds as a Potential Source of Antioxidants

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Introduction: Seaweed is the common name for countless species of marine plants and algae that grow mostly on rocks and other plants in the ocean as well as in rivers, lakes, and other water bodies. Seaweeds are rich source of proteins, polysaccharides fibers, antioxidants and micronutrients such as vitamins and trace elements.

Antioxidants: Antioxidants are attractive as supplements because of their potential preventive role in several diseases associated with oxidative stress, occurring when the balance between antioxidants and reactive oxygen species (ROS) is disrupted because of either depletion of antioxidants or accumulation of ROS (**Bungau *et al.*, 2019**). Natural antioxidants are found in some vegetables, fruits and a variety of other foods (**Moon & Shibamoto, 2009**). There is presence of various antioxidants in seaweeds like amino acids, carotenoids, dietary fibers, minerals, polyphenols, polysaccharides, proteins and vitamins (**Burtin, 2003**).

Properties of Antioxidants: Antioxidant has a potential to prevent cancer and cardiovascular diseases. The nature of these substances varies a lot whereas the most powerful antioxidants are polyphenols, phycobiliproteins, vitamin C, α-tocopherol and some carotenoids (xanthophylls). Furthermore, seaweed contains a high concentration of polysaccharides of various structure and functionality. The indigestible polysaccharides of macroalgae could be important source of dietary fibers. Polyphenolics contain reducing properties as hydrogen or electron-donating agents, thus seen as potential free radical scavengers (antioxidants). Polyphenolic compounds are natural antioxidants which are found mostly in plants and seaweeds. There is strong correlation between the antioxidant activity and total phenolic content.

Superoxide radical scavenging activity: The potential human health advantages depend upon both the respective intake of the plants, and

the bioavailability of the role of reactive oxygen metabolism (ROM) in seaweeds, the stress factors that trigger it and details of the antioxidant response mechanisms. Antioxidants contain reducing properties as hydrogen or electron-donating agents, thus seen as potential free radical scavengers.

Seaweeds contain large quantities of macronutrients and micronutrients as well as other bioactive compounds some of which are pharmacologically active such as phenolics, terpenes and carotenoids, which have antioxidant, antimicrobial and anticancer activities. Seaweed produces various types of antioxidant to counteract environmental stresses (**Lesser, 2006**).

Major groups of antioxidant compounds

Category	Algal Source
Carotenoids	Chondrus crispus, Mastocarpus stellatus
Phenolic compounds	Taonia atomaria, Cystoseira sp.
Phycobilin pigments	Red algae
Polyphenols	Halimeda sp., Palmaria palmate, Fucus vesiculosus
Sulphated polysaccharides	*Turbinaria conoides, Laminaria japonica*, marine red algae
Vitamins	Chondrus crispus, Mastocarpus stellatus, Sargassum sp., Kappaphycus alvarezii

Therefore, seaweed is a potential source of novel antioxidants. In addition, natural antioxidants are more acceptable than synthetic antioxidants as these antioxidants do not contain chemical contaminants and display a variety of beneficial functions. Thus, natural antioxidants are considered safe for use as ingredients in medicine, dietary supplements, nutraceuticals and cosmetics with the objective of improving consumer health, reducing the effects of harmful diseases and other broader aspects of immune system function (**Shahidi, 2009**). Seaweed cells have antioxidative compounds as well as protective antioxidative mechanisms so, they are used as food, feed, fertilizer, a soil conditioning agent, animal feed supplement and human nutritional supplement (**Fan *et. al.*, 2011**). Seaweeds are readily available food source that has been consumed habitually by coastal communities in South-East Asia. However, it is not considered a habitual component of the Western diet (**Jiménez-Escrig *et al.*, 2001**). Seaweeds reduce high blood pressure, cholesterol, and prevent strokes. They can also be used as remedy for rheumatism, diarrhea, and for controlling the growth of tumors (Bhattacharjee and Islam, 2014). Low consumer awareness regarding potential health benefits and a lack of previous experience of seaweed challenges its use in the daily diet.

