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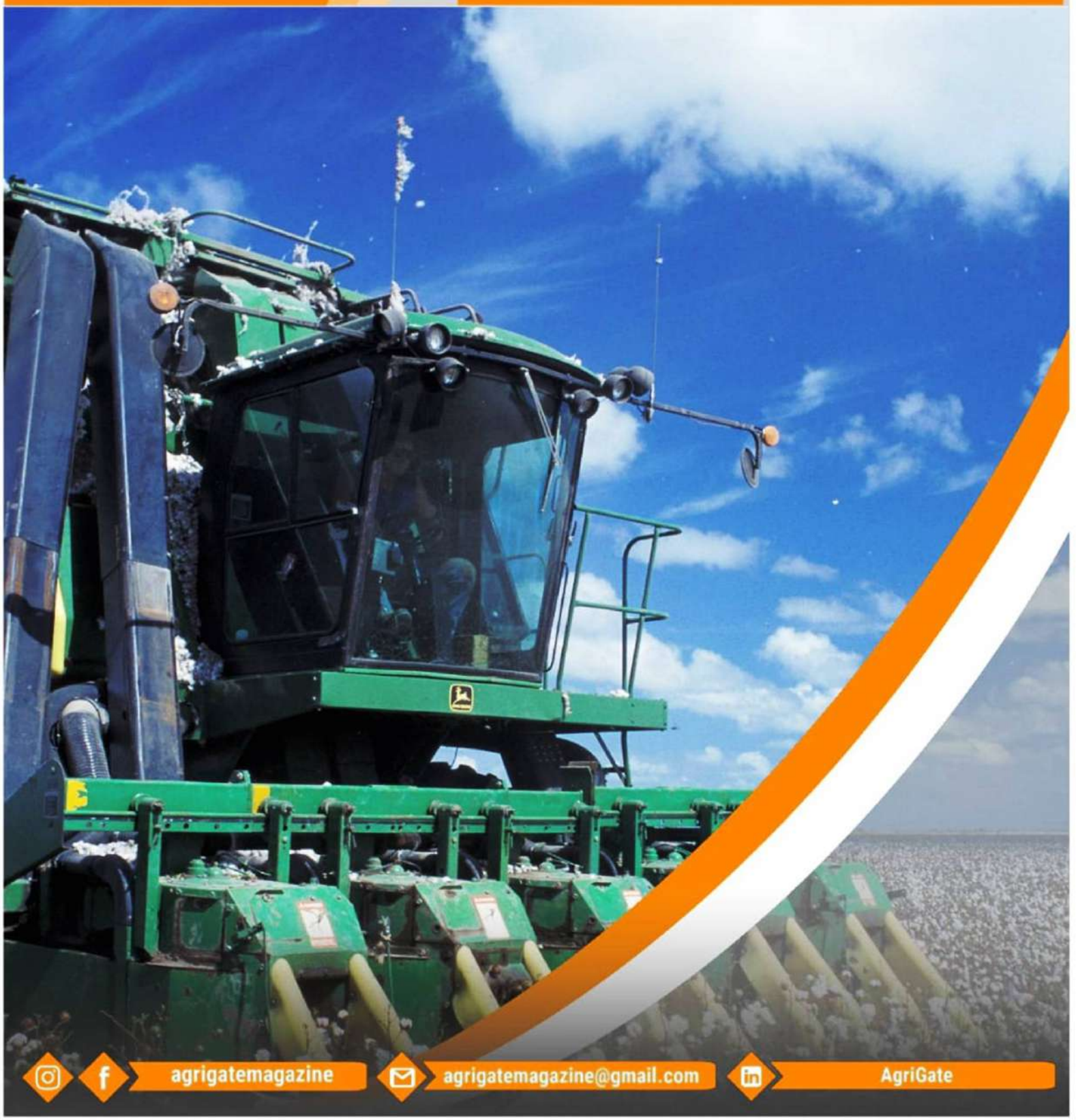

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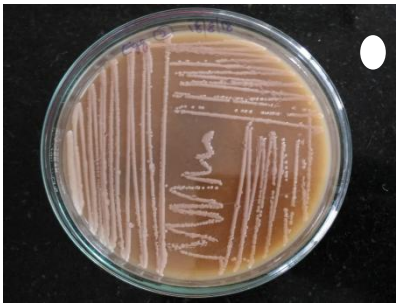

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From the Desk of Editor-in-chief

March 2023| Vol. 03 | Issue No. 03

I would like to introduce the launch of **"AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 03 Issue No. 03 – March 2023"** with immense pleasure. Ourteam is privileged to dedicate this issue to World Forestry Day or International Day of Forests (On 21st March) is celebrated every year to raise public awareness about the values, significance, and contributions of the forests to balance the life cycle on the earth. In 1971, World Forestry Day was established at the 23rd General Assembly of the European Confederation of Agriculture.

The main objective of the magazine is to provide a publishing platform to young researchers and scientists as well as an information hub for the enthusiast, progressive farmer and also common readers. We envisage providing an online platform that appreciates illuminating articles on various topics related to agriculture and allied sciences monthly that will appraise and update the students, farming community and the whole society at large on the updates in agriculture.

Last but not the least, I wholeheartedly thank the editorial team, authors as well as anonymous reviewers for contributing to the release of this issue.

Our team welcomes your constructive feedback and suggestions to improve delivering fruitful content to hungry minds.

