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Encapsulation of Biopesticides

Kolli Bharghavi[1] and Burjikindi Madhuri[1]

[1]Ph.D scholar, Department of Agricultural Entomology, College of Agriculture, Professor Jayashankar Telenagana State Agricultural University, Telanagana, India

Abstract

Today's agriculture faces major challenges due to the improper utilization of synthetic pesticides and chemical fertilizers. By using these chemicals, the natural enemies of the targeted insect are eliminated and the natural microbial content of the soil is destabilized. Furthermore, they have a major impact on the contamination of the environment. Instead, using biopesticides as a substitute source is becoming more and more popular as a viable method of managing pests in agricultural settings. Nevertheless, the conventional use of biopesticides could yield less than ideal results. Encapsulating biopesticides improves their effectiveness and reduces environmental contamination problems, therefore offering solutions.

Introduction

Insects, diseases, and weeds cause 30 million tons of food grain (or 30% of crop output potential) to be lost in India alone. Applying chemical pesticides has been the main tactic used to get rid of the pests in an effort to prevent such losses. But in spite of the accomplishments, new dangers and hazards have surfaced. Biopesticides, or pesticides made from natural materials including plants, animals, microbes, and specific minerals, are becoming more and more popular as a way to combat the risks associated with chemical pesticides (Bailey *et al*., 2010). Biopesticides are insecticides derived from natural sources such as microorganisms, plants, animals, and minerals. Biopesticides have a significant role in sustainable agriculture, however they are typically utilized as part of an integrated pest control strategy that uses a bio-intensive approach, along with some other pest management techniques including the use of synthetic chemicals. These biological insecticides offer effective and environmentally friendly pest management. The integrated approach to plant protection offered by biopesticides necessitates a better balance between development inputs and effectiveness in upcoming formulation products. Insecticidal and microbiological forms of biopesticides are especially well-suited for this approach, even if it will be straightforward to supply solo organism-based to consortium-based solutions. As technology progresses, newer, more effective insecticidal and microbiological formulations, such as nanoemulsions, nanocapsules, and nanosuspensions, have also been found for commercial development (Gupta, S., & Dikshit, A.K. (2010); Kumar G., & Kumar A. (2018); Srivastava, M.P. (2017).

Encapsulation Techniques for Biopesticide Production

The term "encapsulation" describes a procedure wherein an encapsulating or gelling material is used to cage an active ingredient, such as chemicals, medications, or even tissues, to create a stable compound. It's a commonly utilized method in the food and pharmaceutical industries. The research and application of biopesticides in agriculture frequently run into challenges with environmental contamination, chemical residues, and human exposure. In actuality, though, encapsulation of the created biopesticides can aid in reducing all of these problems (Nanda *et al*., 2021). The biopesticide's active component will determine which encapsulation technique is used. Furthermore, a variety of options are available for the encasing chemical, including solids, liquids, and occasionally even gasses. The encapsulation can also have a variety of shapes, including as spherical, multi-core/shell, bead-structural, and capsules. The size of the biopesticide particle, its physical and chemical makeup, its biocompatibility, its release mechanism, and the encapsulating medium all play important roles in the finalization of an encapsulation technique (McClements, D.J. (2018); Singh *et al.*, 2020). Because of their physical or chemical properties, the agriculture industry uses a variety of encapsulation techniques. For instance, spray drying, gelation, and fluidize coating are a few of the most popular physical encapsulation techniques. Additionally, encapsulations assisted in addressing additional drawbacks of the unrefined biopesticides. For example, encapsulation increased carvacrol's water solubility. Environmental efficacy of biopesticides can be increased through encapsulation (Chang *et al.*, 2013; Campos *et al.*, 2018; Feng *et al.*, 2020). For example, rice weevil feeding was decreased by using encapsulated plant oils from tea, pomegranate, and grape. Encapsulate the biopesticides and add surfactants to increase their stability and potency. To increase the activity of citrus fruit oils, for example, emulsion polymerization was used to encapsulate D-limonene, the molecule that is found there. By presumably triggering fungal cytoplasmic disintegration, d-limonene functions as a strong fungicide. Due to oxidative degradation and volatilization, D-limonene loses its action quickly in the absence of encapsulation. Through the addition of phenol aldehyde microparticles, in-situ polymerization enhanced the effectiveness of neem oil. The insecticidal fungus *Metarhizium anisopliae* also demonstrated notable enhancements in its ability to encapsulate against fire ants by coacervation-mediated encapsulation. Fungal spores from *Beauveria bassiana*, *Cordyceps fumosorosea*, and *M. brunneum* have been effectively entrapped to make biopesticides that are used in integrated pest control through the application of the fluid-bed coating process (Qiu *et al.*, 2019; Stephan *et al.*, 2021). Improved biopesticide activity, increased stability and bioavailability, reduced toxicity, and environmental friendliness are just a few benefits of encapsulating biopesticides over their typical *Diabrotica balteata* application (Rad *et al.*, 2019).

Conclusion

Currently, farmers show their interest in using biopesticides as an alternative to chemical pesticides since their application is becoming more widely recognized. Using biopesticides appears to be a cost-effective solution because they are far less expensive than chemical pesticides. Because of their benefits and lower toxicity, biopesticides are becoming more and more popular in India. However, a number of encapsulation strategies are enhancing the biopesticide's bioavailability, release mechanism, and stability. This lowers the cost of production while also lessening the effects of additional chemical solvents that are utilized in encapsulation.

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2. ENTOMOLOGY

Endosymbionts Helping Insects to Development of Insecticide Resistance

Kolli Bharghavi[1] and Burjikindi Madhuri[1]

[1]Ph.D scholar Department of Agricultural Entomology, College of Agriculture, Professor Jayashankar Telenagana State Agricultural University, Telanagana, India

Abstract

Effective plant protection and human health depend on an understanding of the mechanisms. Like all living things, insects are always changing. In pests, the gut microbiota may encourage resistance to pesticides. Insecticide resistance may be mediated by gut symbionts through a variety of channels and direct absorption of pesticide-degrading bacteria from the environment. As a result, in order to effectively manage crop pests, the role of gut symbiotic bacteria and insect resistance must be taken into account while implementing novel pest control measures.

Introduction

Microorganisms and insects interact to develop mutualistic partnerships. Many microorganisms live in symbiotic relationships with their insect hosts (Wigglesworth,1929). These microorganisms are either directly obtained from the environment or inherited from mothers. These are divided into major (Jing *et al.*, 2020) and secondary endosymbionts (Douglas, 2015) based on their roles. They mediate a range of functions, including defense against pathogens and parasites, behavioural manipulation, colonization resistance, nutritional supplementation (Douglas *et al.*, 2001; Salem *et al.*, 2014), adaptation to the environment, population dynamics, and insect-plant interaction (Dillon and Dillon, 2004; Oliver *et al.*, 2005). Insects have evolved to be resistant to harmful substances. Evolutionary modifications in the insect genome, such as altered chemical target sites, greater excretion of drugs, and up-regulation of degrading enzymes, are some of the mechanisms that allow them to possess these capacities. An extra component that enhances insects' capacity for adaptive adaptation is the existence of a largely unexplored realm of microorganisms known as symbionts (Chaitra and Kalia, 2022)

1. **Symbionts help in insecticide**

resistance: Lepidoptera, Diptera, and Hemiptera are the three insect orders that are known to have symbionts that are capable of decomposing pesticides. The process by which different insect groups develop resistance to pesticides varies. Direct collection of environmental bacteria that break down pesticides: In areas where insecticides have been liberally applied, soil bacteria have proved crucial in the breakdown of pesticides. Similar to the situation with other related stink bugs, *Riptortus pedestris* (Fabricius). By feeding on soybean seedlings cultivated in fenitrothion-enriched soil, *R. pedestris'* second nymphal instars can acquire Burkholderia strains that degrade fenitrothion and form a helpful symbiosis with the seedlings ((Kikuchi *et al.*, 2012).

2. **Difference in gut bacterial diversity**: In certain insects, the gut microbiota of susceptible and resistant members of the same species differs in composition. According to Genta *et al.* (2006), pesticides and other toxic substances have a selective effect on the bacterial community that breaks down xenobiotics. The shift in the normal gut microbial composition towards those that can use the pesticide as an energy source can be attributed to the selection pressure caused by insecticidal exposure and the biota's adaptive responses to the new chemical environment in the midgut (Table 1)

Spodoptera litura against chlorpyriphos, indoxacarb, and flubendiamide. When comparing larvae with and without gut microbiota, higher LC50 values were found (Gadad and Vastrad, 2016). *Nilaparvata lugens*, a brown plant hopper, was subjected to a metagenomic investigation that revealed Proteobacteria dominated the gut microbiota of vulnerable strains (99.86%), whereas Firmicutes made up the majority of resistant strains (46.06%), followed by Bacteroidetes (30.8%) and Proteobacteria (15.49%).

Bacteria are known to produce a wide range of extracellular enzymes. Enzymes such as phosphotriesterases, methyl parathion hydrolases, and organophosphorus acid anhydrolases are produced by certain bacteria and are known to breakdown organophosphate compounds (Ramya et 2016). The bacterial enzyme families' carboxylesterases and phosphomonoesterases, which are involved in the breakdown of organophosphorus, were significantly enriched in *A. albimanus* resistant to fenitrothion (Dada *et al.*, 2018). The gut bacterial al., genera Acinetobacter, Bacillus, Enterobacter, Escherichia, and Klebsiella were among the fernitrothion-resistant strains of *A. albimanus*. These bacteria were known to be able to break down organophosphorus and to metabolize other kinds of pesticides (Dada *et al.*, 2018).