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FOOD TECHNOLOGY

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90. Preservation of Fruits/Vegetables: Edible Coating

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Introduction

Fruits and vegetables come under highly perishable food products and the freshness of these products starts deteriorating just after two hours of harvesting if it is not stored properly. Generally, Low temperature processes *i.e.* chilling, cooling, refrigeration, freezing, freeze drying etc. are being used to maintain the freshness and to increase the shelf life of fruits/ vegetables. But, these processes are energy consuming and may not be available at every stage of supply chain. Also, chilling injury can be seen on fruits/vegetables native to tropical climates. In addition, some cold-tolerant pathogenic microorganisms are able to grow even under refrigeration. During handling, storage, transportation and in market, fruits/vegetables lose its moisture content through their skin via transpiration. Respiration keeps continue after harvesting which involves the oxidation of sugars to produce carbon dioxide, water and heat. Respiration gives energy to accelerate metabolic reactions within products. Hence, respiration and transpiration are one of the major factors which influence the storage life of fruits and vegetables. According to ICAR report on Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops/Commodities in India, 2015, 5.8%-18.1% fruits, and 6.9%-13% vegetables were lost during harvesting, post-harvest activities, handling and storage.

Edible coating has taken such an attention, because of its ability to provide a barrier to moisture and gases between the food and the surrounding atmosphere. Edible coating is defined as a thin layer edible material applied to the fruit/vegetable surface in addition to or as a replacement for natural protective waxy coatings and to provide a barrier to moisture, oxygen and solute movement for the food. Generally, its thickness is less than 0.3 mm. Edible coating serves numerous benefits as following-

- Edible films provide replacement and/or fortification of natural layers to prevent moisture losses, while selectively allowing for controlled exchange of important gases, such as oxygen, carbon dioxide, and ethylene, which are involved in respiration processes.
- It extends the shelf life of fruit/vegetable by being a barrier between products and surrounding.
- It is environmental friendly because it serves the duty of packaging and low cost.
- Carriers such as antimicrobial or antioxidants can easily be incorporated with coating which further enhances the storage period.
- It strengthens mechanical properties of fruit/ vegetable which prevents damages which can occur during transportation.
- It enhances color and total appearance of fruit/ vegetable.
- It prevents microbial and pest attack on surface.

FIG. 1 Capsicum without edible coating and with edible coating

Edible coating must be non-toxic, edible and should not contain any allergenic or indigestible components. It should have good adhesive property for uniform application. Coating can be transparent or opaque but consumers are generally attracted towards clear/transparent coatings. Coating on fruits and vegetable can be applied using any one of following method (a) by dipping the product into, or by brushing or spraying it with solution containing film ingredients, so as to deposit the film directly on food surface, or (b) by creating standalone film from solution or through thermo-formation for subsequent covering of food surface. The simplest way to apply a film is directly from solution. Protein, carbohydrates and lipids are generally used as edible coating. They can be used singly or in combination. Different coating material serves different purpose *i.e.* fats are used for reducing water transmission, carbohydrates are used for controlling gas transmission and proteins coating enhances mechanical stability. The article further

includes various types of coating materials.

Protein based edible coating:

Proteins such as casein, whey, lactic serum, collagen, gelatin, zein, soy etc. are major protein used as edible coating material. Protein films are better in serving the mechanical properties as compare to carbohydrate or lipid coating due to their unique structure consisting carboxyl group, hydrogen, amino group etc. **Casein**, a milk protein, contains α, β, and κ-casein components and is easily available commercially is a good edible coating material. Calcium caseinate films have better barrier properties but it more rigid. But, films of sodium caseinate are good at optical and tensile properties. **Whey** proteins contain several materials, such as β-Lactoglobulin, α-Lactalbumin, bovine serum albumin immunoglobulins, and proteose peptones. **Lactose** could enhance water vapor permeability, but worsen the mechanical properties. **Lactic serum** is a good barrier for CO_2 even though it is fragile. For solving this problem, a plasticizing agent such as glycerol could be used to enhance its mechanical properties. **Collagen** edible films were already used in meat products to reserve humidity and give a uniform feature to the product. Pure and dry gelatin is transparent, tasteless, brittle, odorless and glass-like solid, with faint yellow color. **Zein** is a polyamine and the main protein from the corn. It is a virtual hydrophobic and also a thermoplastic stuff because it is shiny, water-insoluble, resistant to bacteria, antioxidant, and form adhesive film. **Soy protein** is extracted from soybeans. Soy protein films are superior to that of lipids and polysaccharides on gas barrier properties.