Dr R Shiv Ramakrishnan
Editor-in-chief
AgriGate Magazine

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AgriGate- An International Multidisciplinary e-Magazine

Volume: 03 Issue No: 03

INSECT PESTS OF CARROT AND BEETROOT

Article ID: AG-VO3-I03-01

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ABSTRACT

Carrots (*Daucuscarota* L.) and beets (*Beta vulgaris* L.) are horticultural, temperate vegetable root crops that are grown on a relatively small scale compared with staple food crops. They have a relatively short shelf life, requiring ready access to cold storage, which limits their long-distance distribution, especially in less-developed countries. However, the production and productivity of these crops are reduced due to incidence of various insect pests which are being discussed in this article.

Key words: Carrot, flea beetle, rust fly, beetroot, leaf miner, and web worm.

INTRODUCTION

Carrot,*Daucuscarota* is an edible biennial herb belonging to family Apiaceae grown for its edible root (Saha*et al.*,2015) originated in Asia.Carrots are particularly rich in carotene (pro-vitamin A) consumed either fresh, as a salad crop, or cooked. Some of the biotic factors, which are limiting the productivity of carrots, areinsect pests*viz.*,Pea leaf miner, Flea beetle and carrot rust fly (Saha*et al.*, 2015).

Beetroot (*Beta vulgaris* L.) belongs to the family Chenopodiaceae commonly known as beet, garden beet, white beet and Chukander (in Hindi). Red beetroot is a rich source of minerals *viz.*, Mg, Mn, Na, K, Fe andCu (Mathangi, 2019). The beetroot has different medicinal properties and help to protect against heart disease and certain cancers (colon cancer) (Kavalcova*et al.*, 2015).Beet root crop experiences various biotic and abiotic stresses during its growth period.

Among biotic stress, insects play a crucial role affecting beet crop growth and yield which includes leaf miner and web worm (Lange *et al.*, 1999).

The pests of carrot and beetroot are discussed below:

PESTS OF CARROT

S. No.	Common name	Scientific name	Family	Order
1.	Pea Leaf Miner	*Phytomyzahorticola*	Agromyzidae	Diptera
2.	Flea beetle	*Phyllotreta*sp.	Chrysomelidae	Coleoptera
3.	Carrot rust fly	*Psilarosae*	Psilidae	Diptera

1. Pea Leaf Miner: Scientific name - *Phytomyzahorticola*

Family - Pyralidae

Order -Lepidoptera

Identification marks: It is a small dipteran fly having black mesonotum and yellowish frons.

(Source: Internet)

Nature of Damage and Symptoms:

- Maggots bore between the epidermal region, feed on leaf tissues, form galleries leaving intact the epidermal layer (Severe attack, entire leaf is filled with mines and 86-93% gets affected).
- The destruction of chlorophyll containing tissues interferes with the photosynthetic activity of the plant.
- Finally, the growth and yield of the infected plant is adversely affected.

(Source: Internet)

Management:

- Spray application of Chlorpyriphos 20 EC @ 2ml/l or Malathion @ 1 ml/l.

2. Flea Beetle: Scientific name -*Phyllotreta*spp.

Family - Chrysomelidae

Order -Coleoptera

Identification marks:

- It is an **occasional pest** of carrot.
- The **larvais delicate and threadlike with white bodies and brown head capsules.**They have characteristically **large hind legs, which makes them excellent jumpers**(Delahaut and Newenhouse, 1998)**.**
- Site of oviposition is soil with an egg period of**7-14 days**.
- The larvae **feed on various plant parts** until full grown.
- Site of pupation is**earthen cells for 11-13 days** before emerging as adults.
- It passes through 2 generations per year. Hence, it is **Bivoltine**.


(Source: Internet)

Nature of Damage and Symptoms:

- It makes small holes or pits in leaves and carrot fruits that givea characteristic "**shot hole**" appearance.
- Young plants and seedlings are particularly susceptible; therefore plant growth may be reduced(CABI, 2008 and Saha*et al.*,2015).


(Source: Internet)

Management:

- **Early planting** helps to avoid the population of flea beetles.
- When the plants are small and vulnerable, **enclosing seed bed with floating row** cover to get protection from oviposition by adults.
- **Mulching** prevents beetles to reach the surface.

- Spray applications of**Neem oil @ 3 g/l,** insecticides containing**spinosad, bifenthrin**and**permethrin**can provide adequate control of beetles.

3. Carrot Rust Fly: Scientific name -*Psilarosae*

Family - Psilidae

Order -Diptera

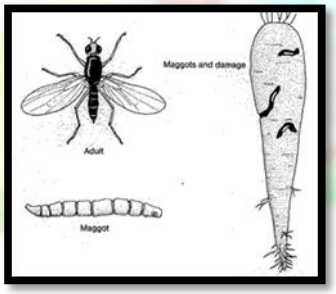
Identification marks:

- Adult is about **6-8 mm long with a shiny black thorax and abdomen, a reddish-brown head and yellow legs.**
- Itisa **dark coloured fly**.The larvae are **white maggots** approximately 1 cm long.
- Site of ovipositionis**Soil**.
- Egg period: **6-10 days**. The larvae (**Maggot**) are the damaging stage; **after hatching feeds on the carrot root.**

(Source: Internet)

Nature of Damage and Symptoms:

- The **larva feeds on the carrot root, rendering the carrots impossible to market.**
- Carrot rust flies obtain their common name from the **rust coloured frass**as they **deposit in the superficial feeding tunnels on the carrot**(Hopper *et al.* 2002).



Management:

- Use of row covers will help to protect plants from damage before adult fly lays eggs on plants.

