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1. AGRICULTURAL SCIENCES

Importance of Drone in Agriculture

C.Sharmila Rahale

Assistant Professor (SS&AC), Department of Nano Science & Technology, TNAU, Coimbatore

Agricultural drone technology has been rising within the previous number of years, and also the edges of drones in agriculture are getting additional apparent to farmers. Drone applications in agriculture vary from mapping and measurement to crop dusting and spraying. On the surface, agricultural drones aren't any different than other kinds of drones.There are, however, several drones specifically made for agricultural use.

Agricultural Drone Technology

There are several ways within which drones help farmers with agricultural challenges:

1. **Soil and field monitoring**: Drones could also be used for soil and field analysis for irrigation, fertilisation and planting activities including checking nutrient levels, moisture concentrations, and erosion among others. All of this information is also pretty useful to figure out the foremost effective planting patterns, as well as, improved crop management. Drones may be sued to identify and monitor water resources more effectively across the fields.
2. **Crop Governing**: Drones can perform continuous and consistent crop surveillance which can trigger actions to mitigate the effect of assorted biotic and abiotic stresses on crops. the data generated through such surveillance can help site-specific agronomy to optimise the employment of inputs and promote sustainable farming.
3. **Crop protection:** Drones are capable of spraying precise amounts of insect, weed and disease control products in an exceedingly way which will ensure correct dosage, minimise accidental exposure to applicators and improve the overall effectiveness of the products and then outcomes of growers.
4. **Productivity:** Drones can significantly alleviate labour pressure on agricultural operations like applying pesticides or fertilizers, while enhancing the crop coverage area per day. this might provide significant simple farming for farmers, who can use the time saved to carry out other activities, while responding quickly to biotic challenges.
5. **Seed Planting:** Seed planting using drone technology could also be a comparatively new technology as compared to other drones applications in agriculture. However, startup companies are testing the technology for faster and more practical seed plantations.
6. **Mapping/Surveying**: the strategy of employing a drone to map or survey crops can be a comparatively straightforward one. more recent agricultural drone models come equipped with flight planning software that permits the user to draw around the area he or she must cover. Then, the software makes an automatic flight path and, in some cases, even prepares the camera shots. because the drone flies, it automatically takes pictures using onboard sensors and so the built-in camera, and uses GPS to determine when to want each shot. But if your drone doesn't have these automatic features, then one person must fly the drone while the other takes the photos.
7. **Solar Pannels Inspection**: Farms across the world are switching to renewable energy sources like solar panels to satisfy their energy needs. By installing large solar farms for agricultural practices, farmers not only ensure an analogous power supply but also significantly reduce the energy expenses.AI-powered drones could also be accustomed significantly reduce the time and price

required for inspection of solar panels . The farming drones are going to be used for normal monitoring of the solar panels and assess any potential defects within the grid before it jeopardizes the full system.

8. **Livestock Monitoring**: The drones within the agriculture industry are widely employed by farmers for effective livestock management. AI-backed programmable drones are perfect tools to automate the monitoring of livestock at the fraction of the value. These drones are accustomed keep track of the livestock, as well as, to identify any injured or missing livestock. It can also be accustomed identify pastures across vast swaths of lands and could be pre-programmed to continue tracking the livestock across the pasture.

Some farming drone manufacturing companies are testing the payload efficiency of drones in variety of tree seeds, fertilizers, water, and herbicide to assess the cost-effectiveness of the technology. Once it gets passed the testing phase, drones would further strengthen the effectiveness and efficiency of the agriculture industry by making it much easier to plant seeds and deliver other required elements to the soil.

Advantages of Drone application in Agriculture

- Efficient Agriculture Practice
- Prevents Infestation
- Moisture Monitoring

Disadvantages of Drone application in Agriculture

- Legal Restriction
- Flight Route Limitations
- Knowledge limitations
- Expensive

As mentioned before, agricultural drone technology is undoubtedly the long run of the Indian agrarian community. It can transform traditional farming methods in uncountable ways. Farmers must understand the entire process. Determination of goals, creating equilibrium within the drone and software utilized, and being tuned in to the principles of using such technology will stand as a challenge. The farmers will inevitably need comprehensive training or partnerships with third-party experts within the drone industry for the acquisition of reliable data. Drones have changed the course of obtaining data in almost every form of industry, and may only deem to become bigger and better within the approaching years.

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2. AGRONOMY: ORGANIC FARMING

Organic Farming in India: Present Status and future

S.V. Varshini[1] and S.P. Sangeetha[2]

[1]Senior Research Fellow & [2]Assistant Professor (Agronomy), Department of agronomy, Tamil Nadu Agricultural University, Coimbatore-3

Agriculture plays an important role in Indian economy. Apart from fulfilling the food requirement of the growing Indian population, it also plays a role in improving standard of the farmers. The Green Revolution adoption has increased wide varieties of agricultural crop yield per hectare which increased 12-13% food supply in developing countries (Yadav, 2015) but the soil fertility showed negative impact which can minimized by practicing organic farming.

Organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc.,) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection" (USDA). From the Figure (1) and Table (1) it can be showed that, from 2016 to 2021 the shares of net area in organic farming get increased. It showed positive spread of organic farming among the farmers and consumers in India.

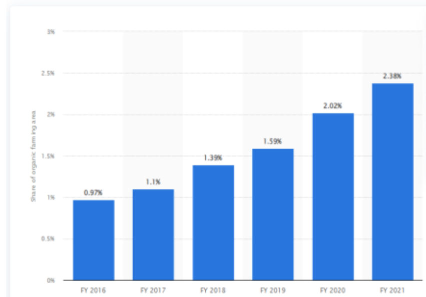
Key characteristics of organic farming

1. Protecting the long term fertility of soils by maintaining organic matter levels through encouraging soil biological activity
2. Providing crop nutrients indirectly using relatively insoluble nutrient sources which are made available to the plant by the action of soil micro-organisms
3. Nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, as well as effective recycling of organic materials including crop residues and livestock manures
4. Weed, disease and pest control relying primarily on crop rotations, natural predators, diversity, organic managing, resistant varieties and limited thermal, biological and chemical intervention
5. Careful attention to the impact of the farming system on the wider environment and the conservation of wildlife and natural habitats (Kalyani and Murugan, 2018).

Problems and Constraints

Lack of awareness, output marketing problems, shortage of bio-mass, marketing problems of organic inputs, low financial support, complex certification procedure, lack in government policies in promoting in organic farming and inability to meet the export demand are the major problems and constraints.

Fig 1. Share of net area under organic farming in India from financial year 2016 to 2021



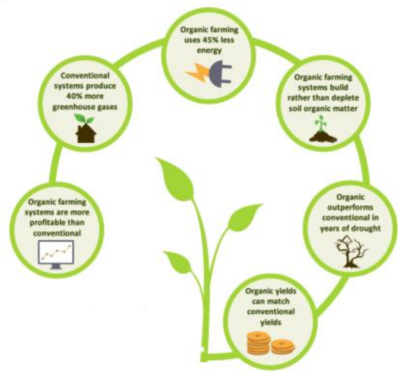


Table 1. Cultivated farm area major states for the Year 2020-21

S. No.	State Name	Organic Area (in ha)	Conversion area (in ha)	Total area (in ha)
1	Madhya Pradesh	540994	479024	1020018
2	Maharashtra	219659	152063	371723
3	Rajasthan	177600	121087	298686
4	Gujarat	72318	75548	147866
5	Karnataka	61116	33934	95050
6	Odisha	78148	14547	92695
7	Sikkim	74647	1082	75730
8	Uttarakhand	31557	43270	74826
9	Uttar Pradesh	53195	14248	67443
10	Jharkhand	0.00	53262	53262
11	Kerala	25657	19414	45070
12	Tamil Nadu	14086	17543	31629
13	Other states	143634	140257	283891
	Total	1492611	1165278	2657889

Source: APEDA (Ministry of commerce and Industry, Government of India)

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3. HORTICULTURE: POST HARVEST TECHNOLOGY

An Overview of Phosphorus Solubilizing Microorganism in inorganic Phosphorus solubilization

Ramaswamy V[1], Sridevi. G[2] and Sivakumar K[3]

[1]PG Scholar, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, [2,3]Assistant professor, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore

Phosphorus is the second most important macro nutrient required by the plants, followed by nitrogen.It constitutes nearly 0.1% of the earth's crust. They occur in soil as both inorganic and organic forms.Inorganic forms are those that are generally derived from parent rocks or through fertilizers application and manuring with bone meal and others. In cultivated soil, the phosphorus present in abundant amount of nearly 1100 $kgha^{-1}$. But most of them are not available to plants, only about 1% of the total phosphorus is in plant uptake form. It has a unique metabolic role in all living systems as it is prominentlyplaying role in the energy reactions of ATP. Phosphate derivatives also are important structural components of nucleic acids, coenzymes, and phospholipids as well as being involved in almost all the significant metabolic pathways pertinent to life.

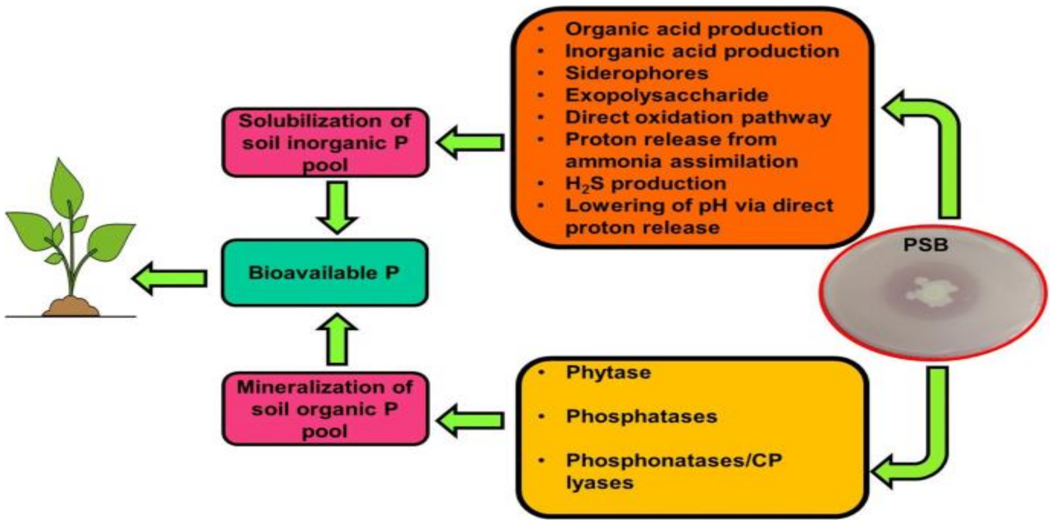
PSM- Phosphorus Solubilizing Microorganism

Phosphorus Solubilizing Microorganisms are the organisms that have the potential to convert insoluble phosphorus into a plant-available form. These are copious in soil, and have their potential for P Solubilization. They are diversified in nature. Bacteria, belonging to the genera Pseudomonas, Enterobacter, and Bacillus, Rhizobium, Arthrobacter, and Burkholderia etc., comes under this category. Fungi like Penicillium brevicompactum, Aspergillus niger, Acremonium, Hymenella are potent Phosphorus Solubilizing Microorganisms. In addition, approximately 20% of actinomycetes could solubilize P, including those in the genera Actinomyces, Micromonospora, and Streptomyces. Algae such as Cyanobacteria have also been reported to show P solubilization activity

Mechanism of InorganicPhosphorus Solubilization

Solubilization of inorganic phosphorus by the phosphorus solubilizing micro-organism was carried out by various mechanisms which are as follows

- Organic acid production
- Inorganic acid production
- H_2S production
- Assimilation
- Indirect mechanism
- Exopolysaccharides
- Siderophores