Carbohydrates based edible coating

Edible films and coatings produced by polysaccharides are transparent, cohesive, and homogeneous with adequate mechanical properties. **Alginates** are being extracted from brown seaweeds lginates react irreversibly and instantaneous with polyvalent metal cations (Ca^{+2} and Ca^{+3}) and produce water insoluble polymers, which are impervious to oils and fats and have high water vapor permeability. **Agar** is a mixture of agarose and agaropectin which is derived from a variety of red seaweeds. It has the ability to form strong, thermal reversible gels, while it is known for its hydrophilicity. **Carrageenans** are water-soluble polymers with a linear chain of partially sulphated galactans. These polysaccharides are extracted from the cell walls of various red seaweeds. They are also used as edible coating materials. Coatings and films produced by **cellulose derivatives** are tough, flexible, transparent, odorless, tasteless, resistant to fats and oils and highly biodegradable, while they are efficient O_2, CO_2, and aroma barriers, but with moderate resistance to water vapor. **Chitosan** is a natural carbohydrate polymer derived by deacetylation of chitin which is a major component of the shells of crustacean, *i.e.*, crab, shrimp, and crawfish. Films from aqueous chitosan are stable, clear, tough, flexible and good O_2 barriers. **Gums** are categorized as: (1) exudate gums (natural exudates of trees—gum arabic), (2) extractive or seed gums (locust bean and guar gums), and (3) microbial fermentation gums (xanthan and gellan gums). Guar gum is used as stabilizer and enhances water binding and viscosity building. Pectins are biopolymers mainly composed of (1□4) α-D-galactopyranosyluronic acid units naturally esterified with methanol. **Pectin-based coatings** have been studied for their ability to retard lipid migration and moisture loss, and to improve appearance during food handling and preservation. **Starch** is a polymeric carbohydrate composed of anhydroglucose units, which contains two types of glucose polymers: amylose, a linear chain molecule and amylopectin, a branched polymer of glucose. **Amylose** is responsible for the excellent film-forming capacity of starches, rendering to strong, isotropic, odorless, tasteless, and colorless films. The main advantages of those edible films and coatings are low cost, biodegradability and good mechanical properties. They are hydrophilic, while they can exhibit selective permeability to O_2 and CO_2.

Lipid based coatings

Lipid coatings are usually waxes, acylglycerols or fatty acids based coatings. Lipids coatings are mainly used for their efficiency as a water vapor barrier. Natural **waxes** such as carnauba wax and beeswax have been used as lipid components in various edible coatings. **Bee wax** has been used in coating formulations for apples, oranges and mandarins. Lipids in coatings provide many features, it provides gloss, minimize moisture loss, reduce cost, and complexity of packaging. Waxes have higher molecular weight since they are formed by alcohol and/or esters of a long chain acid. These are useful for coatings or edible films for efficiency reducing moisture permeability for high. **Resins** are substances that plant cells produce in response to injury or infection in trees and shrubs; and some insects can produce them, which is the case of Lacciferlacca that produces shellac resin. Those films exhibited quick drying nature, transparency, glossiness, and sound emulsion stability. **Essential oils** are rich in hydrophobic and volatile materials. They have an important antimicrobial activity owing to its ingredients from terpenoids, terpenes, and other aromatic compounds.

Conclusion:

The concept of edible coating is a technology that has been recognized to have significant potential for providing a variety of solutions to the food industry. The real advantages of edible coating are prevention of moisture migration, maintaining proper barrier for gas permeation, low cost of application, easy application process and so on. Various combination of coating material is being applied on fruits and vegetable surfaces to give more strength to the coating so that it can perform very well. Effect of edible coating on thermal and non-thermal processes are also being studied which takes the edible coating process to a new dimension.

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FOODS AND NUTRITION

20810

91. Potential Application of Alginate an Edible Coating

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Edible coating

Edible coatings have long been used to retain quality and extend shelf life of fresh fruits and vegetables and have become popular in the food industry, because they produce less waste and offer protection. They are thin layers of edible material applied to the product surface as a replacement for natural protective waxy coatings.