PESTS OF BEETROOT

S. No.	Common name	Scientific name	Family	Order
1.	Beet Leaf Miner	*Pegomyiabetae*	Anthomyiidae	Diptera
2.	Web Worm	*Hymenia recurvalis*	Pyraustidae	Lepidoptera

1. Beet Leaf Miner: Scientific name –*Pegomyiabetae*

Family - Anthomyiidae

Order -Diptera

Identification marks:

- Maggot is **greenish white** in colour. Adult is **7 mm long, pale grey, legs rusty yellow with black tarsi.**

(Source: Internet)

Nature of Damage and Symptoms:

- Maggot bores between the epidermal layers of the leaves, thus causing serious injury to the leaves.
- Consequently the plant growth is checked. Infested leaves show blistered appearance.

(Source: Internet)

Management:

- Destruction of fallen leaves and plant refuge after harvest.
- Spray application of Chlorpyriphos 20 EC @ 2 ml/l, Flubendiamide 480 SC @ 1 ml/l.

2. Web worm: Scientific name -*Hymenia recurvalis*

Family - Pyraustiidae

Order - Lepidoptera

Identification marks:

- Larvae **spindle-shaped, greyish-green in colour with black markings.**
- Adult is a **small brown colour moth with a slender body.**
- Wings are **dark brown in colour with broad white lines in the middle and outer margin.**

Nature of Damage and Symptoms:

- It is a **sporadic pest**.
- Damage is caused by **caterpillar**.
- **Web together the tender leaves** and **skeletonise the leaves by feeding inside the web.**The **affected portion becomes dry up**(Walsh and Hargreaves, 2005)**.**

Management:

- Spray application of Chlorpyriphos 20 EC @ 2 ml/l, Flubendiamide 480 SC @ 1 ml/l.

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CASSAVA INGREDIENTS FOR MODERN DAY FOODS

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Functional pasta from cassava

Functional pasta is a normal pasta product which provides additional benefits. Pasta products with enhanced nutritive value like high protein content or functional value like high dietary fiber content were developed from cassava and sweet potato. These products are characterized by good textural quality and low starch digestibility which make them ideal as food for diabetic and obese people Kadam, S. U., & Prabhasankar, P. (2010).

Fried snack foods from Tuber flour

Cassava Pakkavada: This is a hot snack food having good texture and taste made out of cassava flour. The other ingredients include maida, bengal gram flour, salt, chilli powder, asafoetida, baking soda and oil. The ingredients are thoroughly mixed and made into dough with hot water (50°C), proofed for 1h and then extruded through hand extruder having flat rectangular holes, Into hot oil.

Cassava Sweet Fries: This is a sweet snack food made out of cassava flour, maida, baking soda and oil. The ingredients are mixed well and made into dough with hot water (50°C). The dough after proofing for 1h is hand extruded through die having round holes, into hot oil. The fried product is then coated with sugar by dipping for a few minutes in sugar syrup having thick consistency.

Cassava Nutrichips: This is a high protein snack food made out of cassava flour by mixing with other ingredients like maida, groundnut paste, egg, salt, sugar, sesame, coconut milk, baking soda and oil. After mixing the ingredients, hot water is added and mixed to form smooth dough.

The dough after proofing is made into small balls which are then spread into sheets of 0.2cm thickness. This is then cut into dimon shape using a sharp knife and deep fried in oil. **Cassava crisps:** This is a soft and good textured crispy snack food made from cassava flour, maida, rice flour, bengal gram flour, salt, baking soda, turmeric powder and oil. The dough made with hot water is proofed for 1h and then extruded through the small pore size die having round holes. The deep fried material is mixed with fried nuts, curry leaves etc. before packing. **Other products include:** Cassava nutrichips (without egg), Cassava salty dimons, Cassava hot sticks, Cassava salty fries, Cassava sweet dimons etc. for which also formulations are available.

Cassava Rava

Cassava or tapioca (*ManihotesculentaCrantz*) is one of the important tuber crops valued for its high starch content (20-35%). Cassava rava is a pre-gelatinized granular product similar to wheat semolina and finds use as a breakfast recipe product. For the preparation of cassava rava, the tubers are peeled and sliced into round chips. It is then partially cooked by boiling in water for 5 min, decanting the steep water, sun-drying the parboiled pieces and powdering coarsely in a hammer mill. This is then sieved through fine sieve to separate out the finest fraction which can be converted to porridge powder by flavoring with cardamom and fried powdered cashew nuts. The residue is sieved through larger mesh size sieve to obtain rava. The uneven large pieces are again powdered to recover the rava.

Extruder products from cassava

The tuber crops snack foods were produced by extrusion cooking to develop direct expanded extradites.

Features

• Atpresent no cassava extruded products are available in the market.

• Extrusion of cassava gives a high expanded product with a bland taste. Cassava extrudates are totally oil free and hence has much dietetic value.

• Cassava flour is a cheap raw material at the cassava growing belts

Baked products from cassava flours

The baked food products play a crucial role in Indian diet as they are partially substituting meals in the breakfast and dinners. Major product categories include biscuits, cookies, snacks, cakes, pastries and rusks and puffs, while few new product types like cupcakes, strudels, waffles and doughnuts are also added in the recent days.Gluten is a mixture of proteins found in wheat and related grains, which gives elasticity to dough and gives "spongy" texture to baked foods like pasta, bread, cookies, pizzas, etc. Despite improving the texture of baked goods, gluten is considered as a harmful ingredient as it interferes with the absorption of nutrients, and its consumption leads to Celiac disease. The current prevalence of Celiac disease in India is estimated as 1% and commonly found in north India where wheat is a staple food. A lifelong gluten free diet (maximum of 20 mg of gluten per kilogram of food) is the only treatment available to cure Celiac disease Serrem *et al*., (2011).