Table 1. Insect gut symbionts responsible for insecticide resistance

Insect pest	Symbiont	Insecticide	Reference
Anopheles albimanus Wiedemann	Klebsiella pneumoniae	Fenitrothion	Dada *et al.*, 2018
Plutella xylostella L.	Enterococcus sp. Pseudomonas sp. Stenotrophomonas sp. Serratia sp. and Acinetobacter sp Bacillus cereus	Chlorpyrifos Prothiofos Indoxacarb	Xia *et al.*, 2018 Indiragandhi *et al.*, 2007 Ramya *et al.*, 2016
Bemisia tabaci B-biotype	Rickettsia	Acetamiprid, Thiamethoxam, Spiromesifen and Pyriproxyfen	Kontsedalov *et al.*, 2008
Spodoptera frugiperda J E Smith	Enterococcus sp., Delftia lacustris, Leclercia adecarboxylata,	Lambda-cyhalothrin, deltamethrin, chlorpyrifo	Almeida *et al.*, 2017

	Microbacterium sp., Pseudomonas sp.,	s ethyl, spinosad and lufenuron	

Conclusion

There is widespread concern over insects developing pesticide resistance. Dealing with the issue is difficult since resistance can arise from the gut microbiota or from direct organism response, which includes changes in metabolism, physiology, and target site. Similar to other living things, insects are always changing and adjusting to survive the poisons sprayed on them. There is growing evidence that pests' resistance to pesticides may be enhanced by their gut microbiome. Since their parents are the only source of those bacteria, targeting the gut microbiota, particularly main endosymbionts, can be a unique strategy to pest control. To establish the facts, additional research utilizing in vitro and molecular approaches is required.

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3. AGRCULTURE

Artificial Intelligence (AI) in Agriculture

Sachin S.Chinchorkar and F.G.Sayyad

Polytechnic in Agricultural Engineering, AAU, Dahod, Gujarat

The growth of the global population, which is projected to reach 10 billion by 2050, is placing significant pressure on the agricultural sector to increase crop production and maximize yields. To address looming food shortages, two potential approaches have emerged: expanding land use and adopting large-scale farming, or embracing innovative practices and leveraging technological advancements to enhance productivity on existing farmland.

Pushed by many obstacles to achieving desired farming productivity — limited land holdings, labor shortages, climate change, environmental issues, and diminishing soil fertility, to name a few, — the modern agricultural landscape is evolving, branching out in various innovative directions. Farming has certainly come a long way since hand plows or horse-drawn machinery. Each season brings new technologies designed to improve efficiency and capitalize on the harvest. However, both individual farmers and global agribusinesses often miss out on the opportunities that artificial intelligence in agriculture can offer to their farming methods.

At Intellias, we've worked with the agricultural sector for over 20 years successfully, implementing real-life technological solutions. Our focus has been on developing innovative systems for quality control, traceability, compliance practices, and more. Now, we will dive deeper into how new technologies can help your farming business move forward

Benefits of AI in Agriculture

Until recently, using the words AI and

agriculture in the same sentence may have seemed like a strange combination. After all, agriculture has been the backbone of human civilization for millennia, providing sustenance as well as contributing to economic development, while even the most primitive AI only emerged several decades ago. Nevertheless, innovative ideas are being introduced in every industry, and agriculture is no exception. In recent years, the world has witnessed rapid advancements in agricultural technology, revolutionizing farming practices. These innovations are becoming increasingly essential as global challenges such as climate change, population growth together with resource scarcity threaten the sustainability of our food system. Introducing AI solves many challenges and helps to diminish many disadvantages of traditional farming.

Data-based Decisions

The modern world is all about data. Organizations in the agricultural sector use data to obtain meticulous insights into every detail of the farming process, from understanding each acre of a field to monitoring the entire produce supply chain to gaining deep inputs on yields generation process. AI-powered predictive analytics is already paving the way into agribusinesses. Farmers can gather, then process more data in less time with AI. Additionally, AI can analyze market demand, forecast prices as well as determine optimal times for sowing and harvesting.

Artificial intelligence in agriculture can help explore the soil health to collect insights, monitor weather conditions, and recommend the application of fertilizer and pesticides. Farm management software boosts production together with profitability, enabling farmers to make better decisions at every stage of the crop cultivation process.

Cost Savings

Improving farm yields is a constant goal for farmers. Combined with AI, precision agriculture can help farmers grow more crops with fewer resources. AI in farming combines the best soil management practices, variable rate technology, and the most effective data management practices to maximize yields while minimizing minimize spending.

Application of AI in agriculture provides farmers with real-time crop insights, helping them to identify which areas need irrigation, fertilization, or pesticide treatment. Innovative farming practices such as vertical agriculture can also increase food production while minimizing resource usage. Resulting in reduced use of herbicides, better harvest quality, higher profits alongside significant cost savings.

Automation Impact

Agricultural work is hard, so labor shortages are nothing new. Thankfully, automation provides a solution without the need to hire more people. While mechanization transformed agricultural activities that demanded super-human sweat and draft animal labor into jobs that took just a few hours, a new wave of digital automation is once more revolutionizing the sector.

Automated farm machinery like driverless tractors, smart irrigation, fertilization systems, IoT-powered agricultural drones, smart spraying, vertical farming software, and AI-based greenhouse robots for harvesting are just some examples. Compared with any human farm worker, AI-driven tools are far more efficient and accurate.

Applicability of Ai in Agriculture

- Diagnostic Application Service: Identification of symptoms of water stress, pest and diseases infestation etc. in farm fields.
- Prescriptive Application Service: Soil health analysis and prescription of fertilizer recommendation or any other agricultural inputs
- Advisory Application Service: Weather advisory and Irrigation scheduling
- Predictive Application Service: Yield prediction, disease and pest attack forecasting (early warning system).

Future of AI In India

Applications of AI based tools in

agriculture have initiated in India by several start-ups working in this area to help farmers with improved productivity and profitability from agriculture. India's burgeoning start-up ecosystem has been actively playing its part in developing the agriculture sector. Since, opportunity in Agritech exists across the value chain from improving farmers' access to markets, inputs, data, advisory, credit and insurance; India can tackle the issues associated with adoption of AI based technologies by providing a suitable ecosystem to these start-ups to access the data and market. Moreover, National Strategy for Artificial Intelligence released by NITI Aayog in June 2018 identifies agriculture as one of the focus areas. To maximize farm output from limited resources agriculture in India should to make use of sophisticated deep techs in future. Deep-Tech innovations support farmers to grow crops even in arid areas with high resource use efficiency, using technologies like AI and ML, robots, temperature and moisture sensors, aerial images, and GPS. An important aspect of AI is the system's response time and accuracy. Even behavioral changes in field crops due to changes in microclimate conditions can be analyzed in the quickest response time with accurate information. However, concerns about durability of AI technologies may discourage farmers from its adoption as technologies are changing very fast in this digital era, and changing devices and sensors quickly with advancement in the adopted technologies is not going to be economical for the small-scale farmers of India. It is certain that digital innovation can transform Indian agriculture if there are proper efforts to convince the vend users about the potential of AI based technologies in agriculture sector; not only from the user and consumer side but also to the governance and policy side.

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4. PLANT BREEDING AND GENETICS

Breeding for Herbicide Tolerance in Cotton

Rishee K. Kalaria[1] and H. V. Patel[1]

[1]*ASPEE Shakilam Biotechnology Institute, Navsari Agricultural University, Surat*

Introduction

Cotton (*Gossypium hirsutum* L.) is the most significant and pre-eminent fiber crop along with being a chief source of edible oil in the world. Cotton is a foundation of the world's textile industry. The yield of the cotton is affected by the various biotic and abiotic factors. Weeds are the major constraints for declining crop yield by competing for nutrients, light and water. Hence, effective weed control in cotton production system is a prerequisite for high yields and good quality fibre.

Due to Prolonged use of a single herbicide leads to the occurrence of herbicide-resistant weeds. Herbicides have severe morphological and physiological effects on plants. However, the most important weed-management practices are rotating or combining herbicides with different sites of action.While such practices make herbicide-tolerant crops attractive. Herbicide tolerant cultivars have been developed in many crops by exploiting already available genetic variability in the germplasm or by creating mutations or through transgenic.

Herbicide tolerance

Herbicide tolerance is ability of the plant to survive and reproduce after being treated with herbicides at the normal rate. Herbicide tolerant plant required due to repeated use of higher dose of herbicide lead to evolution of herbicide resistance in weed populations, facilitate broad spectrum weed control, negligible crop injury and provide greater flexibility in application timing and to protect plant from biochemical and physiological damage cause by the herbicide.

Mechanism of Herbicide Tolerance

- Altered target site
- Enhanced metabolism
- Compartmentalization
- Over-expression of the target protein

Breeding Method for Herbicide Tolerance

Conventional Method

- Germplasm Screening and wild relatives
- Mutation
- Backcross method

Non-Conventional Method

- Somaclonal variation
- Site-directed mutagenesis
- Genome editing
- Transgenic

Case Study

Zang*et al.*(2017)usedan*Agrobacterium* -mediated transformation method for transformation of an ewG2-aro Agenethatencodes5-enolpyruvylshikimate-3-phosphate synthase (EPSPS in cotton cultivar K312. The results from polymerase chain reaction (PCR) and Southern and Western blot analyses often selected plant in dicated that the target gene was integrated into the cotton chromosome and was expressed effectively at the protein level. The glyphosate tolerance analysis showed that the transgenic cotton had a high resistance to glyphosate. Further, even cotton treated with45.0mmo lL^{-1} of glyphosate was able to slowly grow, bloom and seed.

Guo *et al.* (2018) introduced glyphosate resistant gene *CP4* into an elite Bt transgenic cotton cultivar within plant a *Agrobacterium* mediated transformation of shoot apex.Trans gene insertion was analysed by South ernblot analysis.Gene transcription and protein expression levels in the transgenic cotton lines were further investigated by RT-PCR, West ernblot and ELISA methods. Results indicate that the cotton shoot apex transformation technique which is both tissue-culture and genotype-independent would enable the exploitation of transgene technology in different cotton cultivars. Since this method does not require sterile conditions, the use of specialized growth media or the application of plant hormones, it can be conducted under the greenhouse condition.