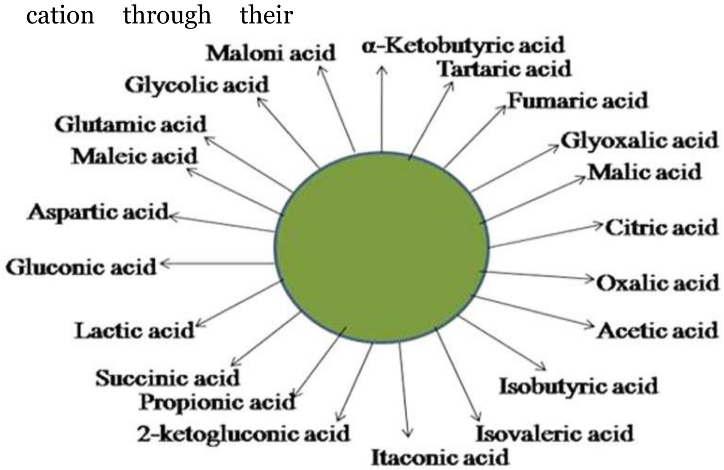
Source: Alori *et al.*, 2017

Production of Organic Acids

Organic acids like citric acid, gluconic acid, oxalic acid, and tartaric acid exuded by Phosphorus Solubilizing Microorganisms solubilize the inorganic phosphates by three different processes. They are

- chelation of cations bound to phosphate,
- reducing pH,
- complexation with metal ions bound to phosphates

Organic acids having low molecular weight compounds that chelate the phosphorus-bound cation through their hydroxyl and carboxyl groups and lower the rhizosphere pH through the gaseous exchange (O_2/CO_2), thereby releasing the bound phosphorus. Fermentation, respiration of organic carbon compounds, or direct oxidation are key metabolic pathways for organic acid production by Phosphorus Solubilizing Microorganisms that result in acidification of microbes, liberating phosphates from complexes by substitution of protons for cations like Fe^{+3} and Al^{+3} or by the exchange of phosphate (PO_4^{2-}) by acidic anions.**2 Keto gluconic acid and gluconic acid** are major acids excreted by Phosphorus Solubilizing Microorganisms



Inorganic Acid

Hydrochloric acid, sulphuric acid, nitric acid, and carbonic acid production by Phosphorus Solubilizing Microorganisms have

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been reported to solubilize phosphate present in the soil. When compared with the organic acids, the efficiency is low.The mechanism of production of inorganic acids like nitric acid and sulphuric acid is adopted by Nitrobacter and Thiobacillus spp**.,** respectively, to dissolve phosphorus.Kim *et al*also reported that the dissolution of phosphorus by HCl was done by reducing pH to the same level as organic acids, but efficiency is lower.

H_2S Production

Acidophilic and Sulphur-oxidizing bacteria produce H_2S as a metabolic byproduct of microbial decomposition of organic matter, sulfate reduction, and other biochemical reactions. This H_2S reacts with ferric phosphate and forms ferrous sulfate, releasing the bound phosphorus. This is reported that the strains producing H_2S exhibited up to 116% higher phosphorus-solubilizing efficiency in inoculated plants of ***Brassica juncea,*** in comparison to uninoculated plants.

Proton Release from NH_4^+ (Assimilation/Respiration)

Proton extrusion is another mode of phosphorus dissolution in soil by microorganisms. When culture filtrate of *Pseudomonas sp***.** was analyzed, they found phosphorus dissolution activity, but no organic acid production exists. Ammonium (NH_4^+) present in soil is assimilated by Phosphorus Solubilizing Microorganisms for synthesis of amino acids.Inside the microbial cell, NH_4^+ is converted to ammonia (NH_3) and the excess proton H^+ is released into the cytoplasm of the microbial cell. This acidifies the medium surrounding the microbial cell which results in proton excretion that lowers the soil pH.This phenomenon is predominant in few microbes only, indicating the prevalence of diverse modes of phosphorus solubilization.

Indirect Mechanism

Rhizospheric microbes assimilate a large amount of phosphorus indirectly from the soil by dissolving insoluble phosphorus. During stress conditions, microbial cell lysis happens which releases this phosphorus into the soil. Hence plantsand other soil organismsutilizes this phosphorus. Investigation showed that soil drying with subsequent fumigation resulted in a decline in microbial biomass phosphorus by 61 and 70%, respectively. This finding proposed the correlation between soil drying, the mortality of microbial cells, and microbial biomass phosphorus, indicating that this indirect mode also contribute the available phosphorus to the soil.

Exo polysaccharides

Exo polysaccharides are homo or hetero polymers of carbohydrates with an organic or inorganic component that is exuded by microorganisms outside their cell wall. This is produced by microbes in response to stress or biofilm formation. Yi *et al.*investigated the ability of Tricalcium phosphate dissolution of four phosphorussolubilizing bacterial strains, i.e**.,** Enterobacter sp. (EnHy-401), Azotobacter sp., Arthrobacter sp., Enterobacter sp. and concluded that the concentration of Exo polysaccharides and microbial origin were responsible for this solubilization.

Siderophore Production

Siderophores are low molecular weight high-affinity iron chelating compounds that are excreted by microorganisms and plants in response to iron stress in the environment.Phosphorus Solubilizing Microorganisms also release siderophores as a strategy to chelate iron from Fe–P complexes in the soil. It was reported that under alkaline conditions, several phosphate solubilizers like Bacillus megaterium, Bacillus subtilis, Rhizobium radiobacterand Pantoea allii produced siderophores which encouraged the survival of organisms under stress environment and also improved phosphorus solubilization

Factors Influencing Microbial Phosphate Solubilization

There are many factors which influences the solubilization of inorganic phosphorus in the soil. Phosphorus Solubilizing Microorganisms which are present in saline alkaline soils, high level nutrient deficiency soil and soil from extreme temperature environments have the tendency to solubilize more phosphate than Phosphorus Solubilizing Microorganisms from soils from moderate conditions.

White et al. (1997) found 20–25^{O}C as the optimum temperature for maximum microbial phosphorus solubilization while 28^{O}C was reported by Kang *et al.* (2002). Other factors influencing microbial phosphate solubilization are interactions with other microorganisms in the soil, the extent of vegetation, ecological conditions, agronomic practices, land use systems, andsoil's physicochemical properties.

In warm, humid conditions, phosphorus solubilized more quickly where as in cold, dry climates it dissolves more slowly. Comparing to a saturated wet soil, a well-aerated soil will readily allow quick phosphorus solubilization. Soil rich in organic matter will encourage microbial development that results in microbial phosphorus solubilization. Soil pH values between 6 and 7.5 are best for P-availability, this is because at pH values below 5.5 and between 7.5 and 8.5 limits P from becoming fixed by aluminum, iron, or calcium, and not being available for plant use.

Conclusion

Therefore, adding phosphate solubilizing microorganisms (PSMs) to the soil is a potential strategy that won't have a detrimental impact on the environment and socio-economic consequences.These microorganisms solubilize the unavailable phosphorus in soil and also restores the nutritional status of soil.Combined application of phosphate solubilizing microorganisms and rock phosphates in the agricultural field is another strategy to improve theuse efficiency of Phosphorus and yield of the crop.Phosphate solubilizing microorganismtechnology can contribute to low-input farming systems and a cleaner environment. However, there is a need to create technologies that are site specific and this should be shared with farmers in a timely manner.

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4. AGRICULTURAL NEMATOLOGY

Integrated Nematode Management (INM) in Solanaceous Vegetables

G Narayana Swamy

SMS (Horticulture) KVK Nellore, Acharya N G Ranga Agricultural University

Vegetable production around the world is being increasingly hampered by the un favourable soil and environmental conditions that include abiotic constraints, as well as biotic ones as soil-borne pests and diseases. Among them Root knot nematode *Meloidogyne* spp. is one of the most important yield limiting constraints in vegetable crops (Kalaiarasan, 2009) causing an estimated yield loss of 5–43% in the tropics and subtropics. Overall, plant-parasitic nematodes cause 19.6 %, an amounting of Rs. 14461.22 million in Vegetable crops. Among the vegetables crops maximum yield losses 23% in Tomato (Rs. 6035.2 million), 21% in brinjal (Rs. 3499.12 million) and 15 % in Chilli (Rs. 744.90 million) (Kumar et al., 2020). In protected cultivation an average yield loss in major horticultural crops due to nematodes goes up to 60%. Hence, the concept of Integrated Nematode Management (INM) gaining importance for management of Root knot nematodes compared to individual approach. INM is not isolated approach from Integrated Pest Management (IPM), rather a component of it.

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1. Objectives of Integrated Nematode management (INM) is
   - To minimize environmental and health hazards.
   - Utilization of several compatible measures.
   - To maximize natural environmental resistance to plant parasitic nematodes.
   - To minimize the use of drastic control measures and also to minimize the input costs.
   - To increase reliance on location specific and resource compatible management strategy.
2. Main components of Integrated Nematode Management: (Manjunatha T., *et al.,* 2017)
   - **Cultural Methods:** Main principles behind cultural practices are (i) Prevention of new area from pest infestations i.e., prevention of infested soil, crop residues, vegetative propagules, human activities and irrigation water. (ii) Reduction of secondary soil inoculum once nematode is infested**.**
     - **Summer Ploughing:** 2 or 3 deep summer ploughings during the hot summer months (May-June) expose the nematodes and infected tissue to solar heat and dehydration. This method reduces the root knot nematode population densities, weeds, soil borne pathogenic fungi and bacteria.
     - **Crop Rotation:** Certain cropping sequences, including non-preferred hosts like sesame, mustard, wheat, maize, etc. are found to suppress the nematode population in vegetable crops. Rotation of non-host crops such as Velvet bean (Mucuna) mustard, garlic, onion and cereals at least for 2 to 3 years in a suitable cropping system helps in minimizing inoculum level of the nematodes.
     - **Antagonistic Crop: Crops** like asparagus (*Asparagus officinalis*), mustard, and African marigold as antagonistic crops in susceptible main crop helps in suppression of root knot nematode population. Growing African marigold (*Tagetes erecta* or *Tagetes patula*) with susceptible crop helps in suppressing root knot nematode population by releasing nematotoxic compounds polyterthienyl (α-terthienyl) through root exudates respectively. Incorporation of *Brassica* spp. such as Indian mustard (*Brassica juncea*) and rapeseed (*B. napus*) as green manures into the soil limits the reproduction of nematodes. After decomposition, they release volatile compound like isothiocyanates produced from glucosinolates, which are highly toxic to root knot nematodes. This process generally termed as bio-fumigation.
     - **Trap Crops:** Trap crops are highly susceptible crops normally grown in root knot nematode infested fields. These crops which allow invasion by root knot nematodes, but do not support their development E.g. *Crotalaria spectabilis*.
     - **Destructions of Crop Residues:** Burning of infected plant debris helps in reducing inoculum densities. Removal of weeds such as *Chenopodium album*, *Solanum nigrum*, *Tithonia rotundifolia* and other unknown weeds are known to be associated with vegetable crops act as alternate hosts for root knot nematodes for the perpetuation of life cycle.

- **Applications of Organic Amendments:** Organic amendments with C: N ratios between 12 and 20 were highly suitable to exhibit high nematicidal activity and even to avoid phytotoxicity on crops. Plant products such as Neem (leaf, seed kernel, seed powders, seed extracts, oil, sawdust, and oilcake) has been extensively used against control of root knot nematodes including other major plant parasitic nematodes. Nematicidal action is due to release of chemical compounds from neem such as salanin, azadirachtin, nimbin, thionemone and various flavonoids. Organic manures i.e., combined application of FYM @ 10 t/ha + poultry manure @ 2.5 t/ha + bio-fertilizers (Rhizobium and Phosphate Solubilizing Bacteria) effectively reduced root knot incidence along with other plant parasitic nematodes at organic farm at ICAR-IIVR, Varanasi.
- **Host Plant Resistance:** Host plant resistance is one of the best environment safe approaches for Root knot nematode management. Resistance sources in Solanaceous vegetables furnished in below table.