At ICAR-CTCRI, gluten free cookies were prepared by replacing wheat flour up to 50% - 60% along with other ingredients like rice flour, tapioca flour, sweet potato flour, taro flour and sorghum flour. The cookies are available in various shapes and sensory quality is acceptable to the consumers.Gluten-free breads were prepared by substituting wheat with 50% sweet potato flour or 30% taro flour with acceptable sensory quality.

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SUMMER GROUNDNUT PRODUCTION TECHNOLOGY-A SUCCESS STORY

Article ID: AG-VO3-I03-03

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Introduction:

Groundnut (*Arachis hypogaea*) is a self-pollinated, important oilseed crops in Indian agriculture. Groundnuts are rich in essential nutrients which are potential to provide health benefits. Groundnut gives 570 calories per 100 g serving and are an excellent source of several B vitamins; vitamin E; dietary minerals, such as manganese (95% DV), magnesium (52% DV), phosphorous (48% DV); and dietary fiber (right table). They also contain about 25% protein per 100 g serving, a higher proportion than in many tree nuts. Groundnut is grown on nearly 23.95 million ha worldwide with the total production of 36.45 million tons and an average yield of 1520 kg/ha in 2009 (Anonymous 2010-11)). China, India, Nigeria, USA and Myanmar are the major groundnut growing countries. However, the low groundnut productivity in many developing countries remains a cause of concern to the scientific community and policy makers. Good crop agronomy is crucial in harnessing the full potential of the crop in addition to appropriate variety and quality seed in order to facilitate a synergistic effect on crop productivity. This farmer friendly booklet provides information on improved cultural practices in groundnut cultivation which will empower smallholder farmer to make his/her own decision on various components of integrated crop management technology. India recorded the highest production of groundnut about 97.14 lakh tonnes in 2013-14, of which, Gujarat contributed

nearly 49.21 lakh tonnes (50.66%), owing record productivity of 2670 kg/ha from 18.43 lakh ha area. Integrated nutrient management (INM) is one among the possible way to improve this soil for sustainable farming.

Situation analysis/ Problem statements:

Consumption of oil in human food is very important for growth and development of body and groundnut is richer source of oil and traditionally essential part of Indian food habit. Even the farmers of district Panchmahal were cultivated traditionally. The average yield of groundnut is very low due to various valid reasons.

Plan, Implement and Support:

To increase the area and productivity of oil seed - Groundnut cultivation the scientist of KVK motivated farmers for cultivating the groundnut crop in summer seasons. There are 150 farmers from 20 villages 05 blocks of Panchmahal district forwarded for groundnut in summer season, under oilseed cluster demonstration with supervision of KVK scientists and provided them package of practices right from the seed treatment, nutritional management, weed management and irrigation method. One farmers meeting were conducted to analyze the technology gap and to get information on soil, water and other conditions.

Output:

The farmers who followed wheat/paddy-sugarcane-ration in past and they were not able to procure even their input cost easily. Groundnut produced on an average 19.5 q/ha in demonstration plots while 15.4 q/ha in farmers practice. The yields were increase over farmers' practice 26.6 per cent. Groundnut Crop

was obtained more yield 66.3 per cent and 41.3 per cent at district level and state level, respectively.

Outcome:

The farmers got relatively higher net return in Groundnut i.e. Rs 65925/ha by adopting improved technology of Groundnut cultivation than the Rs. 40090/ha by using traditional technology in past years and this is at near four time fold from local practice return. The Net Return was 64.4 per cent more recorded in case CFLD demonstration fields. The B:C ratio was recorded higher 3.4 in adopting practices than the local practice 2.9.

Impact:

Finally, it is concluded that the technology of cluster oil seed production technology highly impacted on yield, socio-economic status of the farmers of district Panchmahal. Farmers of the district will increase more area in summer oil seeds (Sesamum and Groundnut) crops. It also recorded improvement in soil health and environment and increase the productivity of the land.

Performance of technology vis-à-vis Local check (Increase in productivity and returns)

Practice used	Yield (q/ha)	Gross cost (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Farmer practices	15.4	26900	66990	40090	2.9
Demonstration	19.5	27600	93525	65925	3.4
% Increase	26.6	-	-		-

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SPECIALISED TECHNIQUES FOR PROPAGATION

Article ID: AG-VO3-I03-04

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Introduction

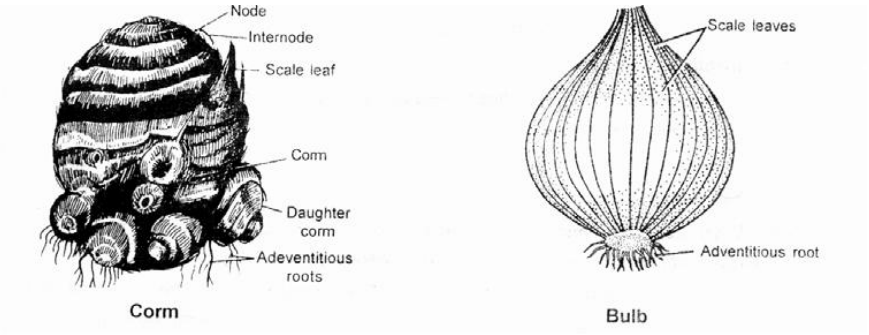
The term "propagation" describes the multiplication or perpetuation of a single or group of plants that have a particular value to humanity Arizaga and Ezcurra, (2002).The plants in several horticulture crops have unique vegetative structures that store food and are used for plant multiplication. These structures can naturally separate from the mother plant, a process known as "separation." It is sometimes necessary to divide these structures into smaller pieces in order to propagate them (Dogra*et al*.,2018).