Chen *et al.* (2023) obtained a mutant cotton (Lu37-1) tolerant to IMI herbicides by EMS mutagenesis. A novel non synonymous substitution mutation (Ser642Asn) in an ALS gene (*Gh_D10G1253*) contributed to the tolerance to IMI herbicides in the mutant cotton Lu37-1. The herbicide tolerance was attributed to the G-to-A transition at the position which encodes Ser642 of the ALS gene *Gh_D10G1253*. In order to further confirm the mutation at the *Gh_D10G1253*, the mutant allele of*Gh_D10G1253*was transformed to Arabidopsis. Transgenic Arabidopsis over expressing the mutant *Gh_D10G1253* confer high tolerance to IMI herbicides.

Conclusion

Genetically engineered(GE)crops are designed to become tolerant to herbicides which kill the surrounding weeds, but leave the cultivated crop unaffected. Number of herbicide tolerance gene were identified from plant and bacteria, out of which major are bacterial genes. Transgenic cotton having *G2-aroA*geneencoding EPSPS confers tolerance to glyphosate and plants having *CP4-EPSPS*shows less amount of shikimic acid indicates normal completion of shikimic acid pathway.

Future Thrust

Multiple sources of resistance should be identified and used in developing HT-cotton to avoid the risk of developing herbicide resistant weeds. Efforts are required to extend plant regeneration from callus to various cultivars or species of cotton grown commercially. There should be a stronger emphasis on strategies to increase the scope of gene transfer and the predictability and preciseness of DNA integration. There should be scope of improve the genetic makeup of cotton for resistance against a wide array of herbicides by use of genes tacking method i.e. more than one herbicide-resistant genes are combined in single plant using molecular biology and conventional breeding approaches.

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5. PROCESS AND FOOD ENGINEERING

3D Food Printing: Innovations in Personalized Nutrition and Food Customization

F.G.Sayyad and S.S.Chinchorkar

Anand Agricultural University

Abstract

3D food printing is an emerging technology transforming the food industry by allowing the creation of customized, nutritionally balanced, and visually appealing food products. Recent innovations include the use of plant-based ingredients, the development of multi-material printers, and advancements in texture control. Globally, 3D food printing is contributing to personalized nutrition for various sectors such as healthcare, space missions, and gourmet dining. In India, the technology is gaining interest in niche markets like high-end restaurants and nutrition-focused industries.

Keywords: 3D food printing, personalized nutrition, multi-material printers, customized foods, India

Introduction

The advent of 3D printing technology in food production has brought about new possibilities for customization and precision in nutrition. This technology involves creating food products layer by layer using specialized printers and food-based materials, often referred to as "inks." Globally, 3D food printing is being used in areas such as healthcare to cater to specific dietary needs (e.g., for elderly patients), space missions where conventional cooking is impractical, and luxury dining where intricate designs are sought after.

In India, though the application of 3D food printing is still in its nascent stages, it has caught the attention of gourmet chefs and nutrition-based startups. Customized food products designed for specific dietary requirements—such as gluten-free or protein-rich meals—are beginning to find a place in the Indian market.

Methodology

3D food printing utilizes various processes depending on the desired outcome. Innovations include **extrusion-based printing**, where soft foods like purees, doughs, or pastes are deposited layer by layer. Recent developments in **multi-material printing** allow the use of different food materials simultaneously to create complex textures and flavor combinations. Globally, researchers are working on improving the nutritional profile of printed foods, making it suitable for various dietary requirements.

In India, research institutions and startups are experimenting with local ingredients to create nutritionally enhanced food using 3D printers. Advances in food-grade materials, like plant-based proteins, are also being integrated into this process to cater to a growing segment of health-conscious consumers.

Recent Innovations

Recent innovations in 3D food printing focus on enhancing both the **functionality and sustainability** of printed food:

- **Plant-Based and Sustainable Ingredients**: There is a growing interest in using plant-based or alternative proteins, like algae and insects, to make 3D printed foods more sustainable and environmentally friendly.
- **Multi-Material and Multi-Flavor Printing**: Advances in multi-material printing enable combining different flavors, textures, and nutrients in a single product, paving the way for more complex and personalized meals.
- **Texture and Nutritional Customization**: In healthcare, 3D food printers are used to create food products that cater to specific dietary restrictions, like low-sodium or high-protein diets, often tailored for patients with specific health needs such as dysphagia (difficulty in swallowing).
- **Edible Sensors**: Research is also exploring the use of 3D-printed foods embedded with sensors to monitor health metrics like blood sugar levels, thus integrating food with health monitoring systems.

Results and Observations

Globally, the integration of 3D printing into food production has led to advancements in **personalized nutrition**. In space exploration, for instance, astronauts benefit from 3D-printed meals that are customized to provide balanced nutrition during long-term missions. The luxury food sector uses 3D printing to design intricate and artistic dishes that cannot be made using traditional methods.

In India, restaurants are using 3D printing to provide unique dining experiences. While still at an experimental stage, nutrition-focused industries are looking into using 3D printing to deliver customized meal solutions based on individual dietary needs, such as for athletes or individuals with dietary restrictions.

Conclusion

3D food printing is set to revolutionize the food industry by offering personalized, customizable, and sustainable food products. Globally, it has shown immense potential in space exploration, healthcare, and luxury food production. In India, the early adoption of 3D food printing in niche markets like high-end restaurants and nutrition-based startups signals a promising future for this technology. Continued innovation, particularly in multi-material printing and plant-based ingredients, will further expand the applications and accessibility of 3D food printing.

6. SOILSCIENCE

Reclamation and Management of Polluted Soils by

Industrial Effluents

M. Paramasivan

Agricultural College and Research Institute,
Tamil Nadu Agricultural University,
Killikulam, Vallanad – 628 252, Thoothukudi – Dt, Tamil Nadu. India

Soil pollution refers to anything that causes contamination of soil and degrades the soil quality. It occurs when the pollutants causing the pollution reduce the quality of the soil and convert the soil inhabitable for microorganisms and macro organisms living in the soil. Soil pollution is creating problems in agriculture and destroying local vegetation. It also causes chronic health issues to the people that come in contact with such soil on a daily basis.

Industrial effluents and their Characteristics

The incorrect way of chemical waste disposal from different types of industries can cause contamination of soil. Human activities like this have led to acidification of soil and contamination due to the disposal of industrial waste, heavy metals, toxic chemicals, dumping oil and fuel, etc. Increased number of industries has enlarged the disposal of effluent to open land or to natural water resources. Industrial waste products may be in gas, liquid or solid form. The most important gases are carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). Effluent of different industries may vary in composition depending upon the source of production. Industrial waste contains organic and inorganic compounds, heavy metals, acids, alkalies, suspended solids and other materials.

In India, seventeen categories of heavily polluting industries have been identified by Central Pollution Control Board. They are cement, thermal power plant, distilleries, sugar, fertilizer, integrated iron and steel, oil refineries, pulp and paper, petrochemicals, pesticides, tanneries, basic drugs and pharmaceuticals, dye, caustic soda, zinc smelter, copper smelter and aluminum smelter.

Composition of some industrial effluents of Zn smelter and paper mills are acidic in nature. The effluents of oil refinery, paper mill and distillery are rich in organic C. When such effluents of high BOD are disposed on soils they may develop anaerobic conditions and thus affect soil quality.

Effect of wastes on soil

The direct use of industrial effluents in agriculture may raise problem like salinity, alkalinity and/or toxicity in the soil as a result of long-term irrigation with such wastewater. The main problem with heavy metals is that, they cannot be biodegraded and therefore remain in the environment for long periods of time. Heavy metals like Cu, Ni, Hg, Pb,As and Zn are known to be carcinogenic. Application of agro-based industrial effluent to agricultural lands influenced germination and growth of different crops.

High accumulation of metals affects both growth and metabolism of plants. Some heavy metals, like Cu and Zn, have known functions as micronutrients in plants, but they become toxic at high levels. Plants grown in heavy metals rich soil, result in introduction of potentially toxic metals into the food chain. Long-term exposure to these metals causes neurological degeneration, Alzheimer diseases, muscular dystrophy, allergic reactions and cause genetic mutation.

Sewage sludge is the one of the product of treatment plants. The materials processed in the treatment plants are domestic and industrial wastes. They are usually liquid mixtures, composed both of solids and of dissolved organic and inorganic materials.

Paper and pulp effluents contain lignin and phenolic compounds resistant to decomposition, have high BOD so direct disposal causes harmful effects to soil. Sugar mill effluents contain higher amount of suspended solids, dissolved solids, BOD, COD, chloride, Ca, Mg affects crop production, soil properties. In some areas of Punjab ground water has been contaminated by Hg and Pb to such an extent that it is causing mutation in DNA to the people who drink it. The tannery water in Tamil Nadu had deteriorated the quality of surface and ground water making it unfit for drinking and agriculture. Effluents of Zn smelter near Udaipur, Rajasthan, contained the high amount of Zn than the permissible limit.

Technologies for reclamation and management of industrial effluents

The industrial effluents must be monitored continuously to avoid the excessive accumulation of toxic metals in the soil. There should be strict Government law that only those industrial effluents be used in the fields which are cleaned through effluent treatment plants. It is set out in the Environment Protection Act 1970, all wastes should be managed in the following order of Preference:

- Avoidance Reuse
- Recycling
- Recovery of energy
- Treatment
- Disposal

Effluents from industries must be diluted to avoid their adverse effect on soil. Application of organic manures boosts the yield of soil as well as decrease the metal availability to plants. Bioremediation is use of biological agents such as bacteria, fungi and plants to remove or degrade the pollutants from the contaminated soil. The tree species like *Azadirachta indica* and *Acacia nilotica* etc., were used. The toxic compounds are trapped into the trunks of such tree which will remain for a longer time and will not come to the food chain as well.

However, considering the fact that there may be some risk of heavy metals and other toxic / undesiderable elements contaminating the plants and then moving into the food chain, utmost care is necessary in the use of such waters. Nine tree species that can be grown with textile effluent water in the arid areas for bio remediation. They are *E. camaldulensis*, *Acacia nilotia*, *A. tortilis, Azadirachta indica, Hardwickia binata, Colophospermum mopne, Prosoposis cineraria, P. juliflora* and *Tecomella undulate*.