Crop	Resistant Variety/Resistant lines
Tomato	SL-120, PNR-7,Hisar Lalit, NT-3, NT12, Pusa Hybrid-2, Arka Vardana
Brinjal	IC-90903, IC-127029, IC-122076,KS-224, IC-127040, *S.seaforthianum*
Chilli	PI322719, PI201234, CM 334, Pusa Jwala, Carolina Cayenne, PM687, PM217

- **Biological Control:** For transplanted vegetable crops such as tomato, brinjal and chilli, nursery beds treated with antagonists (*Trichoderma harzianum*, *Paecilomyces lilacinus* or *Pseudomonas fluorescens*) @ 50g/m^2 area.
- **Physical Methods:**
  - **Steam Sterilization-** Generally used in Protected cultivation.
  - **Soil Solarization:** It is a method of heating moist soil by covering it with 100 gauge Linear Low-Density Polyethylene (LLDPE) clear films were efficient to manage root knot nematode incidence.
- **Chemical Control:** Carbofuran 1kg a.i./ha (33 kg/ha) or Apply Nimitz (Fluensulfone 2% G) @ 1 g/plant before planting or Apply Velumprime (Fluopyram 35%EC) @ 0.3 to 0.5 ml per plant before planting.

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5. AGRICULTURE

Golden Rice: An Application of Genetic Engineering to Eradicate Malnutrition in Human

K. Shamini, R. Nagalakshmi and R. Sangeetha Vishnu Prabha

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Rice is the staple food for more than half of the world's population. It is the first purposefully developed bio-fortified crop to eradicate the vitamin A deficiency in humans. Globally, nearly 124 million children are affected due to the deficiency of vitamin A. It can be rectified through the supply of vitamin A capsules or by developing a crop enriched with beta carotene. Therefore, rice is the staple food crop that is widely consumed by humans and can serve as a means to eradicate vitamin A deficiency. The research started during the 1990's and the concept of golden rice came into existence by the team of Ingo Potrykus and Peter Beyer in 1999. Golden rice is genetically engineered rice developed to biosynthesize beta carotene, which is the precursor of vitamin A. The grain colour of golden rice is yellow. Golden rice possesses three beta-carotene biosynthesis genes which are involved in the production of vitamin A, whereas in golden rice 2, the level of beta-carotene is 23 times higher than in golden rice 1. It increases the vitamin A and carotene levels in humans, thereby reducing the risk of coronary artery disease, cancer, and macular degeneration.

Bio synthetic pathway of beta- carotene in golden rice

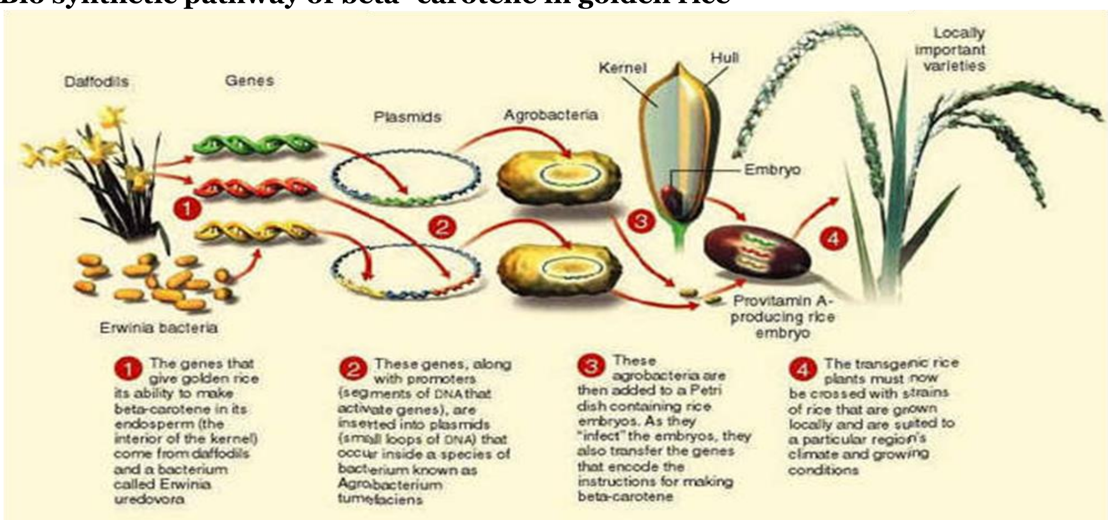

Fig.1: Diagrammatic representation of genetic engineering in rice

Rice endosperm does not naturally contain carotene; instead, it contains geranyl geranyl diphosphate (GGPP), which acts as an early precursor of carotene. Therefore, it is highly essential to combine recombinant genetic engineering to produce beta carotene. To convert geranyl geranyl diphosphate to β-carotene, four additional plant enzymes were needed: phytoene synthase, phytoene desaturase, β-carotene desaturase and lycopene cyclase. These enzymes were identified and their genes were isolated from various plants and bacterium. The phytoene desaturase and β-carotene desaturase were circumvented by using a bacterial enzyme, β-carotene desaturase, that gave the combined result. The entire β-carotene biosynthesis pathway (three genes on three vectors) were nsformed into rice endosperm using Agrobacterium. It was produced by transforming two beta-carotene synthesis genes: *psy* (*Phytoene synthase*) from daffodil (*Narcissus pseudomarcissus*) and *crt I* (*Carotene desaturase*) from a soil bacterium (*Erwinia uredovora*). Through endosperm specific promoter, the above said genes were inserted into rice nuclear genome to express them only in endosperm. The end product of this pathway is lycopene, which is responsible for the red colour. But an endogenous enzyme *lcy* gene inside the plant converts lycopene to beta-carotene giving golden yellow color. SGR 1 is the golden rice which produces 1.6 μg/g of carotenoids.

Fig.2: Biosynthetic pathway of beta carotene in golden riceGolden rice 2

Golden Rice 2

Golden rice 2 was developed by researchers at Syngenta during 2005. In this, the *phytoene synthase* gene from maize combined with *crt1* gene from golden rice. It produces the carotenoids up to 37 μg/g.

Fig.3: The endosperm colour of the grain

Benefits of Golden rice

Golden Rice serves as a source of supplementary vitamin A and β-carotene. The β-carotene linked with reducing risk of coronary artery disease; specific cancers, macular degeneration as well as it act as an antioxidant. It can help to protect the body from destructive free-radical reactions. The major deficiencies include vitamin A, iron, iodine, and vitamin E. Even people in the industrialized nations suffer from vitamin and mineral deficiencies due to poor diets. Therefore, a food staple such as rice, which is widely consumed globally, can serve as a means to address the vitamin A deficiency. Once the Golden Rice has been enhanced and developed, it can be cultivated, grown, and widely dispersed to eliminate vitamin A Deficiency.

Conclusion

Genetic engineering plays an important role in rice, canola seed, and tomato to increase the levels of provitamin A cartenoids in the end food product. Golden rice has been developed which has 1.6 µg of β-carotene /g of dry rice. Golden rice has the most potential to have an impact on vitamin A deficiency globally because rice is a staple food in half of the world's populations.

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6. GENETICS AND PLANT BREEDING

Shovelomics- A Tool for Phenotyping the Hidden Half

Bhimireddy Sukrutha[1]

[1]*Department of Plant Breeding and Genetics, TNAU, Coimbatore, Tamil Nadu, India.*

Introduction:

In order to meet the demand of global increased population in coming future, there is a need to develop high yielding varieties and most importantly to Put Greater Focus on the Modification Root System to Enhance Crop Adaptation and Production. There are several methods to evaluate root under laboratory conditions, but in field conditions SHOVELOMICS is new method for phenotyping roots in field.

Shovelomics for study of root phenotyping was first developed by Treschel *et al* in Maize. It is high throughput phenotyping of root system architecture (RSA) to estimate growth, development and architecture of roots near the base of shoot.

Root System Architecture (RSA):

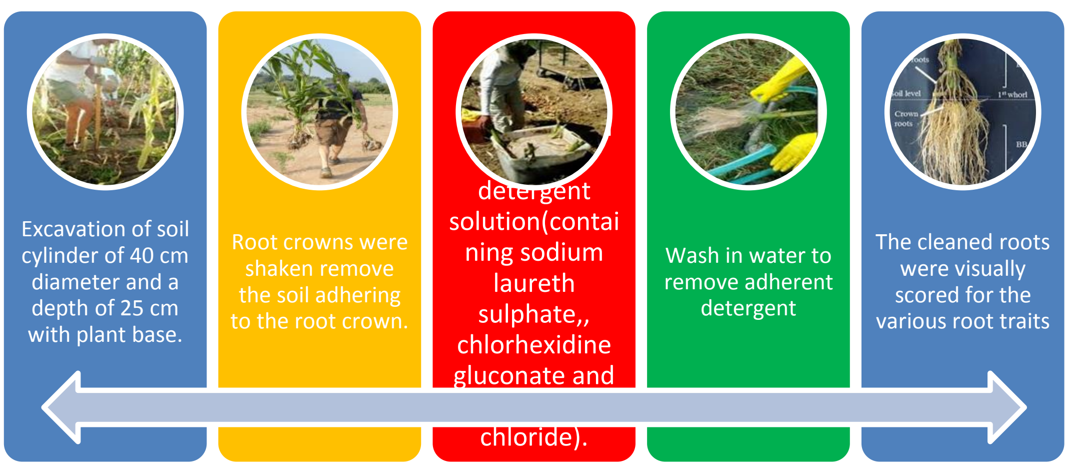
Root system architecture (RSA) is made up of various structural features like root length, spread, number, and length of lateral roots. This exhibits great plasticity in response to environmental changes, and could be critical to developing crops with more efficient roots.

Significance of RSA:

- Supplying water and nutrients
- Acts as food &water storage unit
- Anchoring the plant to soil
- confers to abiotic stress tolerance

Approaches for root phenotyping:

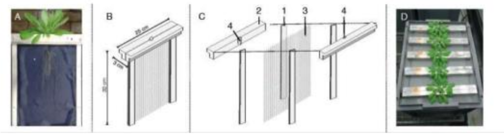
1. **2 D- Phenotyping**



2. **3 D- phenotyping**

In 3D-phenotyping, image of root is carried out by an instrument which gives five root types: primary (pr), embryonic crown (ecr), postembryonic crown (pecr), large lateral (llr), and small lateral (slr) roots that are distinguished easily.

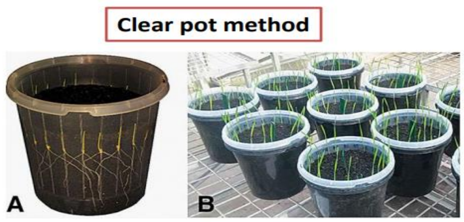
3. **Rhizoponics**



Garcia *et al*. 2015

It Combines hydroponics and rhizotrons. System is made of a nylon fabric supported by an aluminum frame. The set-up is immersed in a tank filled with liquid media. It Allows non-destructive, 2-D imaging of root architecture while simultaneously sampling shoots.

4. **Clear pot Method**



Garcia *et al*. 2015

Uses transparent pots filled with soil or other potting media. Seeds are planted close to the pot wall to enable high-throughput imaging of roots along the clear pot wall. To prevent light exposure, the clear pot is placed in black pots while roots are developing

5. **Minirhizotrons**

A transparent observation tube permanently inserted in the soil. Images of roots growing along the minirhizotron wall at particular locations in the soil profile can be captured over time

Softwares for root phenotyping

- WinRHIZO Tron
- KineRoot
- GiA Roots
- GROWSCREEN-Rhizo
- RootReader3D
- RooTrak

Crops in Which Root Phenotyping Studied

S.No	Crop	Objective of Study	Reference
1.	Wheat	To understand RSA dynamics in the field.	Yinian., et al.2017
2.	Soyabean	Phenotyping of Root traits for drought stress tolerance soyabean.	Lynch., et al.2014
3.	Maize	Developing suitable method for root traits evaluation.	Treschel., et al.2010
4.	Maize	To study the response of different genotypes to low Nitrogen levels	Chantal., et al.2019
5.	barley	Root traits phenotyped for yield improvement	Robinson., et al.2018

Conclusion

Shovelomics is the ideal way of studying various root phenes under various stress conditions in the field.