1. Bulb

It is an underground part. It has short, fleshy vertical stem axis bearing at its apex a growing point or flower primordium enclosed by scales. The outer scales are fleshy and contain food materials whereas the scale towards the inner portion contain less food. Bulbs having dry and membranous outer scale are called as **'tunicate bulb'** (eg. **onion**) and bulb which lack this cover is known as **'non-tunicate bulb'** (eg. **lily**). Tunicate bulbs are protected by outer scale and non-tunicate bulbs are easily damaged.

2. Corm

It is the swollen base of a stem axis enclosed by the dry, scale like leaves. It is a solid stem structure with distinct nodes and internodes, eg. gladiolus corm. The miniature corms develop between the old and the new corms is termed as **'cormels'**. These corms can be cut into sections, retaining a bud in each section and used for planting. Eg.**Elephant foot yam**.



3. Tuber

It is a modified stem structure which develops below the ground as a result of the swelling of the sub apical portion of a stolen and subsequent accumulation of reserve materials. A tuber has all the parts of a typical stem eg. **Potato, Jerusalem Artichoke**. These tubers are used for propagation either by planting whole tubers or by cutting them into sections each containing one or more buds. Some plants produce tubers in the axils of leaves which are known as tubercles (eg. ***Dioscoreabulbifera***) and used for propagation

4. Tuberous roots and stem

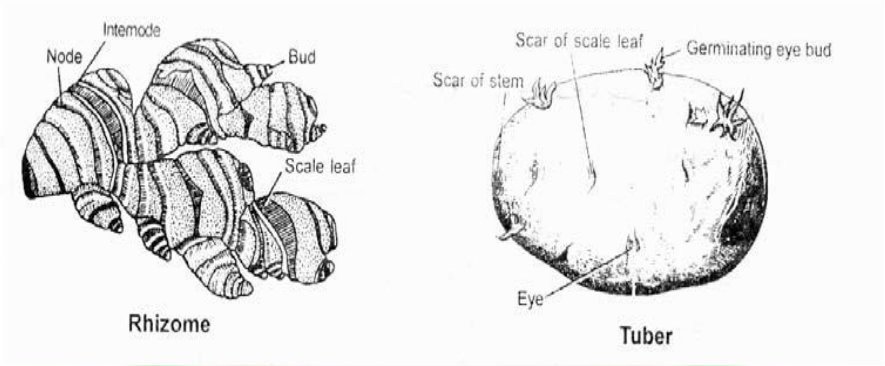
In some plants like **sweet potato** and **dahlia**, the adventitious roots become thickened and they have external and internal structures of roots but lack nodes and internodes. These are known as tuberous roots.

In plants like begonia, cyclamen have thickened structure which have arisen from enlarged hypocotyl tissue. They have a vertical arrangement and may show features of stems. Propagation of plant with such roots or stems consists of division of such materials into sections, but each section should have a section of the crown bearing a short bud.

5. Rhizome

It is a stem structure in which the main axis of the plant grows horizontally at or just below the ground surface. It consists of nodes and internodes having leaf scars on the node. Eg.**Ginger, Turmeric**, Ferns etc. In determinate type of rhizomes each clump ends in a flowering stalk and growth continues only from lateral branches. Eg.**Cardamom**.

Indeterminate type of rhizomes do not produce a clump but spread extensively over an area and grow continuously from the terminal apex and from lateral branches. Propagation through rhizome is by cutting the rhizome into sections and each piece has at least one lateral bud or eye.



6. Runner

It is a stem which develops from the axis of a leaf at the crown of a plant, grows horizontally along the ground and forms a new plant at one of the nodes eg. **strawberry and mint**.

7. Offset

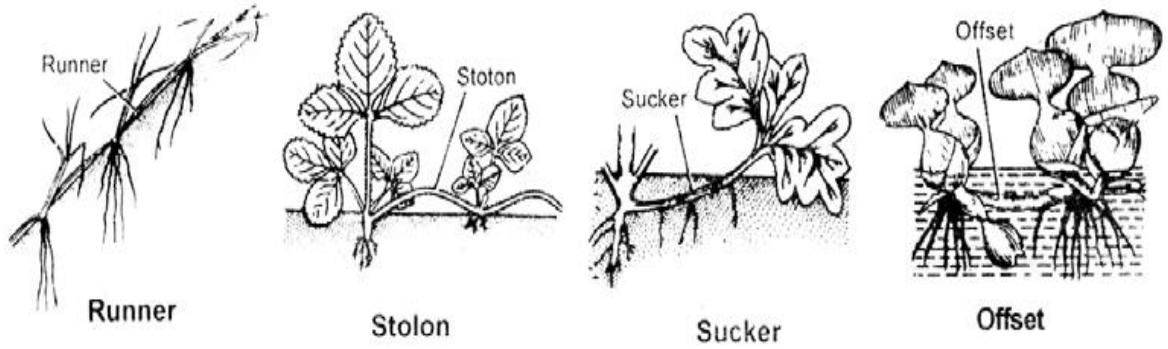
It is a special type of lateral shoot or branch which develops from the main stem in certain plants and it is characterized by shortened thickened stem of rosette like appearance. Offsets which produce sufficient roots can be separated by cutting them close to the main stem with sharp knife and used for propagation Eg. **pine apple, date palm**.