Edible coatings form a semipermeable membrane on the surface of fruit for suppressing respiration, controlling moisture loss and providing other functions like antimicrobials. They are natural and biodegradable substances and can be consumed along with the food, which provide additional nutrients and enhance sensory characteristics.

History of edible coatings

- During 12th and 13th century, in China, oranges and lemons were dipped in wax in order to slow water loss.
- During 15th century, Yuba, the first edible film, was developed from soymilk in Japan.
- In the 16th century, "larding" coating food products with fat, was used to prevent moisture loss in foods in England.
- In the 19th century, nuts, almonds and hazelnuts were coated with sucrose to prevent oxidation and rancidness during storage.

Components of edible coatings

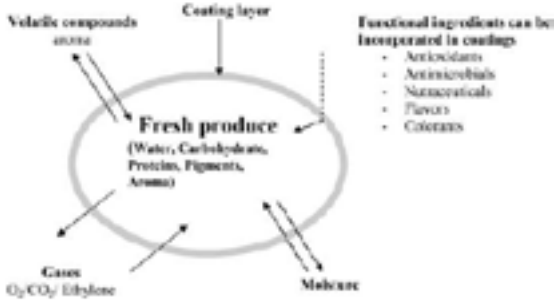
There are mainly three components in edible coatings and they are as follows

1. **Polysaccharides:** coatings are hydrophilic and intermediate among coating materials in gas exchange properties but are poor barriers to moisture. These include cellulose and starch derivatives, chitosan, pectin, carrageenans, alginates and gum.
   a) Microbial polysaccharides: Levan and Pullulan
   b) See weed extract: for *e.g.* Carrageenan and Alginate
   c) Starch: Dextrin and amylose
   d) Chitin/Chitosan and
   e) Cellulose
2. **Proteins:** are similar in properties, being also hydrophilic, and include corn zein, wheat gluten, peanut, soy, collagen, gelatin, egg, whey and casein
   a) Gelatin
   b) Zein
   c) wheat gluten
   d) casein
   e) Whey protein
   f) Albumin + gelatin
   g) Soya protein
3. **Lipids:** Lipids and waxes tend to be more permeable to gasses but present a better to water vapour and includes beeswax, petroleum-based waxes, vegetable oils etc
   a) Surfactants: Tweens and Lecithin
   b) Waxes: Bee wax, camauba and paraffin

Method of Coating Application

1. **Dipping**:
2. **Dripping:** most commonly used methods
3. **Foaming:** usually used for emulsion coating
4. **Fluidized-bed coating:** this technique used to apply a very thin layer on to dry particles of very low density popularly used in pharmaceutical industry and bakery industry
5. **Electrostatic Coatings:** these process employs charged particles to improve efficiently coat a surface and being used in coating of chocolate and confectionary.
6. **Spraying:** again, most used for minimally processed fruits and animal meat
7. **Panning:** used for coating candies nuts and some processed fruits to achieve smooth and polished look

Functional properties of an edible coating on fresh fruits and vegetables



It protects the food from external environment and regulates the movement of moisture, volatile compounds and gases

ALGINATE

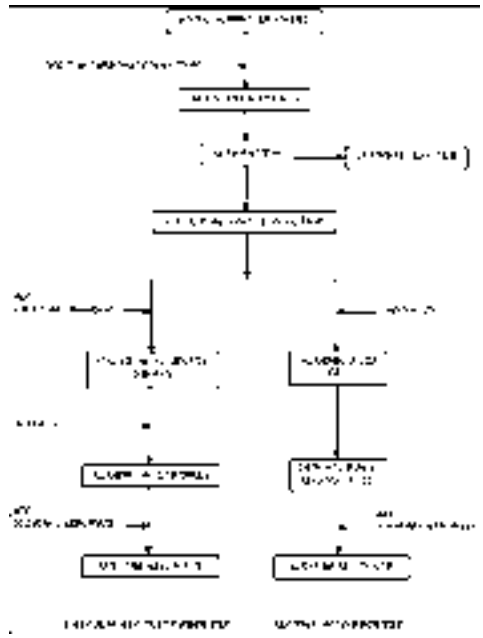
Alginate is a natural polysaccharide derived from marine brown algae (*Phaeophyceae*) that comprises of 30 to 60% of brown algae (on dry weight basis). It is present in skeletal component of brown algae cell walls. As calcium, magnesium and sodium salts of alginic acid. Alginic acid was first isolated and named by a Scottish scientist, Dr. E.C. Stanford, in1883. Since then, Alginic acid and its derivatives have been utilized as a hydrocolloid in a variety of applications.