Different Root phenes can be studied with in less time wherein results in the faster incorporation of genotypes in the breeding programme.

Incorporation of Root phenotyping strategies in root breeding leads to more water and nutrient utlization efficiently, there by sustainability of agricultural systems world wide.

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7. WOMEN EDUCATION

Importance of Education for Women

Sonam Kamboj

Department of English, SJJT University, Jhunjhunu, Rajasthan

Although the world is moving toward gender equality in education, girls still make up a lower percentage of school children than boys. In devolving nations, nearly 20-25 per cent of girls do not attend school specially from families with limited means who can't afford education fees, cost of stationary, uniforms and supplies for all their children's and will prefer education for their sons. Such families also rely on girls for household work, carrying water or woods and childcare, leaving limited time for schooling. But, emphasising girl's education is more important as an educated man goes out to make society better but an educated woman on the other hand whether she stays home or goes out, makes the family and society better place to live in. An educated girl is more likely to postpone marriage, raise a smaller family, have healthier children, and send her own children to school. She has higher potential to earn an income and to participate in political processes. Women's are like root system of plants providing basic support and nutrition to family to face the outer world in more competitive way. Women play immense roles in the society and they are having better understanding of social structure and are more compassionated towards the wellbeing's of others. Therefore, equal opportunities of education for both men and women are must in order to achieve the sustainable development of society. Some of the benefits to educate women/girls are as:

Improved Living Standard

A family relying on double wages is happier and content than a family relying on the income of single parent.

Better Health and Hygiene

Women have a better sense of hygiene and are more concerned about the health of their family than men. So it becomes important that the women who is looking after the family must be educated, so that, she recognizes the health hazards and is confident enough to eliminate them.

Self Respect and Dignity

An uneducated woman may lack the courage to speak for her own dignity while an educated woman will be confident enough to fight for it. It is only when a woman is able to protect her own dignity and honour, that she will be able to protect the dignity and honour of her family.

Self Reliance

Education makes a woman self-reliant; that is, she does not depend on anyone for her own survival as well as the survival of her children. A woman, who is financially independent, can raise her voice against injustice and exploitation.

Eliminating Social Evils

Many of the social evils and crimes against women can be easily eliminated by educating women. Incidents of dowry, flesh trade, female infanticide as well as harmful customary practices can be eradicated by educating women of a society

Better Nursing

An educated woman is more likely to marry later in life improving the chances of survival of the mother and baby. Educated mothers are more aware of their children's needs and nutrition, and take well care of them resulting in a low child mortality rate; providing them better health, hygiene and nutrition.

Sustainable Development

The goals of sustainable developments will be nothing more than mere words without women education and women empowerment. Women must be provided equal opportunities to pursue the professions they aspire.

Exploring the Hidden Potential

Education is important tool to explore the hidden talent or potential of girls. A girl engaged in household works may have the potential to become a doctor, scientist, administrator, athlete etc. if given the right guidance and opportunity to do so.

Conclusion

An educated woman is more likely to fight for women literacy, health, hygiene, self-respect and for the betterment and overall development of society. She is more likely to raise the literacy rate and economy of the nation if proper education is provided to her. Thus, women education is most important for development of any nation.

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8. PLANT PATHOLOGY

Marker-Aided Selection Pyramiding of R Gene

Ravi Regar[1]

[1]*PhD. Scholar, Department of Plant Pathology, S.K.N. College of agriculture, Jobner, Jaipur.*

Introduction

What is a marker?

- Any genetic element which can be readily detected by phenotype, cytological or molecular techniques.
- A marker is a signpost linked to the trait of interest and is co-inherited along with the trait.

Marker types

1. Morphological markers
2. Biochemical markers protein diversity)
3. Molecular Markers/DNA markers

1. Morphological Markers: These are the traditional morphological mutant traits which are mapped and linked to a desirable or undesirable trait in a population which can be used in indirect selection. The major limitations with these markers are; high dependency on environmental factors, undesirable features such as dwarfism or albinism, time consuming. labour intensive and requirement of large plant population (Stuber et al., 1999).

2. Biochemical Markers: Isozymes are used as biochemical markers in plant breeding. Biochemical markers are superior to morphological markers in that they are generally independent of environmental growth conditions. The only problem with isozymes in MAS is that most cultivars (commercial breeds of plants) are genetically very similar and isozymes do not produce a great amount of polymorphism and polymorphism in the protein primary structure may still cause an alteration in protein function or expression.

3. Molecular Markers/DNA Markers: Molecular markers have become important tools for genetic analysis and crop improvement. DNA-Markers, being phenotypically neutral and literally unlimited in number, have allowed scanning of the whole genome and assigning landmarks in high density on every chromosome in many plant species, which makes them fit for indirect selection Narasimhulu, et al. (2013).

Different types of molecular markers have been developed and evolved, including, but not limited to, restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), inter simple sequence repeat (ISSR), microsatellites or simple sequence repeat (SSR), expressed sequence tag (EST), cleaved amplified polymorphic sequence (CAPS), diversity arrays technology (DArT), and single nucleotide polymorphism (SNP) have been used in several crops (Doveri et al. 2008). Each marker system has its own advantages and disadvantages, and the various factors to be considered in selecting one or more of these marker systems have been described (Semagn et al. 2006; Panigrahi, 2011).

Five conditions that characterize a suitable molecular marker are: 1) must be polymorphic, 2) co-dominant inheritance. 3) randomly and frequently distributed throughout the genome, 4) easy and cheap to detect and 5) should be reproducible. PCR-based markers are more attractive for MAS, due to the small amount of template required and more efficient handling of large population sizes. AFLP, RAPD and Sequence tagged site (STS) are dominant markers, which limits its application for differentiation of homozygous and heterozygous individuals in segregating progenies. Among the DNA markers, the most widely used markers in major crops including cereals and legumes are SSRs or microsatellites (Li et al. 2008; Kumar et al. 2011), whereas in oilseed brassicas are RFLPs (Panigrahi et al. 2009). Both SSR and RFLP are highly reproducible, co-dominant in inheritance, relatively simple and cheap to use and generally highly polymorphic.

The only disadvantage of SSRs is that they typically give information about a single locus per assay. This problem has been overcome in many cases by multiplexing several SSR markers in a single reaction (Kalia et al. 2011). STS and SCAR (sequence characterized amplified region) that are derived from specific DNA markers (eg.. RFLPx, RAPDs, etc.) that are linked to a gene or QTL are also extremely useful for MAS (Shan et al 1999, Sanchez et al. 2000; Sharp et al. 2001; Collard and Mackill, 2008; Kumar et al. 2011). In recent years, single nucleotide polymorphisms (SNPs), i.e. single base changes in DNA sequence, have become an increasingly important class of molecular markers. The potential number of SNP markers is very high and micro-array procedures have been developed for automatically scoring hundreds of SNP loci simultaneously at a low cost per sample. Although the use of SNP markers in plants is still in its infancy, SNP markers are expected to become the marker system of choice in the near future, especially as the full sequences of more plant genomes will become availab (Ganal et al. 2009).

Marker Assisted Selection (MAS): The development of DNA (or molecular) markers has irreversibly changed the disciplines of plant genetics and plant breeding. While there are several applications of DNA markers in breeding, the most promising for cultivar development is "marker assisted selection". MAS refer to the use of DNA markers that are tightly-linked to target loci as a substitute for or to assist phenotypic screening. By determining the allele of a DNA marker, plants that possess particular genes or quantitative trait loci (QTLs) may be identified based on their genotype rather than their phenotype. Five main considerations for the use of DNA markers in MAS (Mohler and Singrun, 2004) are;

a Reliability: Molecular markers should co-segregate or tightly linked to traits of interest, preferably less than 5 cM genetic distance. The use of flanking markers or intragenic markers will greatly increase the reliability of the markers to predict phenotype.

b- DNA quantity and quality: Some marker techniques require large amounts and high quality DNA, which may sometimes be difficult to obtain in practice, and this adds to the cost of the procedures.

c- Technical procedure: Molecular markers should have high reproducibility across laboratories and transferability between researchers. The level of simplicity and time required for the technique are critical considerations. High-throughput simple and quick methods are highly desirable.

d- Level of polymorphism: Ideally, the marker should be highly polymorphic in breeding material and it should be co-dominant for differentiation of homozygous and heterozygous individuals in segregating progenies.

e- Cost: Molecular markers should be user-friendly, cheap and easy to use for efficient screening of large populations. The marker assay must be cost-effective in order for MAS to be feasible.

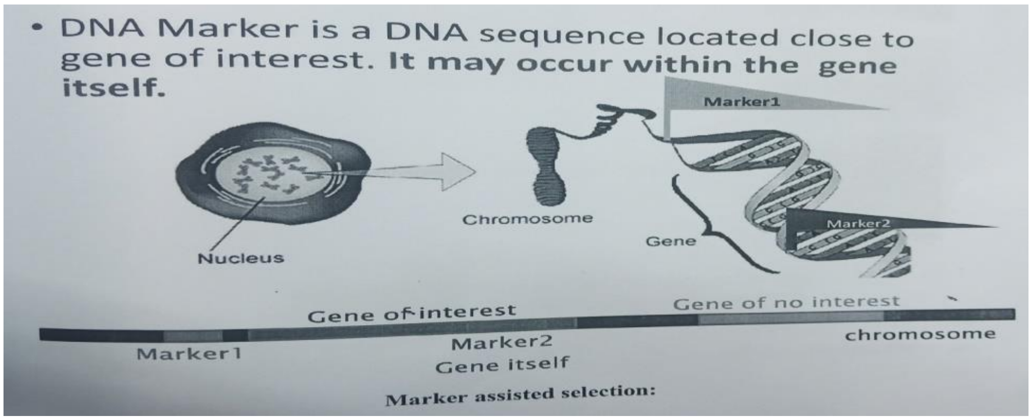
- Heritable DNA sequence differences (polymorphisms)
- Genetic markers are not the target genes but act as signs or flags, they are located close to gene of interest
- Also called as "gene tags"

- DNA markers that is tightly-linked to target loci as a substitute for or to assist phenotypic screening

DNA Marker Illustration

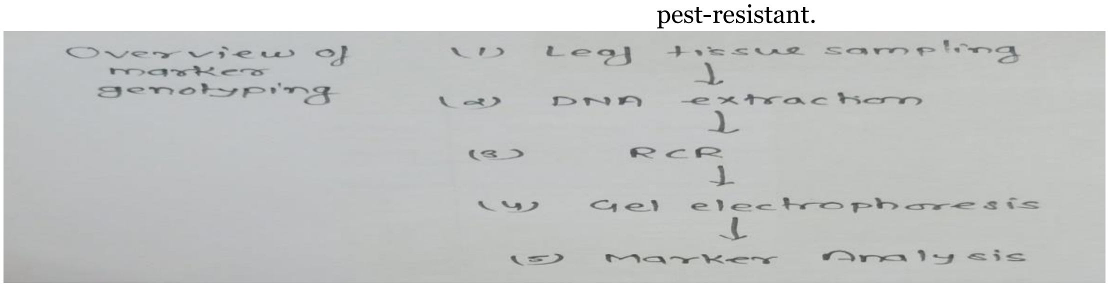
DNA Marker is a DNA sequence located close to gene of interest. It may occur within the gene itself.

- This method is used when the trait of interest is present within the gene pool of the crop of interest
- Transgenic: This method is used when the trait of interest is not present within the gene pool of the crop of interest.



MAS Outcompetes Genetic Engineering

- Three examples of MAS:
- Disease resistance: In rice, 33 genes conferring resistance to bacterial blight have been identified, several varieties already in the hands of farmer.
- Drought tolerance: In 2007, MAS 946-1 became the first drought tolerant aerobic rice • variety released in India.
- Double trouble rice: Saltol for salinity and Subl for submergence
- In contrast, genetic engineering - even after 25 years of global efforts-has basically only delivered two single-trait types of plants: herbicide-tolerant and pest-resistant.