8. Suckers

A sucker is a shoot which arises on a plant from below ground usually from an adventitious buds on a root, eg**. Chrysanthemum**.

9.Stolon :

A stolen is an aerial shoot which comes in contact with the ground and strikes roots. It may be a prostate or sprawling stem which grows horizontally from the crown. Eg.**Cyanodondactylon**. A shoot rooted in this manner is merely cut from the parent plants and transplanted or potted.



10.Bulbils :

Aerial stem bulblets commonly known as bulbils are formed in the axils of leaves of some lily species such as ***Liliumbulbiferum, L.tiginum***. Bulbils develop in the early part of the season and fall to the ground several weeks after the plant flowers. They are harvested shortly before they fall naturally and are then planted. Increased bulbil production can be induced by disbudding as soon as flower buds have formed. Some lily species which do not form bulbils naturally can be induced to do so by pinching out the flower buds. Eg.***Liliumcandidum, L.maculatum***.

11. Crown

This istheextensionof central axisabove the fruit consisting of a short stem bearing closely set, short leaves. These can be cut and planted for producing an individual plant. Crowns used in propagation of pineapple are taken either from the fruit or at the time of harvest. Crowns will produce fruit in about 22 months after planting while slips produce in 12-18 months. Eg.**Pineapple**.

The term crown used in horticultural terminology is that part of a plant stem on the surface of the ground from which new shoots are produced. **In trees or shrubs** with a single trunk, the crown is principally a point of location near the ground surface marking the general transition zone between stem and root. **In herbaceous** perennials, the crown is the part of the plant from which new shoots arise annually. The adventitious roots develop along the base of the new shoots.

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NIPPING ON GROWTH AND YIELD OF CHICKPEA - A SUCCESS STORY

Article ID: AG-VO3-I03-05

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Introduction

Chickpea (Cicer arietinum L) is most important pulse crop in Indian . Among the pulses highest average productivity was noted in chickpea (858 kg/ha (Anonymous 2009-10) at national level followed by pigeon pea, black gram, green gram etc. And several chickpea producing state Andhra Pradesh registered highest productivity 1559 kg/ha followed by Bihar 894 kg/ha, Gujarat 850 kg/ha and Madhya Pradesh 711.8 kg/ha((Anonymous 2009-10). While district Panchmahal (Gujarat) have more productivity of Chickpea 950 kg/ha as compared to Gujarat State Chickpea is as one of the most important pulses crops of the Panchmahal district of Gujarat. However, its productivity of chickpea in the district is very low. Attempts are made to improve productivity and to increase area under chickpea by adopting HYVs (high yielding variety). Apart from other production enhancement indicators, nipping appeared to be a factor increasing yield and yield contributing parameters. To investigate the appropriate topping technique as well as to sort out combination of spacing and topping, an demonstration was conducted during 2019-20 with chickpea variety GG-3. Nipping in chickpea is one of the important parameter for the enhancement of yield and yield contributing parameters. Crop could increase number of branches while restricting profuse vegetative growth thereby promoting crop yield. Nipping at various stages tended to enhance number of branches and number of pods that

in turn boost chickpea yield. Estimate the effect and most appropriate method of nipping on yield of chickpea.

Sowing Time- In middle Gujarat 10 October to 20 November is the ideal period for sowing chickpea. In rice-based cropping systems, chickpea sowing is depending on harvest of rice.

Seed rate and spacing - Seed rate of 80 kg per hectare use of chickpea verity GG-3, line sowing is a must in the crop grown for production. Row-to-row spacing of 35 cm and plant-to-plant spacing of 10 cm are used.

Nipping: Nipping of chickpea especially during December to January. Nipping or cutting back chickpea at various levels would enhance yield and yield contributing parameters of this crop.

Seed treatment: The seeds should be treated with fungicides (2 g thiram + 1 g carbendazim kg-1 seed) before sowing for reducing seed and soil borne fungal diseases.

The recommended doses for chickpea include 20kg nitrogen (N) and 40kg phosphorus (P) ha^{-1}. Foliar spray of 2% urea at flowering has been found beneficial in rainfed crops.

Irrigation: Chickpea is generally grown as a rainfed crop, but two irrigations, one each at branching and pod filling stages, are recommended for higher yield. Higher number of irrigations may lead to excessive vegetative growth in heavy soils.

Weed management: Chickpea is a poor competitor with weeds at all stages of growth. Pre-emergence herbicides, such as Fluchloralin @ 1 kg a.i. ha^{-1} or Pendimethalin @ 1.0 to 1.5 kg a.i. ha^{-1} were found effective in controlling early flush weeds.

Insect Pests and Disease Management:

Gram Pod Borer (Helicoverpa armigera)- Spraying of Novacuron 10EC 1ml/lit of water.

Wilt (Fusarium orthocerus)- Thiram at the rate of 2.5 g per kg of seed.

Rust (Uromyces ciceris arietini)- Spray the crop with 0.2% Mancozeb 75 WP followed by two more sprays at 10 days interval.

Output:

The average yield at demonstration on farmers field was 16.7 q/ ha (maximum yield 17.9q/ha) with cost of cultivation of Rs. 18400 per ha. The average net profit per ha was

recorded Rs. 55915. The yields were increase over farmers' practice 45.28 per cent. Due to high number of pod, number of branch and bold seed variety that possesses high degree of resistant against wilt.