World War II stimulated the alginate industry, when production units were set up in Scotland and California using local seaweed resources of wrack and kelp After the war other production units were constructed close to natural seaweed beds in Norway, France, Germany, Japan, and, more recently, China. The two largest producers of alginate are Kelco Company in USA and Alginate Industries Ltd in UK; these companies produce about 70% of the world's alginate. SNAP Natural & Alginate Products Pvt. Ltd located at Ranipet, TamilNadu, INDIA

The main commercial sources are species of brown algae and are *Ascophyllum*, *Durvillaea*, *Ecklonia*, *Laminaria*, *Lessonia*, *Macrocystis*, *Sargassum and Turbinaria*. Of these the most important are *Laminaria*, *Macrocystis* and *Ascophyllum*.

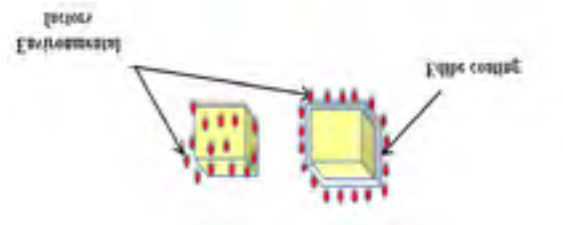
Method of extraction

Alginate is present in the cell walls of brown algae as the calcium, magnesium and sodium salts of alginic acid. The goal of the extraction process is to obtain dry, powdered, sodium alginate. The calcium and magnesium salts do not dissolve in water; the sodium salt does. The rationale behind the extraction of alginate from the seaweed is to convert all the alginate salts to the sodium salt, dissolve this in water, and remove the seaweed residue by filtration. The alginate must then be recovered from the aqueous solution



Working principle

Alginate coatings provide a barrier between a food product and its environment, thereby protecting it against unwanted effects of microorganisms, ambient relative humidity and gas conditions. The specific characteristic that distinguishes alginate coatings from other packaging solutions is that they are food-grade and therefore safe for consumption



Bonilla et al., 2012

Applications of alginate coating

1. **Food:** Alginate has an excellent functionality as a thickening agent, gelling agent, emulsifier, stabilizer, texture-improver (for noodles), to improve the quality of food. Nowadays, based on unique and excellent properties alginate is applied to numerous kinds of food, such as ice cream, jelly, lactic drinks, dressings, instant noodle, beer, et cetera. Safety of alginate for food applications is certified by FAO/WHO, as one of the safest food additives.
2. **Textile printing:** Alginate is used for substrate of colour paste when applying patterns to print fabrics, scarf, towel, etc. Use of alginate for printing of cotton, jute, rayon is mandatory. Alginate, a seaweed extract, is safer and easier to be decomposed compared with other substrate for textile printing, and gives easier waste water disposal
3. **Pharmaceutical:** Alginate acid is used in

pharmaceutical area with several applications. Alginic acid is compounded into tablets to accelerate disintegration of tablet for faster release of medicinal component. Alginate forms gel in the high-acidic stomach and protect stomach mucosa

4. **Welding rods**: Alginate is used for the production of welding rod, as a binder of flux.
5. **Animal feed:** Alginate is used as a binder and thickening agent for pet-food, fish feed, etc.
6. **Cosmetics:** Alginate is used in cosmetics area with several applications with its functionality of thickener and moisture retainer. Alginate helps retaining the colour of lipstick on lip surface by forming gel-network.
7. **Paper**: As a surface enhancers
8. **Other uses:** in taking dental impression, casting and plasters

Alginate and food safety

- The Food Chemical Codex gives specifications for alginic acid, its propylene glycol ester and its ammonium, calcium, potassium and sodium salts These four salts have been granted GRAS status (generally recognized as safe) in the USA.
- Propylene glycol alginate has been approved as a food additive for use as an emulsifier, stabilizer or thickener.
- The joint Expert Committee of Food Additives of the FAO and WHO has also issued specifications for alginates and recommended an acceptable Daily Intake, for alginic acid salts of 50 mg per kg body weight per day, for propylene glycol alginate of 25 mg/kg/day.