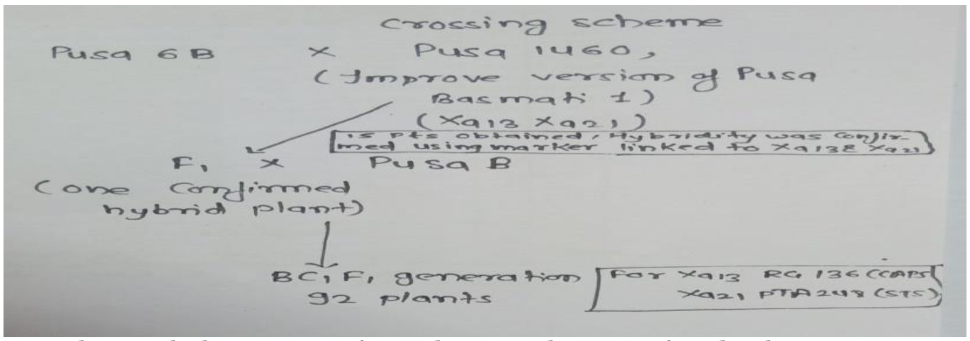


Case Study: Marker aided improvement of pusa 6B, the maintainer parent of rice hybrid Pusa RH10, for resistance to bacterial blight, H. Basavaraj et al. Indian J. Genet., 69(1): 10-16(2009).

MAS Controls Bacterial Leaf Blight in Rice

- Bacterial blight is one of the most destructive rice diseases and can reduce yield by 71 to 80% based on severity of disease (Srinivasan,2005)
- Bacterial leaf blight caused by the pathogen *Xanthomonas oryzae pv oryzae* (*Xoo*)
- Resistance genes have been detected in landraces (eg xa2 and xa5) and in wild rice species (eg, xa21 in O longistaminata) (Pha & Lang 2004).

- So far, 33 genes conferring resistance to different Xoo races have been identified (Cheema et al. 2008)
- PRH10, the world's first superfine grain aromatic rice hybrid
- This hybrid is very popular among the farmers. However, both the parents and the hybrid PRH 10 are susceptible to Bacterial Blight
- Why in B line and why not in R line?
- Pyramiding resistant genes in the restorer lines alone is not enough as the hybrid will have these genes in heterozygous condition, so that the level of resistance imparted will be reduced
- Xal3 is a recessive gene



On analysis with the gene specific markers, 22 plant were found to be carrying xa13 and xa21 genes in BC1F1 heterozygous condition (Foreground Selection)

Marker Assisted Pyramiding: Pyramiding is the process of simultaneously combining multiple genes QTLs together into a single genotype. This is possible through conventional breeding but extremely difficult or impossible at early generations. Using conventional phenotypic selection, individual plants must be phenotypically screened for all traits tested. Therefore, it may be very difficult to assess plants from certain population types (eg. F2) or for traits with destructive bioassays. DNA markers may facilitate selection because DNA marker assays are non destructive and markers for multiple specific genes QTLs can be tested using a single DNA sample without phenotyping. The most widespread application for pyramiding has been for combining multiple disease resistance genes.

In order to pyramid disease resistance genes that have similar phenotypic effects, and for which the matching races are often not available. MAS might even be the only practical method, especially where one gene masks the presence of other genes (Narasimhulu, et al. 2013; Sanchez et al 2000, Walker et al 2002). The Barley Yellow Mosaic Virus (BaYMV) complex as an example is a major threat to winter barley cultivation in Europe. As the disease is caused by various strains of BaYMV and Barley Mild Mosaic Virus (BaMMV), pyramiding resistance genes seems a intelligent strategy. Since, phenotypic selection cannot be carried out due to the lack of differentiating virus strains. Thus, MAS offers promising opportunities. Suitable strategies have been developed for pyramiding genes against the BaYMV complex. What has to be taken into account when applying such strategies in practical breeding is the fact that the pyramiding has to be repeated after each crossing, because the pyramided resistance genes are segregating in the progeny (Werner et al. 2005).

Conclusion

Marker assisted selection can be performed in early segregating populations and at early stages of plant development for pyramiding the resistance genes, with the ultimate goal of producing varieties with durable or multiple disease resistance. Thus, with MAS it is now possible for the breeder to conduct many rounds of selection in a year. Molecular marker technology is now integrated into existing plant breeding programmes all over the world in order to allow researchers to access, transfer and combine gmnes at a faster rate and with a precision not previously possible. However, potential limitations that might restrict the wide application of MAS in breeding were high costs and non-availability of suitable markers but, not as MAS is less efficient compared to phenotypic selection.

On the contrary, especially in breeding of bi- or perennial crops markers were expected to lead to a high efficiency gain. Regarding the impact of MAS on breeding in near future an increase in relevance and application is unanimously expected. New technological developments such as automation, allele-specific diagnostics and diversity array technology will make MAS based gene pyramiding more powerful and effective. Especially the increased application of SNPs and improved technologies for sequencing will contribute to an increasing impact of MAS. The MABC strategies will gain importance and more emphasis is needed on combined selection systems, rather than viewing MAS as a replacement for phenotypic or field selection.

It is also critical that future endeavours in MAS are based upon lessons that have been learnt from past successes and especially failures in using MAS. Further optimization of marker genotyping methods in terms of cost effectiveness and a greater level of integration between molecular and conventional breeding represent the critical aspects for the greater adoption of MAS in crop breeding in the near future. The increase in importance of MAS is not expected to be the same for all crops, for high value crops it may be of top priority. The new tools of molecular breeding will have a better opportunity for demonstrating their true values for crop improvement, when these techniques reach a higher degree of automation; it will be possible to use molecular markers leading to "gene revolution" in the world of agriculture.

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9. AGRICULTURAL ENTOMOLOGY

Traps Useful for the Management of Fruit Flies

Tumma Mounika

Research Scholar, Department of Agricultural Entomology, Uttar Banga Krishi Viswavidyalay, West Bengal-736165

Introduction

Improving the vegetables and fruits production, productivity as well as the quality helps in increasing in the food security, employment and trade opportunities. Several factors lead to the deterioration of the production and quality of fruits/ vegetables. Among them fruit flies (*Bactrocera dorsalis* and *Bactrocera cucurbitae*) are one which causes most of the loss. It is not possible to produce some fruits like mango, peach, guava and some vegetables like cucurbits, tomatoes etc. free from invasion by fruit flies (Narayanan and Batra, 1960; Bateman, 1972). These fruit flies are cause direct damage to vegetables and fruits, which can lead to up to 90-100% yield loss. The loss in the yield depends on the population of the fruit flies, their locality, variety of the crop and season. This causes a huge loss in the trade value and export opportunity due to the quarantine regulation by other countries. To get rid of the fruit flies there is a need of effective control measures of fruit flies. Among them, Trapping of fruit flies is the most effective way in managing the population of fruit flies.

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Traps Used for the Management of Fruit Flies

Mc Phail Traps

The Mc Phail Trap is a transparent glass invaginated pear shaped container. This trap parts includes a rubber cork that seals the upper part of the trap and a wire hanger to place traps on tree branches. A hole in the base helps in allowing the flies to enter. This trap uses liquid food bait, based on hydrolyzed protein or torula yeast/ borax tablets. These traps were widely utilized in government trapping grids.

Multilure Trap: (Dry Synthetic lure)

This trap is the newer version of the McPhail trap. This trap consists of a two piece plastic cylinder shaped invaginated container. The upper part and base part of the trap separates allowing the trap to be serviced and baited. The transparent upper part of the trap contrasts with the yellow base enhancing the traps ability to catch fruit flies. For this trap to function properly it is essential that the upper part of the trap stays clear. This trap can be used with the liquid protein bait (as described for the conventional glass McPhail trap) or with the dry synthetic lure. The dry lure consists of three components that come in separate small flat dispensers. The lure dispensers are attached to the inside walls of the upper clear portion of the trap or hang on the ceiling using a clip. Since the conventional glass McP trap are in one piece the three dispensers are not easily attached to the glass walls.

Steiner Trap (ST)

This trap is horizontal, clear cylinder with a large opening at each end. This trap uses the male specific parapheromone lures like TML, ME and CUE. A wire hanger is placed on the top of the trap body which is used to hang the trap from the tree branches. As in the case of other dry traps (except for the sticky traps that use TML), an insecticide has to be used to prevent flies escaping and predation of captured flies.

Probodelt Cone Trap:

The Probodelt Cone trap comes with flat packed, and is easily clipped together. Because it is pre-coated with insecticide inside the lid, it can be put together without gloves. A tyvec sachet holds the cuelure, which is then placed inside. Flies enter the inverted side holes, and then fly towards the light, where they are killed when they come into contact with the lid.

Lynfield Trap

Lynfield trap is frequently baited with dental wicks soaked in cuelure or another parapheromone, as well as maldison. The OCP trap avoids handling concerns by using a fabric wick already impregnated with cuelure plus maldison. The wick is protected by a plastic protection, which is then securely fitted beneath the lid.

Female Biased Trap

Female biassed traps are designed to attract and kill a significant portion of the fly population. Food, fruit volatiles, or fruit analogues can all be used. Despite years of effort, no pheromone-based lures for female fruit flies have been discovered. There are basically two types of female biased traps are discovered:

Cera Trap

The Cera Trap is made of food and contains a liquid protein mixture that smells like mild ammonia. Flies simply drown, so no insecticide is required. In hot weather, the liquid must be kept adequately topped up; therefore units must be serviced on a frequent basis.

Fruition trap

This novel device was launched in November 2016, in which a slow-release sachet of fruit volatile fragrances is combined with a huge, sticky cobalt blue spherical. Visual and olfactory stimuli attract flies, which become stuck on the sphere. The creators say that their synthetic ripe fruit aroma is very appealing to *Bactrocera tryoni* and possibly other species for up to eight weeks. The usefulness of this gadget for vegetable crops has not been tested because it is a new device.

Conclusion

By using a variety of control measures fruit fly free crop can be possibly produced by remaining the damage below the economic threshold level. This comprises the exploitation of the biology and behaviour of fruit fly, physical barriers, chemical control and postharvest treatments. Trapping technique is one of the effective measures for the management of fruit flies on vegetables and fruits.

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10. SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Functions and Deficiency Symptoms of N, P and K

M. Bhargava Narasimha Yadav*, G.R. Vishwas Gowda

Ph.D. Scholar, UAS Dharwad, Dharwad-580005, Karnataka,

Introduction

Plants, like all other living things, need food for their growth and development. Plants require 16 essential elements. Carbon, hydrogen, and oxygen are derived from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organic matter or by organic or inorganic fertilizers. For plants to utilize these nutrients efficiently, light, heat, and water must be adequately supplied. Cultural practices and control of diseases and insects also play important roles in crop production. Each type of plant is unique and has an optimum nutrient range as well as a minimum requirement level. Below this minimum level, plants start to show nutrient deficiency symptoms. Excessive nutrient uptake can also cause poor growth because of toxicity. Therefore, the proper amount of application and the placement of nutrients is important. Soil and plant tissue tests have been developed to assess the nutrient content of both the soil and plants. By analyzing this information, plant scientists can determine the nutrient need of a given plant in a given soil. In addition to the levels of plant-available nutrients in soils, the soil pH plays an important role in nutrient availability and elemental toxicity. This chapter describes the essential nutrients, the chemical forms in which they are available to plants, their function in plants, symptoms of their deficiencies and recommended nutrient levels in plant tissues of selected crops.

Nitrogen

Symbol: N; available to plants as nitrate (NO_3^-) and ammonium (NH_4^+) ions.

Nutrient functions

- N is biologically combined with C, H, O and S to create amino acids, which are the building blocks of proteins. Amino acids are used in forming protoplasm, the site for cell division and thus for plant growth and development.
- Since all plant enzymes are made of proteins, N is needed for all of the enzymatic reactions in a plant.
- N is a major part of the chlorophyll molecule and is therefore necessary for photosynthesis.
- N is a necessary component of several vitamins.
- N improves the quality and quantity of dry matter in leafy vegetables and protein in grain crops.