Outcome:

This technology may be capable for increasing seed replacement ratio in district with extra net return. Due to higher demand of seeds of this variety emerged an entrepreneurship programme of seed production at farmer's field for better income.

Performance of technology vis-à-vis Local check (Increase in productivity and returns)

Specific technology	Yield (q/ha)	Gross cost (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Farmer practices	11.5	17500	51175	33625	2.9
Yield after nipping in the variety (GG-3) demonstration	16.7	18400	74315	55915	4.03
Increase in yield (%)	45.2				

Impact:

As a result, this technology was horizontally spread in 21 villages covering 150 farmers in 60 ha. during these three years. This technology is gaining momentum among the tribal farmers of Panchmahal district through constant contact by the scientists of Krishi Vigyan Kendra, Panchmahal and CFLD, following the training, advisory service, field day etc. guidance. Adoption of this technology also increased income of the farmers.

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GARDEN DESIGNING COMMERCIAL AND OPEN SOURCE SOFTWARE

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Introduction

Most popular landscaping software allows you to digitally build landscape elements around your home or import images of your home, and then view finished designs by day, night, or season. The versatility and benefits that many of the free internet downloads for landscape design programmes typically lack are provided by landscape design software for designers.

There is a tool for garden landscape design that helps you choose plants that will survive in your area's climate, and even see how they will look after a certain amount of time. You no longer have to even test a plant or do extensive research on it, you can just know by looking it up on your software. 3D landscape software is an opportunity for homeowners like you to plan out everything you have in mind for your property before you even plant the first seed. It's easy, fun, affordable, and allows you to pick whatever decks, fencing, pools or gazebos will fit your vision of a home.

LANDSCAPE DESIGN SOFTWARE: WHAT TO LOOK FOR

Exceptional Landscape Design Software offers numerous easy-to-use tools and gives you all of the support you need to learn how to use the program like a pro (Peng*et al*.,2014).

Features & Tools

The feature set is the landscape design toolbox. A larger set of tools isn't necessarily better; look for landscape design software that has features you need to create the type of landscape plan you want. For example, some landscape design software has templates for decks,

gardens, and patios, and some software focuses more on the objects you can put onto a landscape, such as plants. Having a plant encyclopedia with a vast object library is great for whatever kind of design you have in mindEvans and Kelley (2004).

Design Quality

We like programs that have 3D flyaround, walkthrough, and object editing so you'll have an excellent idea of what the finished product will look like after all the work has been completed. There are also 2D photo import options on most software, and we determine quality partly on software's ability to convert 2D to 3D.

Ease of Use

Landscape design software controls should be easy to find, use, and understand. Powerful, intuitive controls often make all the difference between successful landscape design software and a product you'll abandon on the shelf out of frustration.

Help & Support

You'll want landscape design software that comes with good help online: a help index, help tutorials, FAQs and support forums and help menus or other help options included with the software. So before you grab your trowel or spend thousands at your local nursery, design your landscape virtually, without breaking a sweat.

Finding the right landscaping software should be fun, and seeing the property of your dreams will be even better. Look at all the options and find the one that will give you the best deal.

Top 10 Home designing paid software

1.Home& Landscape Design($49.99)

Standout Home Design Features:

- Easy drag and drop room-by-room building with QuickStart
- Large furniture and fixture library
- 2D and 3D design and views
- Easy 3D navigation
- Automatic Roof Generation

- Power Tools allow custom 3D object design
- Print materials lists and estimate costs with Power Tools
- Landscape design software included

Home & Landscape Design is a great tool for experienced and new users alike, but "prosumers" and contractors may need more professional grade solutions. For the prosumer, Punch! Home & Landscape Design Suite offers everything in the basic package reviewed here, but adds more deck and landscaping design options, and brand name interior deco and trim from Sherwin Williams, Enviroglas, Beuchel, Daltile and more. If that's not enough, in the design suite you can import 3D objects (furniture, cabinets, fixtures, etc.) directly from Google's online library. It's a great deal, giving you thousands more options for $50 more.

2. Better Homes and Gardens Home Designer Suite 8.0($99.99)

Home Designer Suite 8.0 is also a great all-in-one solution if you want to design decks and landscapes, and validate your designs against standard building principles in addition to home design. If you need a professional, high end home design solution, Better Homes and Gardens has more professional-level functionality in store with Home Designer Pro 8.0, also by Chief Architect.

This is where Home Designer Suite 8.0 really shines. The interface is just as simple as it can be: not cluttered, and the most common tools are at your fingertips. The editable home plans are just beautiful, as are the fixtures, furniture, and appliances in their object libraries. You can even download new object libraries from the web, from home theater accessories to water sports equipment, Home Designer Suite 8.0 has you covered. It’s almost like you’re in your own little dream world when using Home Designer Suite 8.0 in 3D mode.

3. Instant Architect 12($27.99)

Instant Architect has a great house builder wizard that guides you through the process of setting up a basic home, from the foundation up. It literally takes about a minute to build a home and then customize to your liking. The object library, or catalog, has 3D models for appliances, furniture, fixtures, and lighting, but what really set it apart was the ability to edit object properties: You can edit the appearance, dimensions, and even enter the manufacturer and price

information, to aid in creating a budget. In fact, we really liked how we could double-click and edit just about any object in real-time.