Remediation technologies based on containment and immobilization strategies

Technology	In situ /ex situ	Contaminants / application	Limitations	Advantages
Contaminant technologies				
Cover barriers	In situ	Organic and inorganic contaminants	It require careful design and implementation (specially excavation and backfilling of trenches) It is susceptible to failure or damage It doe snot treat for the contamination It is not a permanent solution It requires long-term monitoring (ground water and gases) Wall materials depend on the type of contaminants	Applicable to wide range of contaminants, specially complex mixtures Applicable small and large sites
Immobilization				
Solidification/ stabilization	Ex situ / in situ	Inorganic including radionuclides and heavy metals Organic in case of	Weathering and water infiltration can affect the integrity of stabilized mass causing contaminant mobility The selection of immobilizing agent require treatability	Reagents are widely available and inexpensive The maintenance of immobile metal can be reduced if proper conditions are maintained

		asphalt batching	studies The process may increase the waste volume In situ, it is difficult to get complete and uniform mix of the immobilizing agent with the soil In situ, the depth of contaminants may limit the process Volatile compounds (VOC) may be released during the process.	It greatly reduces the leaching of contaminants
Vitrification	In situ / ex situ	Inorganic including radionuclides and heavy metals Organic although other methods are preferred	High energy is required It needs special equipment and trained personal Soil moisture increase the time and cost of process The soil must contain enough silica and alkali oxides to allow the vitreous mass formation The resulting materials may limit future land use It does not support vegetal cover	Applicable to wide range of contaminants Applicable to broad range of media: solid, liquid and sludge The resulting glass structure is durable and resistant leaching

7. SOIL SCIENE

Nutrient Management through Organic Farming

M. Thirunavukkarasu

Subject Matter Specialist (Soil Science),

Krishi Vigyan Kendra, Gandhigram Rural Institute-DTBU, Gandhigram-624 302, Dindigul, Tamil Nadu

Introduction

Organic farming is a method of farming which avoids or largely excludes the use of harmful chemicals such as chemical fertilizers, pesticides and herbicides and use of natural resources such as organic matter, minerals and microbes to maintain the environment clean, ecological balance and to provide stability to the production level without polluting soil, water and air. Organic farming system relies on large-scale application of animal wastes or farmyard manure, compost, crop rotation, crop residues, green manure, vermicompost, bio-fertilizers, VAM, bio-pesticides and biological control.

Nutrient Sources

Crop rotations are the key techniques for managing overall nutrient supply on organic farms. Crop diversification can deliver many agronomic and ecological benefits simultaneously, while maintaining or enhancing efficiency of production. Growing of cover crops and green manure crops that includes N-fixing legume is the most economical way to provide N to a succeeding crops and also reduce nitrate leaching, nutrient runoff, and soil erosion. Typically, a green manure crop will require approximately 50 to 60 days of growth to fix between 60 and 90 kg N per ha. Compost, vermicompost and other enriched composts are the relatively cost-effective organic source of N. These composts also provides P, K, Ca, Mg, S, and other minor nutrients in fairly well-balanced amounts. Although actual concentrations of P and K in composts are low, the total additions may be quite high due to the high volume of material applied. Nutrient sources commonly used for organic farming are green manure, farm yard manure (FYM), vermicompost, compost, enriched compost, bio-gas slurry, oil cakes, poultry manure, biofertilizer, and Panchgavya.

Green Manure

Green manures, often known as cover crops, are plants which are grown to improve the structure, water holding capacity and organic matter content of the soil. They are a cheap alternative to artificial fertilizers and can be used to compliment animal manures. Green manures are usually dug into the soil when the plants are still young, before they produce any crop and often before they flower. They are grown for their green leafy material which is high in nutrients and provides soil cover with view to increase organic matter and humus content in the soil. The crops to be taken for green manuring should be fast growing, rich in nutrient like legumes, resistant to biotic and abiotic stresses, has smoothening effect against weeds and with more foliage. Crops that are commonly used for green manuring are Sesbania aculeata (suitable for rice-wheat, 55 days old crop producing 17-30 tonnes green matter per ha), Sesbania speciosa (suitable for wet lands, when raised on field borders along the bunds, 90 day old crop contributes 2-4 tonnes green matter per ha) and Crotolaria juncea (suited to almost all parts of country and adds 15-25 tonnes fresh biomass in 50-60 days). They can be grown together with crops or alone. Because the C:N ratio of green manure crops increases as they age, it is generally recommended that green manure crops be harvested or incorporated into the soil when close to full bloom (but prior to seed set) to assure a C:N ratio of 22:1 or less so that net mineralization occurs.

Green manure crops generally used are Sesbania aculeata (Daincha) and Crotalaria juncea (Sunnhemp). A seed rate of 25-30 kg per ha of daincha and sunnhemp should be used for raising green manure. Generally broadcasting of green manure seeds is practiced. One pre-sowing irrigation should be applied with 1-2 irrigations in between green manure crop depending on summer rains, sufficient for growth of green manure crop. Sowing is usually done in last week of April to first fortnight of May. The green manure crop to be turned down around 55-60 days after sowing. The Trichoderma (10 g per litre) should be sprayed on turned Sesbania/Crotalaria crop in the field before puddling and transplanting rice crop. The 60-day-old crop can contribute approximately 100 kg N/ha, 25-30 kg P_2O_5/ha and 75 kg K_2O/ha and these can meet the requirement of organic rice crop.

Farm Yard Manure

Farm yard manure is partially decomposed dung, urine, bedding and straw. Dung comes mostly as undigested material and urine from digested material. More than 50 per cent of the organic matter that is present in dung is in the form of complex products consists of lignin and protein which are resistant to further decomposition and therefore the nutrients present in dung are released very slowly. The nutrients from urine become readily available. Dung contains about 50 per cent of the nitrogen, 15 percent of potash and almost all of the phosphorus that is excreted by animals. On an average, about 3-5 kg bedding material per animal is used by farmers. FYM contains approximately 5-6 kg nitrogen, 1.2 to 2.0 kg phosphorus and 5-6 kg potash per tonne. If properly preserved, the quantity of manure that can be produced per animal per year would be as much as four to five tonnes containing 0.5 per cent nitrogen. If available, well decomposed FYM should be applied @15-20 tonnes per ha for cereals and 5-10 tonnes per ha for pulses, which can supply about 75-100 kg N per ha, 35-40 kg P_2O_5/ha and 75- 100 kg K_2O per ha. FYM should be decomposed by adding Trichoderma powder. The nutrient contents of various organic manures are given in Table 1.

Table 1. Nutrient content of organic manures

Manures	**Nutrient content (%)**		
	N	p	k
Farm yard manure	0.5	0.3	0.5
Poultry manure	3.0	2.5	1.5
Vermicompost	0.5-1.5	0.1-0.3	0.15-0.56
Compost (Rural)	0.5	0.5	1.0
Compost (Unban)	1.0	0.5	0.5

Night soil	5.0	3.0	2.0
Cow dung	1.5	0.5	0.5
Coir pith Compost	1.24	0.06	1.2

Vermicompost

Vermicomposting is a simple biotechnological process of composting in which certain species of earthworms enhance the process of waste conversion and produce a better end product i.e vermicompost. The worm castings (vermicompost) contain higher percentage (nearly twofold) of both macro and micronutrients and it is evident that vermicompost provides all nutrients in readily available form and also enhances uptake of nutrients by plants. Vermicomposting converts household compost within 30 days, reduces the C: N ratio and retains more N than traditional method of preparing compost. Vermicomposting can be done by using several methods viz., pits below the ground, heaping above the ground, tanks above the ground and cement rings. Among these methods, considering bio-degradation of waste as the criterion, the heap method of preparing vermicompost was better for earthworm population, biomass production and consequently vermicompost production was also higher. The African species of earthworms, Eisenia foetida and Eudrilus eugenae are ideal for the preparation of vermicompost and earthworms should be protected against birds, termites, ants and rats. The plant based materials such as grass, leaves or vegetable peelings should be utilized in preparing vermicompost. For the preparation of vermicompost, pits are made of 1 m deep and 1.5 m wide, however, the length varies as required and bottom of the pit is covered by polythene sheet on which 15-20 cm layer of organic waste material (it helps in improving nutritional quality of compost) and finally cow dung slurry should be sprinkled. Culture of Pseudomonas fluorescens may also be added @ 200g/100 kg. Pit is filled completely in layers as described and finally the top of the pit is pasted with soil or cow dung and material is allowed to decompose for 15-20 days. During the decomposition of the materials has subsided (15-20 days after heaping). Selected earthworms (500 to 700) were released through cracks and water is sprinkled every three days to maintain adequate moisture. Vermicompost is ready in about 2 months if agriculture waste is used. When compost is ready water should not be allowed for 2-3 days and compost is piled in small heaps and left under ambient conditions for a couple of hours when all earthworms move down the heap in bed and finally upper portion of the manure is sieved from lower portion to separate earthworm from manure. This processed vermicompost is black, light in weight and free from bad odour. Vermicompost is recommended for cultivating agricultural crops @ 2.5 t/ha, horticultural crops @ 5 t /ha and fruits crops @ 500g/plant/year.

Compost

Compost is organic matter (plant and animal residues) which has been rotted down by the action of bacteria and other organisms, over a period of time. The biodegradation process is carried out by different groups of heterotrophic microorganisms like bacteria, fungi and actinomycetes etc. Organic materials undergo intensive decomposition under thermophilic and mesophilic conditions in heap, pits or tanks with adequate moisture and aeration and finally yield a brown to dark brown coloured humified material called compost. Materials such as leaves, fruit skins and animal manures can be used to make compost. Compost is cheap, easy to make and is a very effective material that can be added to the soil, to improve soil and crop quality and also improves the structure of the soil. This allows more air into the soil, improves drainage and reduces erosion. Compost improves soil fertility by adding nutrients and by making it easier for plants to take up the nutrients already in the soil which produces better yields.