Deficiency symptoms

- Stunted growth may occur because of reduction in cell division.
- Pale green to light yellow color (chlorosis) appearing first on older leaves, usually starting at the tips. Depending on the severity of deficiency, the chlorosis could result in the death and/or dropping of the older leaves. This is caused by the translocation of N from the older to the younger tissues.
- Reduced N lowers the protein content of seeds and vegetative parts. In severe cases, flowering is greatly reduced.

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- N deficiency causes early maturity in some crops, which results in a significant reduction in yield and quality.

Phosphorus

Symbol: P; available to plants as orthophosphate ions (HPO_4^{2-}, $H_2PO_4^-$).

Nutrient functions

- In photosynthesis and respiration, P plays a major role in energy storage and transfer as ADP and ATP (adenosine di- and triphosphate) and DPN and TPN (di- and triphosphopyridine nucleotide).
- P is part of the RNA and DNA structures, which are the major components of genetic information.
- Seeds have the highest concentration of P in a mature plant, and P is required in large quantities in young cells, such as shoots and root tips, where metabolism is high and cell division is rapid.
- P aids in root development, flower initiation, and seed and fruit development.
- P has been shown to reduce disease incidence in some plants and has been found to improve the quality of certain crops.

Deficiency symptoms

- Because P is needed in large quantities during the early stages of cell division, the initial overall symptom is slow, weak, and stunted growth.
- P is relatively mobile in plants and can be transferred to sites of new growth, causing symptoms of dark to blue-green coloration to appear on older leaves of some plants. Under severe deficiency, purpling of leaves and stems may appear.
- Lack of P can cause delayed maturity and poor seed and fruit development.

Potassium

Symbol: K; available to plants as the ion K^+

Nutrient functions

- Unlike N and P, K does not form any vital organic compounds in the plant. However, the presence of K is vital for plant growth because K is known to be an enzyme activator that promotes metabolism.
- K assists in regulating the plant's use of water by controlling the opening and closing of leaf stomates, where water is released to cool the plant.
- In photosynthesis, K has the role of maintaining the balance of electrical charges at the site of ATP production.
- K promotes the translocation of photosythates (sugars) for plant growth or storage in fruits or roots.
- Through its role assisting ATP production, K is involved in protein synthesis.
- K has been shown to improve disease resistance in plants, improve the size of grains and seeds and improve the quality of fruits and vegetables.

Deficiency symptoms

- The most common symptom is chlorosis along the edges of leaves (leaf margin scorching). This occurs first in older leaves, because K is very mobile in the plant.
- Because K is needed in photosynthesis and the synthesis of proteins, plants lacking K will have slow and stunted growth.
- In some crops, stems are weak and lodging is common if K is deficient.
- The size of seeds and fruits and the quantity of their production is reduced.

Nitrogen deficient corn; yellowing proceeds down the midrib of older leaves.

Nitrogen deficient soybean; lower leaves turn uniformly pale green, then yellow.

Severe nitrogen deficiency in citrus

Nitrogen deficient cucumber fruit.

Phosphorus deficient sugar beet plants are stunted, with dark green leaves.

Phosphorus deficient corn; lower leaves become reddish-purple.

Potassium deficient banana; older leaves become chlorotic, then necrotic, and the tip of the midrib bends downward.

Potassium deficient corn; margins of older leaves become chlorotic and necrotic.

Potassium deficient tomato leaves have chlorotic and necrotic spotting.

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11. PLANT PATHOLOGY

Major Fungal Diseases of Turmeric and its Management Practices

Ravi Regar[1]

[1]PhD. Scholar, Department of Plant Pathology, S.K.N. College of agriculture, Jobner, Jaipur

Major fungal Diseases of Turmeric

Rhizome Rot: Pythium graminicolum

Symptoms

- Mostly the symptoms starting from the margins the leaves get dried up, collar region of pseudo stem becomes soft also water-soaked and plants collapse.
- The rhizomes decay as a result of the attack of the fungus and later stage root infection is also noticed.

Rhizome Rot

Disease cycle

- Pathogen is soil-borne, therefore primary inoculam comes from soil.
- Infected rhizomes used for seed purpose may also transmit the disease.
- Irrigation water from diseased field helps in the spread of the disease.

MANAGEMENT

Cultural practices

- Seed material should be selected from disease free areas.
- Avoid water stagnation in the field. Light soil may be preferred and drainage facility to be ensured.
- Crop rotation to be followed.
- Deep plough in summer. Planting is to be done in ridge and furrow method.

Use of resistant varieties

Grow tolerant varieties like Suguna and Sudarshan.

Chemical management

- Remove diseased plants and the soil around plants to be drenced with Mancozeb (3gm/lit) or 3gm Ridomil M.Z.
- Keep rhizomes in 3g Metalaxyl or 3g Mancozeb mixed in one litre of water for one hour and shade dry before planting.

Leaf Spot - Colletotrichum capsici

Symptoms

- Oblong brown spots with grey centres are found on leaves.
- The spots are about 4-5 cm in length and 2-3 cm in width. In advanced stages of disease black dots representing fungal acervuli occur in concentric rings on spot.
- The grey centers become thin and gets teared. Severely effected leaves dry and wilt. They are surrounded by yellow halos.
- Indefinite number of spots may be found on a single leaf and as the disease advances; spots enlarge and cover a major portion of leaf blade.

Leaf Spot

Disease cycle

- The fungus is carried on the scales of rhizomes which are the source of primary infection during sowing.

- The secondary spread is by wind, water and other physical and biological agents.
- The same pathogen is also reported to cause leaf-spot and fruit rot of chilli where it is transmitted through seed borne infections.
- If chilli is grown in nearby fields or used in crop rotation with turmeric, the pathogen perpetuates easily, building up inoculum potential for epiphytotic outbreaks.

Management

Cultural management

- Select seed material from disease free areas.
- Crop rotations should be followed whenever possible.
- The infected and dried leaves should be collected and burnt in order to reduce the inoculum source in the field.

Use of resistant varieties

Cultivate tolerant varieties like Suguna and Sudarshan.

Chemical management

- Treat seed material with mancozeb @ 3g/litre of water or carbendazim @ 1 g/litre of water, for 30 minutes and shade dry before sowing.
- Spray mancozeb @ 2.5 g/litre of water or carbendazim @ 1g/litre; 2-3 sprays at fortnightly intervals.
- Spraying Blitox or Blue copper at 3 g/l of water was found effective against leaf spot.

Leaf Blotch -Taphrina maculans

Symptoms

- This disease usually appears on lower leaves in October and November.
- The individual spots are small 1-2 mm in width and are mostly rectangular in shape.
- The disease is characterized by the appearance of several spots on both the surfaces of leaves, being generally numerous on the upper surface.
- They are arranged in rows along the veins. The spots coalesce freely and form irregular lesions.
- They first appear as pale yellow discolorations and then become dirty yellow in colour.
- The infected leaves disort and have reddish brown appearance.

Disease cycle

- The fungus is mainly air borne and primary infection occurs on lower leaves with the inoculum surviving in dried leaves of host, left over in the field. The ascospores discharged fromsuccessively maturing asci infect fresh leaves without dormancy, thus causing secondary infection.
- Secondary infection is most dangerous than primary one causing profuse sprouting all over the leaves. The pathogen persists in summer by means of ascogenous cells on leaf debris, and dessicated ascospores and blastospores in soil and among fallen leaves.

Management

Cultural management

- Select seed material from disease free areas.
- Crop rotations should be followed whenever possible.
- The infected and dried leaves should be collected and burnt in order to reduce the inoculum source in the field.

Chemical management

- Treat the seed material with Mancozeb @ 3g/litre of water or Carbendazim @ 1 g/litre of water for 30 minutes and shade dry before sowing.
- Spray mancozeb @ 2.5 g/litre of water or Carbendazim @ 1g/litre; 2-3 sprays at fortnightly intervals.
- Spraying Cpper oxy chloride at 3 g/l of water was found effective against leaf blotch.

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12. CROP MODELLING

Crop Modelling: Introduction and its Applications to Agriculture

[*1]Amisha Choudhary and [2]Ram Singh Choudhary

*[*1]Ph.D. Research Scholar, Sri Karan Narendra Agriculture University, Jobner, Jaipur, [*2]Ph.D. Research Scholar, Agriculture University, Kota*

Agriculture is a backbone of the Indian economy. Agriculture nowadays posed with multiple issues related not only to crop production and natural resource, but also circumscribes environment quality, global economy, climate change, and policy. This requires multidisciplinary approach to find out the solution in a more comprehensive way. One such approach is quantitative modelling of agricultural systems that can provide simpler solutions to complex problems. A crop model is a mathematical representation of a real crop system that helps in understanding the behaviour and function of the system. Model simulates or imitates the behaviour of a real crop by predicting the growth of its components, such as leaves, roots, stems and seeds. The primary goals of crop modeling is to help agricultural decision making; the early attempts were based on conventional experienced base agronomic research; crop yields were related to some defined variable based on correlation and regression analysis. However, with advent of high performance computing and techniques of large data analysis, crop modeling has seen progress in many directions.

Crop Modelling in Agriculture

1. **Statistical models**: This model is also known as the empirical model. These models express the relationship between yield or yield components and weather parameters. In these models, statistical techniques (range, simple correlation, multiple regression, *etc*) are used to measure the relationships.
2. **Mechanistic models**: These models not only explain the relationship between weather parameters and yield, but also the mechanism of these models (explains the relationship of influencing dependent variables). These models are based on physical selection. It can be divided into Static, Dynamic, Stochastic, and Deterministic models.
3. **Simulation models**: Computer models, in general, are a mathematical representation of a real-world system. One of the main goals of crop simulation models is to estimate agricultural production as a function of weather and soil conditions as well as crop management.
4. **Descriptive model:** The model reflects little or none of the mechanisms that are the causes of phenomena. But, this model consists of one or more mathematical equations. The equation is helpful to quickly determine the weight of the crop where no observations were made.
5. **Explanatory model:** This model gives quantitative description of the mechanisms and processes that cause the behavior of the system.
6. **Process models:** This model defines the interdependence among a number of variables (representing process) with or without time dependence. These models are necessary to create interfaces between different systems, like climate system and crop, thus a typical process model will relate crop parameters like yield to climate/weather parameters (temperature).
7. **Optimization model:** This model has the specific objective of forming the best option in terms of management inputs for the practical operation of the system. This model can be also used to explore options (good and best practices) as well as decision support. In addition, such models can be used optimize agronomical practices, and they can be used to investigate a wide range of management strategies at low costs.

Application of Crop Models

(1) Site–specific Farming (2) Precision Agriculture (3) Risk Assessment and Investment Support (4) Yield Forecasting (5) Identification of New Crops

Benefits

The crop modelling approach can provide the following benefits:

1. Crop system management: crop modelling efficiently evaluates the optimum management production for cultural practices.
    a. Seed rate: Optimum seed rate for a different situation can be found out with these model
    b. Irrigation: Sufficient amount and time of irrigation can be stimulated
    c. Fertilizer: Optimum amount and time of application of the fertilizer can be found out
2. Yield gap analysis: The difference between potential yield and actual yield is called yield gap. The yield gap can be evaluated with help of these models.
3. Yield forecasting and prediction.
4. Assessment of climate variability and change.
5. Various practical problems of agriculture like the decision of sowing time and variety, disease control, etc will be solved by these models.
6. These are resource–conserving tools.
7. Possible impacts of climate change on crop performance are also predicated and analyzed by these models.
8. Helps in adaptation strategies, by which the negative impacts due to climate change can be minimized.

Limitations

- Accurate projections of natural processes always not possible.
- Untrustworthy and impractical projections of changes in climate variability.
- There are chances of misuse of models.
- Improper results for the heterogeneous plot.
- Inherent soil heterogeneity over relatively small distances.
- Model performance is incomplete to the quality of input data.
- Sampling errors also supply inaccuracies in the observed data.
- Rudimentary model validation methodology.
- Plant, soil, and meteorological data are rarely precise and come from nearby sites.
- An ideal crop model cannot be developed because of the complex biological system.