Conclusion

Edible coatings have long been used to retain quality and extend shelf life of some fresh fruits and vegetables. The use of alginate coatings for the preservation of minimally processed fruit is a promising technology that can improve the quality of fresh fruits and increase their shelf life as well as stability.

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SOCIAL SCIENCES

20427

92. Women Friendly Agricultural Tools and Equipments for Drudgery Reduction

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Introduction

Women are the backbone of the agricultural workforce and are a vital part of Indian economy. More than 300 million women reside in rural India and playing a key role in agricultural development for their contribution in the field of agriculture, food security, horticulture, dairy, nutrition and other allied sectors. Women comprise the majority of agricultural labourers and putting labour not only in terms of physical output but also in terms of quality and efficiency. However, they are not active in decision making like their male counterparts. It is often argued that agricultural technologies are gender-neutral, but most of tools/ equipments are designed keeping in view of the male workforce. As, the anthropometric data, muscular strength are different for man and women, the tools/ equipments designed for men are not fully suitable for women. Keeping all these parameters in mind some equipments are specifically been designed for women.

Role of Women in Agricultural Sector

In India, about 74 per cent of the entire female workforce is engaged in agricultural operations. The nature and extent of women's involvement in agricultural operations varies greatly from region to

region. Beside agricultural activities, on average, rural women spend almost an hour each day gathering fuel and carrying water to prepare meals. Women work harder and for longer hours than men. Operations that involve less physical labour and more drudgery are left to women.

The involvement of women in different farming operations are:

- Transplanting
- Weeding
- Intercultural
- Water lifting for irrigation purpose
- Spraying, Dusting (pesticides, herbicides, weedicides etc.)
- Reaping and Harvesting
- Threshing (including decortication)
- Winnowing
- Chaff cutting for fodders
- Post-harvest operations (cleaning, grading, sorting, parboiling etc.)

Why Farm Women??

- Women workers on an average
  - have a smaller stature and have less physical strength
  - their vital capacity is 11% less
  - their hemoglobin is app. 20% less
  - their skin area is larger as compared to circulating volume
  - they have larger body fat content
- They have lower heat tolerance and greater cold tolerance.
- Reproductive function
- Having 40-75% less upper body strength and 5-30% less lower body strength
- Having smaller stature (avg. female is 5" shorter than avg. male)
- More fat tissue
- Narrower shoulders and wider hips
- Proportionally shorter legs & arms
- Smaller grips, grip strength 50-67% that of males
- Greater flexibility
- Lower center of gravity

Role of Improved Farm Tools and Equipment

For an economically viable and ecologically sustainable agriculture, the involvement of women in the process of modernization of farming practices is prime concern. Women are still struggling for activity-specific tools and equipments. However improved tools and equipment serve same purpose for both genders. The role of improved farm tools and equipments are:

- To reduce drudgery
- To increase inputs utilization efficiency
- To ensure timeliness in field operations
- To increase productivity of man- machine system
- To conserve energy
- To improve quality of work and also quality of produce
- To enhance the quality of life of agricultural workers

Women Friendly Tools and Equipments in Agriculture

A number of women-friendly small tools and equipments have been designed and developed. Some of them which can be easily used by women are depicted below:

1. **Dibbler:** It is single row manually operated equipment for dibbling bold or medium seeds in row or gap filling into well prepared soil in small plot.
2. **Dibbling stick:** The dibbling stick is a simple manually operated device for creating a conical cavity in the soil for sowing of seeds.
3. **Rotary dibbler:** The rotary dibbler is a manually operated push type device for dibbling of medium and bold size seeds.
4. **V blade hand hoe:** V blade hoe is used for weeding of the vegetable crop planted in the rows and earthing operation.
5. **Three blade hand hoe (Grubber):** It is for weeding, interculture and breaking of the soil crust in vegetable gardens, flower crops and nurseries.
6. **Single wheel hoe:** It is used for weeding and interculture of vegetables and other crops sown in rows.
7. **Double wheel hoe:** It is manually operated equipment for weeding and inter-culture in upland row crops.
8. **Nail Weeder:** It is used to weed out young composite weed flora including germinating ones in upland row crops.
9. **Improved cycle weeder:** It is manually operated equipment for weeding and inter-culture in upland row crops.
10. **Seed treatment drum:** It is used for mixing of chemicals and seeds before sowing.
11. **Paddy drum seeder:** It is used for line sowing of pre-germinated paddy seeds in puddled soil.
12. **SRI marker:** It is used for marking of points for transplanting of 15 days old paddy seedlings in the puddled field.
13. **Manual rice transplanter:** For transplanting 20-25 days old mat type rice seedlings at 3-4 leaves stages in four rows simultaneously under puddled condition.
14. **Manual multi-row seed drill:** It is used for line sowing of small seeded up-land crops.
15. **Fertilizer broadcaster:** Used for broadcasting of granular fertilizers.
16. **Groundnut decorticator:** It is a manually operated equipment to separate kernels from groundnut pods.
17. **Tubular maize sheller:** It is a hand operated tool to shell maize from de-husked cobs.
18. **Hand compression sprayer:** A small capacity pneumatic sprayer for applying chemicals.
19. **Improved sickle:** A common hand tool used for harvesting of the crops, grass and cutting of other vegetative matters.

20. **Vertical conveyor paddy reaper:** An engine operated machine used for harvesting of cereals.
21. **Paddle operated paddy thresher:** It is used for threshing of paddy crop.
22. **Manual paddy winnower:** A hand operated equipment for cleaning of threshed grain.
23. **Vegetable plucker:** A manual tool used for harvesting of vegetables.
24. **Hanging type grain cleaner:** It is a simple hanging grain cleaner for cleaning of cereals, pulses etc.

Constraints in usage of Agricultural Tools by Women

1. **Training:** Imparting skills to women workers for proper use of the improved farm tools/equipment is very important. Training for operation, repair and maintenance of farm tools and equipment for rural women may be accomplished either by training them in their own environments or by bringing them to the training centres located in their close proximity.
2. **Extension Services**: The major constraints in taking the technologies to farm women include Illiteracy among farm women, social customs and taboos, lack of infrastructural facilities for women extension programmes and lack of coordinated and concentrated efforts.
3. **Availability of Improved Tools in Rural Areas:** The supply of improved tools and equipment need to be ensured at block level, so that assured availability is ensured to the farm women as per their requirement.

Strategy for Technology Development and Promotion for Women

Tools/equipments should be designed using anthropometric and strength data of women workers. Proper trainings to rural women on various improved equipments should be provides so that they can operate them properly and safely. Assisting farm women in getting loans after being duly trained by trainers so as to procure various tools/equipments, building up of linkages with central/ state departments, NGOs, banks, and other stakeholders to promote these improved tools and equipments.

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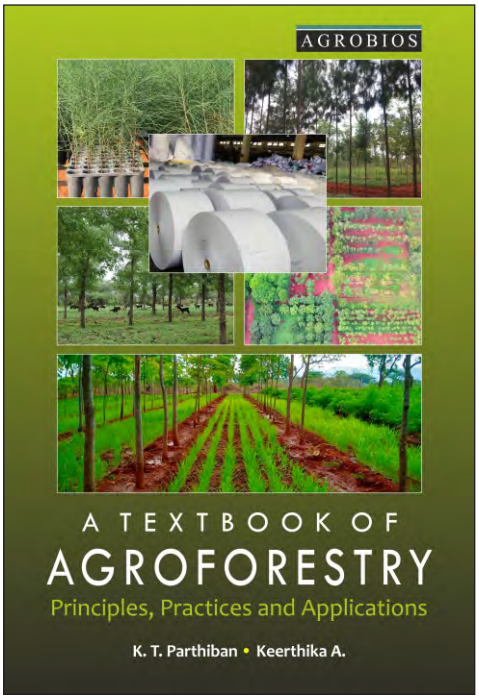

A Textbook of AGROFORESTRY Principles, Practices and Applications

By: Prof. KT Parthiban and Keerthika A

ABOUT THE BOOK

Wide range of textbooks on Agroforestry are available but most of them has not witnessed the recent advances made in Agroforestry which necessitated an advanced book in Agroforestry incorporating basic to the recent advances. Under such circumstances, the current book entitled Agroforestry- Principles, Practices, and Applications has been conceived and presented with 21 chapters.

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