C:N ratio affects the rate of decomposition of compost. Low C: N ratio (below 25:1) may result in too rapid decomposition and the loss of nitrogen in the form of ammonia. A C: N ratio that is too high may result in too long a decomposition process and a low quality end product. Ideal C: N ratio range is 25:1 to 40: 1. The moisture of decomposing organic material should be maintained around 50-55 per cent.

Enrichment of compost

Various methods of composting for nutrients enrichment through rock phosphate, pyrite and micro-organism have better quality with respect to N, P, K and S content. For enriching the compost with rockphosphate, rockphosphate is added at the rate of 12.5 per cent in a mixture of plant residue+ FYM+ soil in ratio of 8: 1.0: 0.5 in the form of slurry on plant residue during composting. Likewise, for enriching the compost with pyrite, pyrite is added at the rate of 10 per cent in a mixture of plant residue+ FYM+ soil in ratio of 8: 1.0: 0.5 in the form of slurry on plant residue during composting. While for enriching the compost with inoculums, a mixture of FYM (10 kg) + soil (2kg) + inoculums (1 kg Azotobacter + 1 kg Phosphobacteria + 1 kg Pseudomonas + 1 kg Thiobacillus + 1kg Beauveria) in a 100-150 litre of water was added on the top of layer while composting which is sufficient for 1 ton of enriched compost.

Bio-gas slurry

Bio-gas slurry is a good source of organic manure. Anaerobic digestion of raw animal dung by microbes in the bio gas plant offers more advantages in improving the manorial value of the slurry as compared to the manorial product of aerobic decomposition. An aerobic decomposition of organic matter results in about 30 to 50 per cent loss of nitrogen, whereas there is almost complete conservation of nitrogen in anaerobic digestion. During anaerobic bio-digestion, about 15 to 18 per cent of total nitrogen is converted into ammonical nitrogen as main source of soluble nitrogen. It is therefore, necessary to take precaution for proper storage of slurry and also during its application to soil to reduce the loss of ammonical nitrogen. All chemical elements except carbon, oxygen, hydrogen and sulphur contained in animal dung are conserved in bio-digested slurry which is reported to be rich in plant nutrients both macro and micro nutrients compared to FYM. Air dried bio gas slurry can be applied by spreading on the agricultural land at least one week before sowing the seed or transplanting the seedlings. Nutrient content of Bio-gas slurry is approximately 1.43 % N, 1.21 % P and 1.01 % K on dry weight basis. In general, 10 tonnes per ha bio-digested slurry is recommended to be applied once in three years to maintain organic content in soil, beside providing nitrogen, phosphorus and potassium in form of organic fertilizers to the crop

Oil cakes

Oil cakes have higher nutrient content as compared to other organic manures. Many oil cakes such as castor, neem, mahua groundnut, Safflower, linseed, rapeseed and cotton seed may serve as good organic source. Neem cake contains the alkaloids-nimbin and nimbicidine which effectively inhibits the nitrification process and increasing the yield, nitrogen uptake and grain protein content of rice. Mahua cake has been successfully used in coastal saline soils for cultivation of rice. They are insoluble in water but their N become quickly available to plants about a week or 10 days after application. Most of the non-edible oil cakes are valued much for their alkaloid contents which inhibit the nitrification process in soils. Commonly available non-edible oil cakes used as organic nutrient and their nutrient content is presented in Table 2.

Table 2. The nutrient content of non-edible oil cakes

Oil cakes	**Nutrient content (%)**		
	N	p	k
Groundnut cake	7.3	1.53	1.33
Neem cake	5.2	1.08	1.48
Castor cake	4.4	1.85	1.39
Linseed cake	5.6	1.44	1.28
Safflower cake	8.0	2.0	2.0
Cotton seed cake	6.0	3.0	2.0
Mahua cake	2.5	0.8	1.2
Rape seed cake	5.2	1.8	1.2

Poultry manure

Poultry waste comprises waste feed, solid and liquid dropping, litter, eggshell, diseased and dead birds, culled birds, feathers and the wastes from poultry sheds. Poultry manure is concentrated organic manure used as a nutrient source in organic farming particularly for vegetables comprising of 2.08-2.13 % nitrogen, 2.41-2.60% % phosphorus and 2.03-2.94 % potash. The C:N ratio of poultry compost is 13:1-14:1. Broiler litter also contains 23-125 ppm copper, 125- 667 ppm manganese and 106-669 ppm zinc. Poultry waste manure is highly complex and challenging because of associated problems like nitrate and heavy metal contamination in soil, crops, surface and ground water, air quality and odour, disposal of dead and diseased. Good quality poultry manure can be obtained by mixing the poultry waste with selective carbonaceous material such as coirpith and inoculation with suitable microorganism. It can be used as an eco-friendly technique for the conversion of poultry waste into valuable compost. The poultry waste compost will be a very good organic manure@6 ton / ha for all the crops.

Biofertilizers

Biofertilizers means the product containing carrier based (soild or liquid) living microorganisms which are agriculturally useful in terms of nitrogen fixation, phosphorus solubilization or nutrient mobilization to increase productivity of the soil and/or crop. In case of carrier based formulations, the product should have 30-50 per cent of moisture throughout the shelf life period to sustain microbial population and the microbial population should be in the range of 10^7 to 10^9 cells/g of moist product. In case of liquid formulations, the cell load should be in the range of 1×10^8 to 1×10^{10} during the entire period of shelf life. In addition to this, it should be free from other contaminating microorganisms and should have sufficient shelf life (minimum 6 months for carrier based and 12 months for liquid). Three types of biofertilizers are used i.e. Symbiotic Nitrogen fixers such as Rhizobium culture for legumes; free living nitrogen fixers (non-symbiotic bacteria) such as Azotobacter and Azospirillum spp. for cereals, blue green algae and Azolla for paddy and P solubilizers such as Phosphobacterium. While symbiotic nitrogen fixers inoculated in legumes can fix substantial amount of atmospheric nitrogen to feed the host plant, free-living Nitrogen fixers contribute much less, usually 10-30 kg/ha. P solubilizers enhance the availability of native inorganic P.

Table 3. Method of biofertilizer application and its recommended dose for different crops

Methods	**Biofertilizer application**	**Crop**	**Recommended dose of biofertilizers**
Seed treatment	Dissolve required amount of biofertilizer in one litre of water and slowly spread the solution on the seeds and mixed by the hand till the seeds are coated with uniform layer of biofertilizer. Dry the seeds in the shade and cover the seeds with soil after sowing the seeds in the furrow	Maize, Sunflower, Sesamum, Okra, Pearl Millets, Mustard, Toria, Wheat,	200 g for 10 kg seeds
Root treatment of seedling	Dissolve required amount of biofertilizer in the bucket or tub having (1 kg) in 4 to 5 litres water. Dip the roots of seedling in the solution for 10 minutes.	Rice, Chilli, Tomato, Cabbage, Pearl Millets Cauliflower, Capsicum, Apple, Pear, Peach, Apricot	1.5 to 2 kg/ha
Tuber treatment	Dissolve required amount of biofertilizer (2 kg) in 15 litres of water and dip the tubers in the solution for 5 to 10 minutes or equally spread the solution on the tuber and sow in the field.	Potato, Ginger, Turmeric,	2 to 2.5 kg/ha
Soil treatment	Mix required amount of biofertilizers in 40-50 kg compost or fine soil and broadcast just after the last harrowing or before the first irrigation in one acre area	Suitable for long duration crops	3 kg/ha
Blue green algae	Apply 10-12 kg BGA before one week of transplanting of rice for one hectare. 3-4 cm standing water is required at the time of application.	Rice	10-12 kg/ha

Panchgavya

Panchgavya, an organic product has the potential to play the role of promoting growth and also provides immunity in plant system. Physico-chemical properties of Panchgavya revealed that they posess almost all the major nutrients, micronutrients and growth hormones (IAA and GA) required for crop growth. Predominance of fermentative microorganisms like yeast and lactobacillus might be due to the combined effect of low pH, milk products and addition of jaggery/ sugarcane juice as substrate for their growth. Panchgavya consists of nine products viz., cow dung, cow urine, milk, curd, jaggery, ghee, banana, tender coconut and water. When suitably mixed and used, these have miraculous effects. Here for its preparation, the product of local breeds of cow is said to have potency than exotic breeds. For this mix, 7 kg cow dung and 1 kg cow ghee thoroughly both in morning and evening hours and keep it for 3 days. After 3 days, mix 10 litres of cow urine and 10 litres of water and keep it for 15 days with regular mixing both in morning and evening hours. After 15 days, mix cow milk-3 litres, cow curd-2 litres, tender coconut water – 3 litres, jaggery- 3 kg and well ripened poovan banana-12 nos. and Panchgavya will be ready after 30 days. All the above items can be added to a wide mouthed mud pot, concrete tank or plastic can as per the above order. The container should be kept open under shade and covered with a wire mesh or plastic mosquito net to prevent house flies from laying eggs and formation of maggots in the solution.

Panchgavya is sprayed on crops at a concentration of 3 per cent (3 litres panchgavya to every 100 litre of water is ideal for all crops). The solution of panchgavya can be mixed with irrigation water at 50 litres per hectare either through drip irrigation or flow irrigation. Also, 3 per cent solution of panchgavya can be used to soak the seeds or dip the seedlings (20 minutes before transplanting). Rhizomes of turmeric, ginger and sets of sugarcane can be soaked for 30 minutes before planting. Panchgavya is used at pre-flowering phase (once in 15 days, 2 sprays depending on duration of crop), flowering and pod setting stage (once in 10 days, 2 sprays) and fruit/ pod maturation stage (once during pod maturation).