Conclusion

Crop modelling has been developed comprehensively over the past 50 years and a miscellaneous range of crop models are now available. Crop growth models play, as an agronomic and user–friendly research tool to appraise the various agronomic practices for most advantageous crop production and mitigation of climate change impacts. Various kinds of models in the agriculture field such as statistical, mechanistic, deterministic, stochastic, dynamic, and static, and simulations are in use for assessing and predicting crop performance. It is considered that effective crop modelling must combine a scientific approach to enhance the consideration of application orientation and to retain a focus on prediction and problem–solving approaches regarding agriculture field issues. The major importance of models is that issues like yield forecasting, operations management, input management, pest and irrigation management, consequences of management decisions on environmental issues, are well supported and resolved. Superior use of crop simulation models has also been suggested to enhance the effectiveness of different field trials. While simulation models successfully capture the temporal variation, they use a lumped parameter approach that assumes the spatial variability of the soils, crops, or climate. Thus, modelling represents a superior way of collecting knowledge about different components of a system, summarizing data, and transferring better research outcomes to users (farmers).

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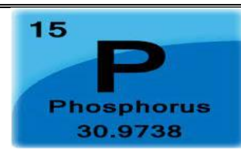
13. SOIL SCIENCE

Determination of Nutrient Potentials and Potential Buffering Capacities for Phosphorus and Estimation of Phosphorus Fixation Capacities of Soils

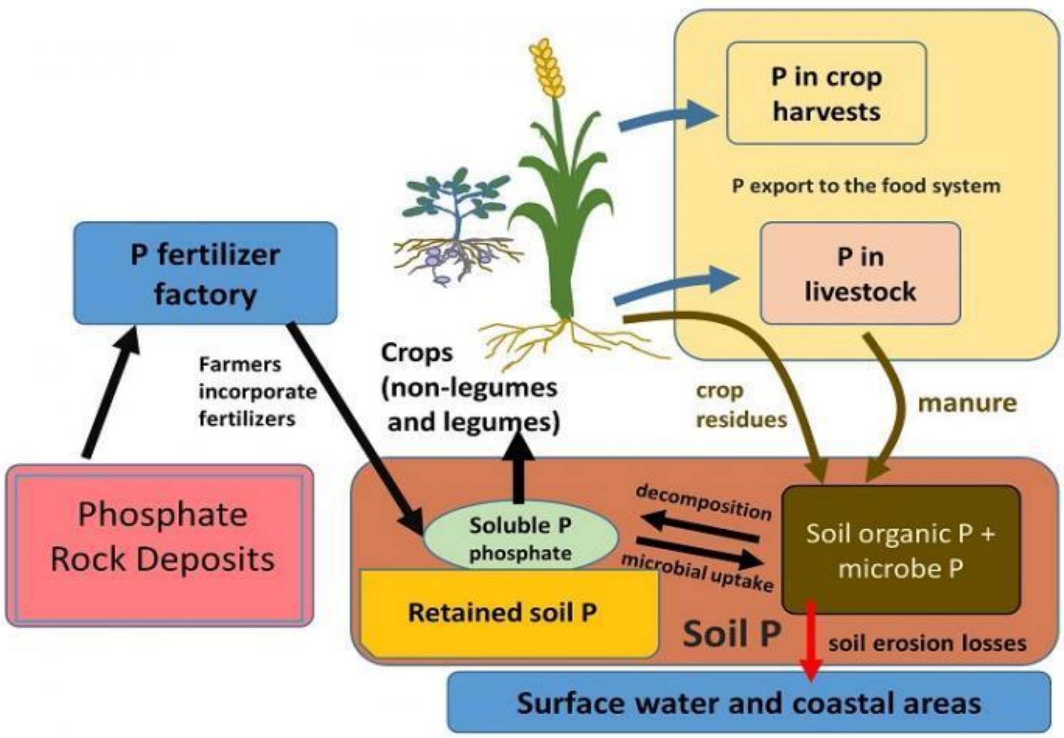
*[1]Amisha Choudhary and [2]Ram Singh Choudhary

*[1]*Ph.D. Research Scholar, Sri Karan Narendra Agriculture University, Jobner, Jaipur,*
*[2]*Ph.D. Research Scholar, Agriculture University, Kota*

Phosphorus is an essential nutrient for all living organisms. It plays a role in virtually all biochemical processes that involve energy transfer.It is also known as Energy Currency of the plant cell. The total P-content in agricultural crops generally ranges from 0.1% to 0.5 %. It is main constituent of ATP.



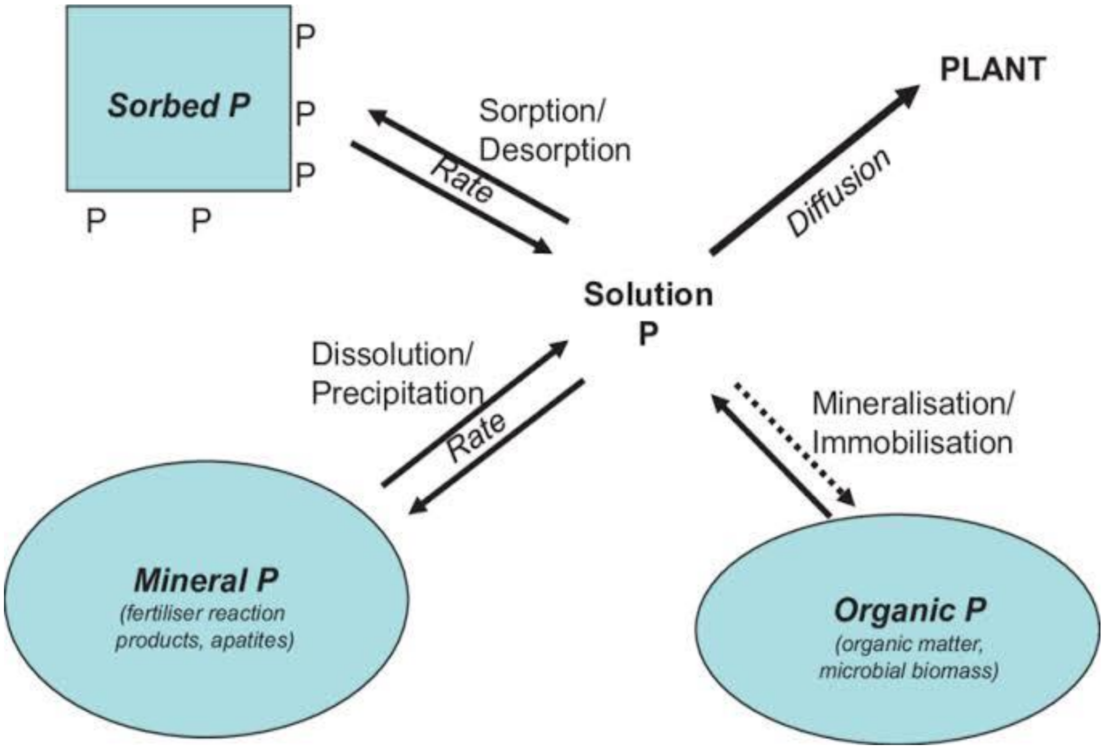
Phosphorus cycle in soil:-



Phosphorus buffering capacity

- Phosphorus buffering capacity of soil characterizes the dynamics relation between labile solid phase (Quantity) and solution phase phosphate (intensity).
- The sandy soils have less PBC less than the fine textured soils.
- The P equilibrium buffering capacity (PEBC) significantly decreased and the equilibrium P concentration (EPC) significantly increased after biosolids amendment.

- P desorption from soil samples with and without biosolids amendment was investigated for different equilibration periods and at various liquid/solid ratios.
- Soils with high PBC will have less P-concentration in soil solution for exploitation by plant roots.



Phosphorus fixation capacity:-

- Phosphorus fixation reactions involving iron oxide & aluminium oxide. While the adsorbed phosphate is labile and considered to be in a reversible (desirable) condition.
- The fixed pool of inorganic and organic phosphate compounds are very insoluble and may remain in soils for years without being made available to the soil.
- Phosphate fixation reactions between iron/aluminium and phosphate through the creation of coordinate (chelation) bio-dentate linkage.
- In alkaline soils, soluble phosphate ions quickly react with calcium to form a sequence of products of decreasing solubility.
- Initial fixation reaction of calcium carbonate with phosphoric acid resulting in the formation of Di-calcium phosphate.

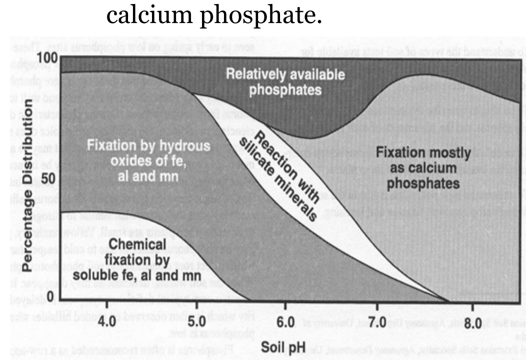


Figure- Soil phosphorus compound in relation to soil pH

Factors affecting P fixation of soils

- P fixing capacity: dependent on clay type and clay content 2:1 clay <1:1 clay < crystalline Al, Fe and Mn oxides etc.
- Soil pH - P fixation highest at pH extremes i.e. very acid and very alkaline soil conditions.
- Phosphate fixation is lowest at pH = 6-7.
- Presence of high organic matter decreases the fixation of phosphate.
- Over liming increases the fixation of phosphate by forming more insoluble Ca-P compounds in soil.

14. HORTICULTURE

Biofortified Vegetable Crops for Nutritional Security

Pekila Bhutia[1*] and Aditya Pratap Singh[2]

[2]*Deptartment of Genetics and Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya, Mohapur-741252, West Bengal, India*

[1]*Department of Vegetable Science, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India*

Abstract

As a result of traditional agricultural practices, plant food has increased in nutritional content, but biofortification enhances the bioavailability of food by adding beneficial components, thereby providing a longer-term and more sustainable strategy. An essential micronutrient is fortified in a food to improve the nutritional quality of the food supply and provide a public health benefit with minimal health risks, i.e. vitamins and minerals. Unlike conventional fortification, biofortification involves adding nutrients to crops during the growth phase rather than through manual means during processing

Keywords: agriculture, bioavailability, fortification, health

Introduction

The process of adding micronutrients to staple crops (cereals and vegetables) through a combination of conventional breeding techniques, modern biotechnology, and agronomic methods is known as biofortification. As a plant grows and develops, plant-derived nutrition and vitamins become more concentrated in its edible organs (O'Hare, 2015). A low-cost, long-term supply of adequate micronutrients can be achieved by breeding nutrients into food crops. In this technique, micronutrients and vitamins are added to edible parts such as grain, straw, roots, fruits, and tubers in a biotechnological way (Saltzman et al., 2013). Despite the fact that biofortified staple foods don't contain as many essential vitamins and micronutrients as industrially fortified foods, they may be able to reduce "hidden hunger" by increasing micronutrient absorption over time (Bouis et al., 2011). Genetic engineering, conventional breeding, and agronomic approaches can all be used for biofortification.

Methods of Biofortification

In order to achieve biofortification, three techniques can be used.

- Agronomic Biofortification
- Conventional plant breeding
- Genetic engineering.

1. **Agronomic Biofortification**: In this method, fertilizer is applied either directly to the leaves or deep into the soil (Weng et al. 2008b). Foliar application of these nutrients has been shown to enhance Fe and Zn in plant tissue and edible parts (Saltzman et al., 2013). For agronomic biofortification (foliar applications of $ZnSO_4$), selenium (as selenate), iodine (soil application of iodide or iodate), and zinc are the most important micronutrients. It is possible to provide micronutrients to plants directly through the foliar application of micronutrients (Fe, Zn, Cu, etc.). Micronutrients such as copper, iron, and zinc can be effectively produced and absorbed through the use of AM-fungi. The sulphur content of onions is increased by sulfur oxidizing bacteria. Fortification with

vitamin and nutrient content is called biofortification. It is the process of fortifying a living commodity (edible part) so that vitamins and nutrients are accumulated naturally by the plant. This would be difficult, however, for tree fruits and nuts, which have even longer juvenile periods (O'Hare, 2015).