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8. PLANT BREEDING AND GENETICS

Maize Breeding for High Oil Content

Rishee K. Kalaria[1] and H. V. Patel[1]

[1]*ASPEE Shakilam Biotechnology Institute, Navsari Agricultural University, Surat*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crop next to wheat and rice. It is known as “Queen of cereals” and grown in unmatched diversity of environments. The intensive use of the maize kernel is due not only to its high starch content but also to the oil stored in the embryo. Oil, in fact, is the important valuable product from industrial processing of maize grain, and it represents a source of good quality oil for humans.It is considered to be better than most of other edible oils due to its fatty acid composition and stability during storage and cooking. There is about 3–4 % oil content in maize kernel. However, more than 6–7 % oil is reported in high-oil corn genotypes. High-oil lines, in general, have reduced kernel yield. A combination of conventional breeding methods, marker-assisted selection and transgenic approach would help in developing high-yielding genotypes with enhanced oil content in maize.During the year 2020-21, over the globe, it is cultivated in about 201.98 m ha area with production of about 1162.35 mt and productivity of 5750 kg/ha. In India, during 2020-21, it occupies area of about 9.89 m ha, with production of about 31.65mt and productivity of 3199 kg/ha [https://iimr.icar.gov.in]. During 2020-21, in Gujarat, it was cultivated in about 3.91 Lakh ha area and with 8.16 Lakh tonnes of production it had 2080 kg/ha of productivity [https://dag.gujarat.gov.in].

Factors Affecting Oil Content:- 1.Size of Germ 2. Positionof Kernels 3. Size of Kernel 4. Incomplete pollination

Various oil content measuring methods are: 1.Soxhlet Method 2. NMR Spectroscopy 3. Nuclear Infra-red Reflectance

Genetic Studies:

- **Conventional /Traditional Approaches**:- 1) Variability 2)Correlationcoefficient 3) Heterosis and Combining abilities 4) Gene Action
- **Non-Conventional / Non – Traditional Approaches: -**_Marker Assisted Selection 2. QTL Mapping

Case Studies

Conventional /Traditional Approaches:-

Bisen*et al.* (2017)conducted an experiment in *Rabi*-2014 using45 F_{1s}(derived from half diallel mating design), 10 inbreds and four checks *viz.,*Pratap QPM Hybrid- 1, Vivek QPM- 9, HQPM- 1 and HQPM-5 for oil content, kernel yield.They found thatgenotypes, parents, crosses and parents*vs* crosses differed significantlyfor oil content as well as grain yield/plant. This indicates the presence of variability for oil content and thus provides better scope for selection of high oil types. Among 10 parents, EIQ-112 and EIQ-109 recorded significant desirable GCA effect for oil content (0.36 & 0.15 respectively) as well as grain yield/plant (10.46 & 8.89 respectively). So these parents can be used in further breeding programme to enhance oil content and grain yield simultaneously.Ratio of σ^2gca /σ^2sca was less than one for both the traits thus suggesting the involvement of non additive gene action in the inheritance of these traits.

While evaluating parents and hybrids (generated by 6 lines and 2 testers), **Darshan and Marker(2019)**reported that genotypes, parents, parents *vs* crosses and crosses differed significantly for oil content and grain yield/plant.CrossDMR-N21 X IC-31890identified as best cross as it recorded highest Economic Heterosis (24.8%) together with significantly early maturity (-8.06%) also. General Combining Ability analysis revealed that among 8 parents,for oil content 3 parents (DMR-N21, TSK-194 and EIQ-109)while for grain yield/plant 2 parents (LM 13 &DMR-N21) recorded significant and desirable GCA effect. DMR-N21had significant desirable GCA effect for both the oil content and grain yield/plant. This indicates that genotype/s available in maize that have capacity to produce superior hybrids/genotypes in breeding programme.

Orhun and Korkut (2011) studiedcorrelation coefficientsamong fatty acids and oil contentusing28 F_{1s} obtained by 8x8 half diallel. The results showed positive correlations between most traits and it also reflected that oleic acid has the most positive correlation with the oilcontent.

Soni*et al.* (2014) conducted an experiment involving 10 inbreds and 45 hybridsthat are generated by half diallel mating design. They revealed that crosses I-07-43-7-3 x I-07-35-7-3 and I-07-44-4-3 x I-07-42-6-3registered highly significant and desirable Relative Heterosis, Heterobeltiosisand Economic Heterosis for bothoil content as well as grain yield /plant. They found that sca variance is higher thangca variance. Ratio of σ^2gca /σ^2sca was less than one for both that traits *viz*; oil content and grain yield/plant. This indicates the presence of non-additive gene action in the inheritance of these traits. Under such condition, hybrid breeding is most suited.

Non-Conventional / Non – Traditional Approaches:-

Hao*et al.* (2014) transferred major QTL'qho6' for oil content through back cross breeding (using Marker Assisted Selection) into both the parents (Chang7-2&Zheng58) of Hybrid (Zhengdan958). The resultant hybrids (with qtl and without qtl) were evaluated at five different locations of china for two years *viz;* 2011 & 2012. Hybrid with qtl*i.e.*Zhengdan958-qHO6 recorded 0.62% to 0.79% more oil content at all the locations over non qtl hybrid *i.e.*Zhengdan958 both the year. They also recorded grain yield and found that grain yield was at par in both hybrids.

Shen *et al.* (2010) identified two genes*viz;* ZmWRI1a and ZmWRI1b in maize for high oil contentwhich are express in embryo and exhibit peak performance durng kernel maturity. ZmWRI1a is induced by ZmLEC1. Transcriptomic analysis of ZmWRI1a gene lines over expressing led to the identification of target genes of ZmWRI1a involved in late glycolysis and fatty acid metabolism that was responsible for increase oil content in maize up to 4.8%.

Conclusions

Efforts directed toward increasing oil content in maize kernels through breeding have been successful.

Variation observed for oil content in maize genotypes thus facilitating the further identification of high oil genotypes, correlation studies help in selection of trait/s for increasing oil content.

Presence of heterosis for oil content help in enhancing oil recovery in hybrids.

Oil content is mostlygovern by non additive gene action.

Major QTL *viz;*qHO6 and Genes *viz;* ZmWRI1a and ZmWRI1b are identified for high oil content.

Integration of both conventional and non-conventional approaches help in developing maize genotypes having high oil content.

Future Thrusts

- Large scale screening of maize genotypes should be practiced for oil content.
- To enhance the value of maize oil in term of consumer preference and industrial uses, efforts should be made to improve oil quality.
- Non-conventional approaches like marker assisted selection together with other biotechnological approaches should be utilized for speedy increasing oil content in maize.

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9. POST HARVEST TECHNOLOGY

Existence and Application of Polyamines in Plants

[1]Aresh Jinnamu and [2] Nagarathna S.B

1 Ph.D. Scholar, Discipline Post Harvest Technology, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal – 736165 2 Ph.D. Scholar, Department of Processing and Food Engineering, CTAE, MPUAT, Udaipur, Rajasthan- 313001

Plants are living resources that undergo different metabolic processes, such as respiration and transpiration, making them a perishable commodity. Preservatives and chemicals normally used to improve their shelf life may contribute to adverse effects on humans. One of the several solutions could be to overcome the use of naturally derived products from these problems. Among them, the most useful isThe use of polyamines, which are considered healthy, without altering the product quality. Polyamines are biological compounds that are ubiquitous in nature with hydrocarbon chains of aliphatic nitrogen groups with two or more main amino groups. Range between micromolar concentrations and millimolar concentrations. They have various levels of amines, ranging from diamines to tetraamines to triamines.These are common in living organisms, occurring in actively proliferating cells at a high concentration. They exist either in free form or as conjugates attached to phenolic acids and other compounds of low molecular weight or to macromolecules such as proteins and nucleic acids. As such, they induce DNA replication, transcription and translation.It is due to their cationic nature to their biological activity. They are involved in different physiological functions that encourage development and growth (Takashashi and Kakehi, 2010).

History of Polyamines

Polyamines are about two hundred years older than nucleic acids in their history. In 1678, Antonie van Leeuwenhoek discovered crystalline substances in human semen using his rudimentary microscope. In 1791, Vauquelin stated that the crystals were phosphate derivatives of a new compound that was unknown. Schreiner described the new compound as an organic base in 1878. Ladenburg and Abel gave the name “spermine” in 1888. In 1911, Ciamician and Ravenna discovered diamine putresine in Daturastramonium for the first time in plants. Herbst and Snell discovered putrescine in 1948 in orange juice. In 1924, the right structure awaited by Rosenheim's work.

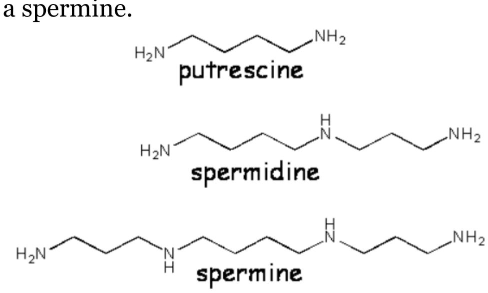
Polyamines are present in three main types, namely putrescine, spermidine, and spermine. Putrescine is graded as diamine among them, whereas the other two are regarded as higher polyamines. The intensity of the amines that gradually increase from putrescine to spermidine and spermineis based on this classification. These are present in all living organisms and are accountable for various roles. The biological workings of all of them are identical. These take place in various ways, i.e. free life, conjugated and titers (Tang et al. 2004). They are found in plants in fractions of the cell wall, vacuoles, mitochondria, and chloroplast.In apical shoots and meristems prior to flowering and flower parts of several plants, high levels of endogenous PAs and their conjugates have also been found.

Structure of polyamines:

Putrescine is a four-carbon alkane-diamine formed by putrefaction from the decarboxylation of arginine and ornithine. Putrescine is a solid compound belonging to the polyamines. These are compounds containing more than one amine group. putrescine bind to periplasmic protein, ornithine decarboxylase, and S-adenosylmethionine decarboxylase proenzyme.

Spermidine is a triamine formed from putrescine. It is found in almost all tissues in association with nucleic acids. It is found as a cation at all pH values, and is thought to help stabilize some membranes and nucleic acid structures. It is a precursor of spermine,a triamine that is the 1,5,10-triaza derivative of decane.

Spermine is a polyazaalkane that is tetradecane in which the carbons at positions 1, 5, 10 and 14 are replaced by nitrogens. Spermine has a broad range actions on cellular metabolism. It has a role as an antioxidant, an immunosuppressive agent and a fundamental metabolite. It is a polyazaalkane and a tetramine. It is a conjugate base of a spermine.



Method of application

Polyamines can be applied on fruits in 3 different methods. They are immersion or dip method, vacuum infiltration method and spraying method.

A. Immersion method

In this method fruits are dipped in 1mm standard solution. The standard solution is prepared by calculating the molecular weight of the compound and dissolving it in the 1 liter of water thus gives 1mm solution.

B. Vacuum infiltration

Solution is feed into the vacuum pump and fruits are kept in container where the polyamines solution will be infiltrated on the fruits.

C. Spraying

The solution will be used in sprayer and its used for spraying of on fruits on largescale for outdoor foliar spray.

Conclusion

PAs are positively charged nitrogenous compounds derived from amino acids. The commonly used PAs are putrescine (PUT), spermidine (SPD) and spermine (SPM).PAs are helpful in horticulture by way of their positive effects on flowering, improving fruit set, fruit retention, fruit quality, reducing mechanical damage, enhancing shelf life of fruits and protecting the plants against stress conditions. In the case of post-harvest technology, the usual method of application to crops is foliar spray and pressure infiltration.

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10. GENETICS AND PLANT BREEDING

Molecular Approaches of Crop Improvement: Male Sterility

Deepayan Roy[1]

PhD Research Scholar, Department of Genetics and Plant Breeding, GBPUAT, Pantnagar-263145

Introduction

Male sterility is literally the absence of functional pollen grains in otherwise hermaphrodite flowers. Male sterility is of great value in experimental populations particularly in the production of hybrid seed. It was 1st reported by Kölreuter in 1763. T-Cytoplasm in Maize is one of the classical model System (cms-T)- this mutant cytoplasm was first described in the Golden June line in Texas and was Commercially utilized and during 1970's and about 85% of maize hybrids in U.S. was based on T-cytoplasm. It was characterized by failure of anther exertion and pollen development. Male Sterility is due to T-Urf-13 gene (chimaeric) ; T-Urf-13 gene is a unique sequence which produces a 13 kD polypeptide not produced in normal cytoplasm. Responsible for the CMS. But the system suffered from disease susceptibility in maize, hence new systems are sought for to bring about improvement in crops through hybrid breeding utilisinggenetic engineering to get the elixir of male sterility.

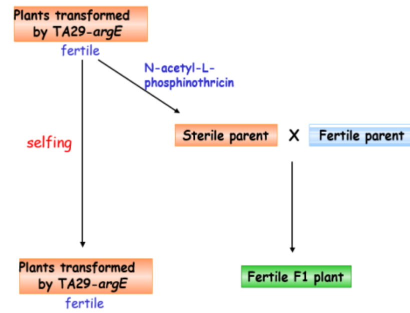
Classical examples of Genetic Engineering for Male sterility

Barnase- Barstar system Of Male Sterility

A bacterial protein having ribonuclease activity named *Barnase*, which is produced by the bacterium *Bacillusamyloliquefaciens*is lethal to the cells. These barnase gene is expressed in the plant cell using a tapetum-specific TA29 promoter where the lethality of the gene leads to degradation of the tapetum and thus causing hindrance to normal pollen production and rendering the plant to be male sterile. The lethal gene can be neutralized by the effect of *Barstar* gene to regain fertility. This mechanism is used for crop improvement commercially in crops like canola and maize.**(Marianiet *al.* 1990, 1992)**

Deacetylase System Of Male Sterility

In this system, the tapetum is induced to be disrupted by the mechanism of deacetylation of the non-toxic compound N-acetyl-L-phosphinothricin. Here plants are transformed with TA29-argE promoter (argE codes for N-acetyl-L-ornithine deacetylase), such transformed plants on application of N-acetyl-L-phosphinothricin produced male sterile plants but in the absence of such treatment plants are completely fertile. So, this system is relatively easier to be used in hybrid breeding programmes.**(Kriete G. *et al.*, 1996)**

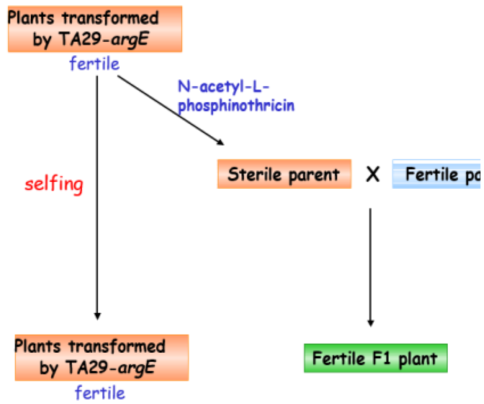


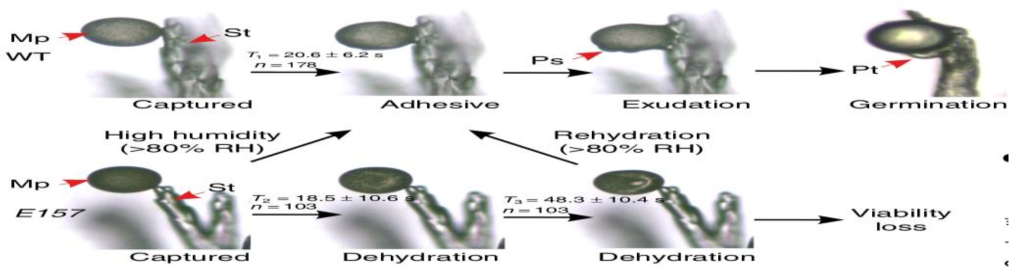
Two-component System of Engineering Male-sterility

Instability of male sterile lines and absence of restorer systems have always been an issue and in order to tackle such problem the two component system has been devised where the RNAse (*Barnase gene)* has been cleaved into two components both driven by the tapetum specific TA29 promoter namely- 'Bn-5' and 'Bn-3'. When the two complementary component comes together in a plant they lead to male sterility but on crossing to a inbred inorder to produce hybrids the two components segregate in the progeny and thus produces viable hybrids, thus addressing the issue of unavailability of good restorers. **(Burgess DG. *et al.*, 2002)**

Engineering CMS via Chloroplast Genome

Here, in case of normal pathway Acetyl-CoA is converted to malonyl-CoA with the help of the enzyme Acetyl-CoA carboxylase and the plant is normal in terms of its fertility. This normal pathway is engineered by using*phaA* genewhich was expressed through the chloroplast genome. This engineered gene in a transgenic plant led to hyperexpression of beta-ketothiolase in anthers which then produces AcetoAcetyl-CoA instead of malonyl-CoA and led to male sterile plants. And fertility of such plants can be restored by continuous illumination. **(Ruiz O. *et al.*, 2005)**





Novel male sterile systems: Humidity-sensitive genic male sterility

Temperature and photoperiod are highly fluctuating environmental factors and so relative humidity which suffered from considerably low fluctuations is looked for to be utilized as an alternative to TGMS and PGMS. In principle, a plant lacking the triterpene synthase gene namely- *OsOSC12*has deformities in pollen due to no pollen coat formation. So, pollen grains of such mutants undergoes dehydration at normal/low humidity areas due to no pollen wall i.e., OsOSC12-defective mutants plants are male sterile at low relative humidity (RH < 60%), but fully male fertile at high relative humidity (>80%). These principle of Humidity-sensitive genic male sterility (HGMS) is being developed in rice in china.**(Zheyong X. *et al.*,2018)**

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11. CROP PHYSIOLOGY

High Temperature Tolerance Studies through TIR Approach

Surekha S., Umesh Babu B S. Afsanabanu Manik and Manjunath S

Ph.D. Research Scholar, $_1$ Department of Crop physiology, $_2$ Department of Genetics & Plant Breeding & $_3$ Department of Seed science & technology UASR, Raichur, Karnataka-584104

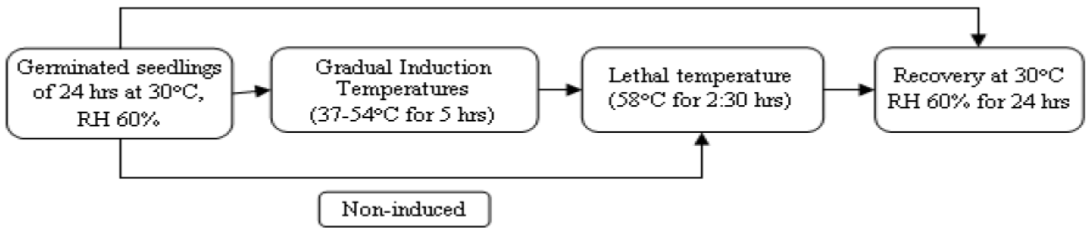
Temperature is an important environmental factor that determines the growth and development of crops in the tropical and subtropical region. In the absence of other biotic and abiotic constraints, plant growth and subsequent yield is maximum when grown as close to its temperature optimum as possible. The day temperatures to which the plants are exposed in many tropical areas are often above their optimal growth temperature and a small increase above optimum has a large effect on growth rate (Howarth 1996). Prevalence of high temperature is the major limitation for the cultivation of crops in tropical conditions. To increase the productivity and to stabilize production in the ever changing environment, development of genotypes that are capable to survive better under high temperature stress is paramount vital and inevitable.

There are some of the techniques to induce acquired thermotolerance in plants along with some of the avoidance mechanisms. The acquired thermotolerance is a complex trait and dependent on many attributes. Thermotolerance is one of the various acquired stress tolerance phenomenons observed in all living organisms, when the stress is imposed gradually. Based on this fact a very efficient technique termed as Temperature Induction Response (TIR) technique has been developed to identify and select the thermotolerant genotypes. It involves exposing seedlings or seeds to induction stress and subsequently challenging with severe temperature and selecting the surviving seedlings at the end of a recovery period. (Venkatachalayya *et al.,* 2001)

One of the approach is to improve thermotolerance is through various screening techniques based on specific physiological parameters such as single leaf photosynthetic capacity, quantification of chlorophyll fluorescence under stress are being used to screen thermotolerance at field level and other approach to improve thermotolerance at lab conditions, from this perspective a protocol called temperature induction response (TIR) have been developed and standardized for several crops. Temperature induction response (TIR) technique has been standardized to identify thermotolerant genotypes.