2. **Conventional plant breeding:** Unlike genetic engineering, conventional breeding relies on natural selection. The folate content of vegetables like tomato and potato has been found to double thanks to newly developed breeding lines (Hanson and Gregory, 2011). Genetic engineering, traditional breeding techniques, and genetic engineering may allow large quantities of crops to be biofortified and disseminated around the world (Welch and Graham, 2004). Over the last four decades, conventional breeding has emphasized yield attributes and resistance breeding at the expense of nutrition. In a variety of plant-based foods, the concentration of minerals Fe, Zn, Cu, and Mg has decreased. The focus of traditional breeding has recently been on fortifying essential vitamins, antioxidants, and micronutrients. As a result of the green movement, which began in the early 1960s, the world has been able to combat food insecurity. The reduction of local fruit and vegetable production, which is the people's primary source of micronutrients, was the result of this decline (Welch and Graham, 2004).
3. **Genetic Engineering:** Biotechnology has proven to be an effective method of biofortification that is being used around the world to address mineral and vitamin deficiencies. With the development of genetic engineering tools and techniques, traditional breeding techniques can no longer achieve traits that were previously impossible (Rana et al., 2019). Food, feed, and energy needs are often addressed by genetic engineering (GE). Since 1996, when Flavr Savr tomatoes were first launched on a large scale, it has been a record. It is possible to introduce beneficial genes into previously unavailable cultivars through genetic modification or transgenesis, which enhances the value of the plant and provides exclusive opportunities to combat viruses, insects, and other pathogens, as well as improving nutritional value and health benefits of the crop. Micronutrient bioavailability and concentration in edible crop tissues can be increased by genetic engineering when there is insufficient variation among genotypes for the desired character/trait within a species. Transgenes are being incorporated into novel vegetable cultivars using genetic modification, increasing their value. The technology allows for the improvement of food quality and health benefits. Breeding vegetables to increase flavour, nutritional status, bitterness, slow ripening, seedless fruit, sweetness, and antinutritional factors is one type of genetic engineering.

Biofortification Using Transgenic Approaches

1. Tomato:
   a. **Antioxidants**: As well as anthocyanins and carotenoids, such as lycopene and beta-carotene, vitamins C and E are found in fruits and vegetables. Giovinazzo (2005) found that transgenic fruits accumulating trans resveratrol have higher glutathione and ascorbate levels, soluble antioxidants from primary metabolism.
   b. **Carotenoids -rich tomato**: Human health can be improved through the use of lycopene, a powerful antioxidant. To improve the nutritional quality of tomatoes, genetically modifying tomato carotenoids levels may be of interest. Phytoene is generated by Psy-1 by converting GGPP to geranylgeranyl diphosphate, which is the first step in carotenoid biosynthesis. To increase the carotenoid content of tomato, the Psy-1 gene was continuously expressed.
   c. **Flavanols rich tomato**: Petunia chi-a gene-encoded chalcone isomerase has been introduced into tomato. Because of an accumulation of rutin, the transgenic tomato lines produced 78-fold more fruit peel flavanols. There was a 78-fold increase in fruit flavanols when chalcone

isomerase was expressed ectopically.

d. **Folate -rich tomato**: The vine-ripened tomato fruit accumulated 25 times more folate than the control when crossed with PABA- and pteridine overproduction traits. A yeast S-adenosylmethionine decarboxylase gene (ySAMdc; Spe2) fused with a ripening-inducible E8 promoter was used to increase tomato fruit levels of spermine and spermidine during ripening. Consequently, vine life was prolonged, fruit juice consistency was improved, and lycopene levels increased.

2. Potato:

A substantial increase in anthocyanins and phenolic acids was observed in potatoes when chalcone synthase (CHS) and dihydroflavonol reductase (DFR) were overexpressed (Lukaszewicz Marcin, 2004).

a. **Starch-rich potato**: Potato tubers store carbohydrate primarily as starch, which accounts for 70% of their dry matter. Transgenic potatoes developed high-starch tubers when the ADPGP Pase gene from Bacterium *Escherichia coli* was transferred to them.
b. **Protein-rich potato**: Potatoes with the AmA1 seed protein gene will become more nutritious by expressing the non-allergenic seed albumin gene from Amaranthus hypochondriacs (Amaranth Albumin 1). A biochemical analysis shows that AmA1 expression increases lysine, tyrosine, and sulfur amino acids, as well as the total protein content in both types of transgenics.
c. **Amino acids-rich potato**: Transfer of the high essential amino acid encoding HEAE gene to potato clones K-2 and K-7 resulted in an increase in essential amino acids. These 292 base pair synthetic gene fragment (HEAAE-DNA) codes for a protein that contains around 80% essential amino acids.

3. Cauliflower

The cloning of cauliflower has been successful. Carotenoid accumulation can be significantly affected by manipulating chromoplast formation to provide a metabolic sink for carotenoid sequestration. Transgenic potatoes are shown to have higher carotenoid content when the Or gene is expressed, demonstrating a novel approach to increasing carotenoid levels by expressing carotenogenic genes.

4. Cabbage

Cancer, cardiovascular disease, and brain disorders can be reduced by the high antioxidant properties and anthocyanin content of red cabbage.

5. Carrot

Enhanced calcium levels in genetically modified carrots may prevent calcium deficiencies like osteoporosis by increasing calcium uptake. Transgenically modified carrots expressed higher levels of the Ca transporter SCAX1.

Conclusion

As a result of the biofortification strategy, everyone in the family consumes a large amount of nutrients-dense foods each day, especially children and women who are at greatest risk of micronutrient deficiencies. Since food staples predominate in the diets of the poor, this policy indirectly targets economically disadvantaged households. Providing natural fortified foods to people who do not have access to commercially fortified foods, which are more readily available in towns, is a simple way to target malnourished people in rural areas. Consequently, biofortification, as well as industrial fortification, are closely related to one another.

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15. SOIL SCIENCE

Natural Farming- Serve Mother Earth

A. Premalatha[1] and S. Saravanakumar[2]

[1]Scientist (Soil Science), [2]Scientist (Agronomy)

ICAR – Krishi Vigyan Kendra, MYRADA, Gobichettipalayam, Erode District, Tamilnadu

Background

Modern agricultural practices have a major impact on the environment. Climate change, deforestation, genetic engineering, irrigation problems, pollutants, soil degradation and waste are some of the concerns that are connected with agriculture. Excessive use of fertilizers such as urea, nitrate, phosphorous along with many other pesticides has affected air, water, and soil quality.

Genetically engineered crops are herbicide-tolerant and their overuse has created herbicide-resistant 'super weeds'. Non-target plants, birds, fish and other wildlife have also been killed because of pesticide application. Soil degradation has affected the microbial community of the soil, altering the nutrient cycle, pest control and chemical transformation properties of soil. Natural farming practices are an ideal solution to reducing all these types of hazards which brings life to the soil.

Natural Farming

Natural farming also referred to as "the Fukuoka Method", "the natural way of farming" or "**do-nothing farming**", is an ecological farming approach established by Masanobu Fukuoka (1913–2008). Fukuoka, a Japanese farmer and philosopher, introduced the term in his book "The One-Straw Revolution" in 1975. Natural farming aims to increase farmer's yield by maximizing production factors (labor, soil, equipment) and by avoiding the use of non-natural inputs (fertilizer, herbicides and pesticides) to optimize production potential and thus provide abundant, high quality, healthy food at the best price.

Natural farming aims at improving and preserving the quality of soil, whereas in every case conventional farming destroys. The important step in natural farming are conservation of crop diversity, no tillage, watershed management, efficient water management, integrated nutrient management, integrated weed management, integrated pest management and crop diversification.

Natural farming an overview:

- It can be defined as a "chemical- free farming and livestock based". Soundly grounded in agro-ecology, it is a diversified farming system that integrates crops, trees and livestock, allowing the optimum use of functional biodiversity.

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- Internationally, Natural Farming is considered a form of regenerative agriculture—a prominent strategy to save the planet.
- Natural Farming, as the name suggests, is the art, practice and, increasingly, the science of working with nature to achieve much more with less.

Natural farming principle:

- There is no need to till the field
- Bugs and weeds are not enemies
- There is no need for external inputs of any kind into your farm
- Let nature decide what grows

The main features of natural farming system are:

- Physical work and labor can be highly reduced as compared to other agricultural systems.
- Yields similar to chemical agriculture is possible.
- There is an increase in soil fertility year after year.
- Water requirement is minimized.

Differences between Natural farming and Organic farming:

Organic Farming	Natural Farming
In organic farming, organic fertilizers and manures like compost, vermicompost, cow dung manure, etc. are used and added to farmlands from external sources.	In natural farming, decomposition of organic matter by microbes and earthworms is encouraged right on the soil surface itself, which gradually adds nutrition in the soil, over the period. In natural farming, neither chemical nor organic fertilizers are added to the soil.
Organic farming still requires basic agro practices like plowing, tilting, mixing of manures, weeding, etc. to be performed.	In natural farming there is no plowing, no tilting of soil and no fertilizers, and no wedding is done just the way it would be in natural ecosystems.
Organic farming is still expensive due to the requirement of bulk manures, and it has an ecological impact on surrounding environments	Whereas, natural agriculture is an extremely low-cost farming method, completely molding with local biodiversity.

Zero Budget Natural Farming (ZBNF)

There are many working models of natural farming all over the world, the Zero Budget Natural Farming (ZBNF) is the most popular model in India. This comprehensive, natural, and spiritual farming system was developed by Padma Shri Subhash Palekar.

The word Zero Budget refers to the **zero net cost of production of all crops** (inter crops, border crops, multi crops). The inputs used for seed treatments and other inoculations are locally available in the form of cow dung and cow urine. ZBNF farmers thus have lower cost of inputs and thus have better capacity to increase the incomes. At the same time ZBNF crops helps in retaining soil fertility and is climate change resilient.

Four principles of ZBNF

- **Jeevamrutha**: A composition of cow dung and cow urine, jaggery, pulse flour, water and soil is applied on the farmland. It helps in the addition of nutrients in the soil and also in catalysing the microbial activities in the soil.
- **Bijamrita**: It is a mixture of neem leaves and pulp, tobacco and green chillies prepared for insect and pest management that can be used to treat seeds. Bijamrita is effective in protecting young roots from fungus as well as from soil-borne and seedborne diseases that commonly affect plants after the monsoon period.
- **Acchadana**(Mulching):
    - **Soil Mulch:** This protects topsoil during cultivation and does not destroy it by tilling. It promotes aeration and water retention in the soil. Palekar

suggests avoiding deep ploughing.

- **Straw Mulch:** Straw material usually refers to the dried biomass waste of previous crops, but as Palekar suggests, it can be composed of the dead material of any living being (plants, animals, etc).
- **Live Mulch** (symbiotic intercrops and mixed crops): According to Palekar, it is essential to develop multiple cropping patterns of monocotyledons (monocots; Monocotyledons seedlings have one seed leaf) and dicotyledons (dicots; Dicotyledons seedlings have two seed leaves) grown in the same field, to supply all essential elements to the soil and crops. For instance, legumes are off the dicot group and are nitrogen-fixing plants. Monocots such as rice and wheat supply other elements like potash, phosphate and sulphur.

- **Whapasa**: It is the condition where there are both air molecules and water molecules present in the soil. Thereby, providing water to maintain the required moisture-air balance

It is a farming method that our Prime Minister Narendra Modi mentioned in the United Nations Conference on Desertification (COP-14) while stating that India is focusing on this method. The farming method offers resilient food systems. Through two of their initiatives:

Paramparagat Krishi Vikas Yojana (PKVY)

Rashtriya Krishi Vikas Yojana (RKVY)

The Government of India has been promoting natural farming in the country.

Advantages of Natural farming:

- Produce nutritious crops.
- Prevent soil erosion
- Preserve biodiversity
- Mitigate climate change
- Protect water quality

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