The standardization through this technique is usually followed through this procedure i.e 70% imbibed seeds or the seeds which are ready to germinate are prepared and then the seeds are exposed to graded temperature for a specific period of time and the seeds are allowed to recovery at 32°C 65% RH and later after the recovery the seeds are allowed to germinate in the germination paper and the seedling survival, seedling growth and seedling vigour index has been measured and the temperature in which the there is maximum seedling survival, seedling vigour index and less reduction with seedling growth is considered as an sub optimum induction temperature and the temperature in which there is more than 90% seedling mortality and less than 50% seedling survival is considered as an lethal temperature and lethal dosage temperature respectively.

Similarly the standardization is also followed for the seedlings where the seeds were sown in an aluminum trays of 5mm in size and then the trays were watered with a known quantity of water at an interval of one day and then the seeds were allowed to germination and grow at an height of 10 to 15 cms or 5 to 6 leaflets stages and at this time the aluminum trays were exposed to graded temperature for a specific period of time and the seedlings are allowed to recovery at 32°C 65% RH and later after the recovery the temperature in which the there is maximum seedling survival, seedling vigour index and less reduction with seedling growth is considered as an sub optimum induction temperature and the temperature in which there is more than 90% seedling mortality and less than 50% seedling survival is considered as an lethal temperature and lethal dosage temperature respectively. (Raghavendra *et al.,* 2017)



The accuracy of the TIR technique depends on optimum induction cycle and lethal temperature. The standardization of induction temperature and lethal temperature is based on percent growth reduction and survival percentage of the seedlings at the end of recovery period.

Through this technique we can standardize the lethal, lethal dose 50 and sub optimum temperature based on this standardization it will be very beneficial and useful to the researchers and breeders in order to minimize or reduce the time in selection or determination of thermotolerant genotypes in many of the crop species. The major benefits of this technique is the time consuming process, more amount of skilled labours is not essential, huge number of genotypes can be screened at once within a short period of time, identifying tolerant lines from segregating populations and subsequently developing tolerant progenies. This technique as been standardized in many of the agricultural and horticultural crops such as fingermillet (Venkatesh *et al.,* 2013), rice (Sudhakar *et al.,* 2012), pearl millet (Ravi *et al.,* 2015)etc..

The TIR technique is a robust and constructive technique to identify genetic variability at cellular level within a short period of time and it is suitable for screening a large number of genotypes. This technique can be very useful to the breeders for determining the potential donar parents for obtaining thermotolerant varieties.

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12. HORTICULTURE

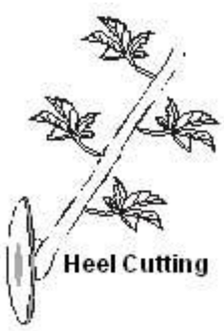
Greenhouse Technology for Plant Propagation and Production

Venugopala Reddy, M.

Department of Horticulture,University of Agricultural Sciences, GKVK, Bangalore-560065

Plant propagation is the process of creating new plants from a variety of sources: seeds, cuttings, bulbs and other plant parts. Plant propagation can also refer to the artificial or natural dispersal of plants. Plants can be propagated by two methods, namely – sexual and assexual.

1. **Sexual Propagation:** Seed formation takes place only after pollination. After fertilization, seeds are formed. Seeds when sown give rise to new plants.
2. **Assexual Propagation:** This process is also called as vegetative propagation. Stem cuttings, root cuttings, leaf cuttings, root division, layering, grafting and budding are all vegetative methods of propagation.

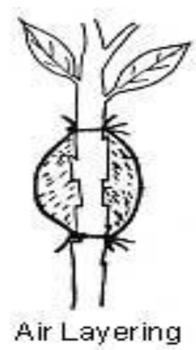


a. **Stem Cuttings:** Herbaceous stem cuttings of plants like Dahlia, Mint, Portulaca etc. easily root. They do not need any special treatment. In herbaceous plants tender, growing and leafy sections make better plants. Semi-hard cuttings like Schefflera, Aralia, Philodendrons, Hibiscus can be easily rooted. Hardwood cuttings of Bougainvillea, Ixora etc. can be rooted with good amount of success if root promoting hormones are used. These hormones – normally available in powder form – are applied on the lower end of the cutting.

b. **Root Cuttings:** Some plants like Breadfruit, Curry patta, White Poinsettia and some Jasmines and Ixora can be propagated with root cuttings. Roots of such plants if cut at the plant end and the cut tip of the root if exposed to air will start growing in to a new plant.

c. **Leaf Cuttings:** Entire leaves removed from many succulents and kept in moist sandy medium will sprout plantlets. Echeveria, Kalanchoe, and Sedum are such plants. Herbaceous plants like African violets, Begonia Rex, Peperomia also can be propagated through leaf cutting. Sansevieria, Gasteria and Drimiopsis also can be propagated through entire leaf or by planting leaf sections.

d. **Root Division:** Bamboo, Asparagus and Gerbera plants grow in clumps. This clump can be divided into sections, with each section having some roots. The sections are then planted as separate plants.



e. **Air Layering:** Plants which cannot be propagated with any of the above mentioned methods may respond to layering. Layering actually is a type of stem cutting only. But the difference between the two is that in normal stem cutting the stems are cut away from the mother plant and then they are forced to root. In layering, first the roots are formed on a stem of a mother plant and only after that the stem is cut off and is planted as a new plant. Plants grown from layering will fruit earlier than the ones grown from seeds. Mature or semi-mature branches are selected for layering, depending upon the species.

f. **Stooling :** Stooling is a type of air layering only. In this method the branch from which the ring of bark has been removed, is bent down and the portion of the stem from where the bark was removed is inserted in the ground. A stone is kept on the soil to prevent the branch from springing out of soil. After the roots are formed, the branch is cut off from the plant end. The newly rooted branch then is replanted.

g. **Grafting:** Mango, ChikooAnd Golden Champa are available mostly as grafted plants. These days even Cashew, Jackfruit AndJamun plants are being successfully being grafted. Decorative plants such as hybrid red Mussaenda and cactus plants too are available as grafts. "Stock" is a rooted plant upon which a branch of a desired variety of the plant is grafted. The branch, which is being grafted, is called as "scion". Grafting is done on a stock plant, which has a very strong root system. Chikoo plant is always grafted on a sapling of Rayan (also called as Khirni) tree. Following are some important methods of grafting like Wedge grafting, Side grafting, Veneer grafting, Approach grafting (inarching) and Butt grafting (used for grafting cacti plants).

h. **Budding:** Budding, actually, is a type of grafting only. Howerver, in budding, the scion is in a section of shield-shaped skin along with an eye (lateral axillary bud, not a flower bud). On the stock a "T" shaped cut is given. The skin is opened and the bud is inserted inside the skin. After this, the cut is covered by winding a strip of polythene sheet, keeping only the bud exposed. The growing tip of the stock then is severed. Growth of the grafted bud starts within 15 days. Rose, Bougainvillea, limes and other citrus plants, Hibiscus, Ber can be budded.

Plant tissue culture is a collection of techniques used to maintain or grow plant cells, tissues or organs under sterile conditions on a nutrient culture medium of known composition. Plant tissue culture is widely used to produce clones of a plant in a method known as micro-propagation. Different techniques in plant tissue culture may offer certain advantages over traditional methods of propagation, including:

- The production of exact number of plants that produce particularly good flowers, fruits, or have other desirable traits.
- To quickly produce mature plants.
- The production of multiples of plants in the absence of seeds or necessary pollinators to produce seeds.
- The regeneration of whole plants from plant cells that have been genetically modified.
- The production of plants in sterile containers that allows them to be moved with greatly reduced chances of transmitting diseases, pests, and pathogens.
- The production of plants from seeds that otherwise have very low chances of germinating and growing, *i.e.*:orchids and *Nepenthes*.
- To clean particular plants of viral and other infections and to quickly multiply these plants as 'cleaned stock' for horticulture and agriculture.

Plant tissue culture relies on the fact that many plant cells have the ability to regenerate a whole plant (tot-potency). Single cells, plant cells without cell walls (protoplasts), pieces of leaves, stems or roots can often be used to generate a new plant on culture media given the required nutrients and plant hormones.

Applications

Plant tissue culture is used widely in the plant sciences, forestry and in horticulture.

Applications include

- The commercial production of plants used as potting, landscape, and florist subjects, which uses mere-stem and shoot culture to produce large numbers of identical individuals.

- To conserve rare or endangered plant species.
- A plant breeder may use tissue culture to screen cells rather than plants for advantageous characters, e.g. herbicide resistance/tolerance.
- Large-scale growth of plant cells in liquid culture in bioreactors for production of valuable compounds, like plant-derived secondary metabolites and recombinant proteins used as biopharmaceuticals.
- To cross distantly related species by protoplast fusion and regeneration of the novel hybrid.
- To rapidly study the molecular basis for physiological, biochemical, and reproductive mechanisms in plants, for example in vitro selection for stress tolerant plants, and in vitro flowering studies.
- To cross-pollinate distantly related species and then tissue culture the resulting embryo which would otherwise normally die (Embryo Rescue)?
- For chromosome doubling and induction of polyploidy, for example doubled haploids, tetraploids, and other forms of polyploids. This is usually achieved by application of antimitotic agents such as colchicine or oryzalin.
- As a tissue for transformation, followed by either short-term testing of genetic constructs or regeneration of transgenic plants.
- Certain techniques such as meristem tip culture can be used to produce clean plant material from viruses stock, such as potatoes and many species of soft fruit.
- Production of identical sterile hybrid species can be obtained

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