4. Total 3D Home Design Deluxe ($24.99)

Total 3D Home Deluxe is not as eye-candy-filled as the higher-ranked programs, but it has some really interesting design options to play with, like the Decorating Tools. You can choose any room in the house, and "decorate" each room with pre-designed templates, or make your own. It's easy to use, and fun! To put your home design together, you simply click on the specific room block you want, drag it to the appropriate location on your plan and then drop and resize it to fit. It's quite simple. Total 3D Home Deluxe also includes over 20,000 real product images to help you better visualize and reach your home design goal. Once you've completed your design, you can use Total 3D Home Deluxe's 3-D feature to walk through the inside or fly around the outside your virtual home. This is what we found a little more than cumbersome. We found in 3D mode you must "walk" through an opening, like a door, otherwise you can't get inside the house by moving your mouse through. This can get a little annoying when trying to move through the interior.

5. My Virtual Home 1.8.3 ($39.95)

Tried and tested for several years in Australia's expanding housing market, MyVirtualHome offers the features and tools necessary to design, plan, experiment and, ultimately, to communicate ideas to contractors and other building professionals that could otherwise be unclear or lost in the blueprints. With an established goal of connecting consumers to manufactuers, suppliers, professionals and consultants in a more efficient manner,MyVirtualHome helps reduce consumer cost, material waste and time spent by all involved parties, which ultimately benefits not only the consumer and contractor, but the community whose resources they share, too. Now, with the premiere of their Global Edition, MyVirtualHome offers the same features and tools used with great success in Australia within an expanded and updated user interface with improved tools and a broader feature set. More importantly, MyVirtualHome offers the same in-built features for finding consultants, contractors and other building and design professionals in your local area that made the program so successful and practical in Australia.

6. 3D Home Architect & Landscape Design Deluxe Suite 9.0($39.95)

3D Home Architect Home & Landscape Design Suite from Encore is actually a rebranded and toned down version of Punch! Software's Home and Landscape design products, but it's still a good deal for the price. Punch! products are known for quality, and this offering from Encore is no different. You can complete the most common tasks with this software, from designing and landscaping a home to sprinkler and deck design, this product does it all. The only catch is the tools are basic and have less options than the more expensive products. You get what you pay for in this case. Bottom line, if you're looking for a program to quickly and roughly model a home and landscape with, this product is for you.

7. Instant Home Design 3($24.95)

Instant Home Design 3.0 is definitely an entry-level program, offering home design newcomers all the basic features they need for a low price tag. There are no landscaping features available in this program; it is strictly for home design. Instant Home Design 3.0 by Topics Entertainment is a well-designed, basic home design program that beginners may find useful, but there are much better products available for slightly more money.

8. Your Custom Home 2005($48.99)

Your Custom Home is different than most home design software in that you start by selecting a room design by shape (square, rectangle, T-shaped and so on) and then go from there. The program allows you to resize wall length easily, but doesn't allow you to alter the original shape you selected. If you find you need a different-shaped room, you'll need to start over and choose different predefined shapes. There is also a tool available to create your own shaped rooms if the shapes supplied don't meet your needs. There are no landscaping features in Your Custom Home. Your Custom Home has a 3-D view for a walkthrough or a helicopter view of your design, and you can take "snapshots" of your home design as you move by. Your Custom Home by ValueSoft offers an easy-to-learn, room-by-room design package that may suit some beginners, but the program doesn't offer options and customization tools required by serious home designers.

9. Design Workshop Classic($79.95)

Design Workshop Classic is a powerful tool that can help you create very realistic 3D designs - in the right hands. Again, this product is more for the intermediate CAD pro than for the average home user. This product is available for both PC and Mac computers, and Artifice offers support through the application, email, and online forums. There is some confusion about which Mac Operating Systems this program runs on. Users have reported that it doesn't work on newer OS X versions, like 10.4 and beyond, so buyer beware. Design Workshop Classic can help you create some really nice 3D environments, but be prepared to invest a good deal of time learning the ins and outs of the program.

Quickie Architect 3.0($39.95)

Quickie Architect, from Upperspace, is a newcomer this year, and is aptly named: It's best suited for quick and dirty two-dimensional (2D) design, and is geared more for amateur CAD hobbyists than home users. If terms like Line Snap, Hatch Fill, Orthogonal Mode, and Point Polar make sense to you, then this product is right for you. It is easy to display and alter any of their 150 floorplans, but there is no 3D viewer to see your design come to life. Quickie Architect has a decent help system complete with tutorials and walkthroughs, and ifyou're an amateur home designer, you'll certainly need it. Quickie Architect is a formidable program, but it's best suited for those familiar with CAD software.

Top 10 Free Landscaping Software That You Can Download for Your Designing Ideas

10. 3D Landscape for Everyone

The 3D Landscape for Everyone is a free landscaping software, which provides users with the basic tools in landscape design; however, this is not the program for people who simply want to take pictures and then use the photo to design the landscape. Nevertheless, this program can provide simple and basic three-dimensional imaging manipulation and modification. Regarding the results of using this program, do not expect a realistic or very impressive image.

9. 3D Home Architect Home & Landscape Deluxe Suite

If you can spend some money, you can try the 3D Home Architect Home & Landscape Deluxe Suite. This paid program is very affordable and worth it for the features and functionality. The 3D Home Architect Home & Landscape Deluxe Suite has a user-friendly

interface. Even beginners will have an easy time navigating and creating designs using this program. The basic landscaping features are included in this program. However, for advanced users, there are other software that can do the job better than this one.

8. Imagine Pro

The Imagine Pro landscaping program is another software recommended by some landscape designers. It is necessary for users of this program to listen to the tutorials in order to get the hang of using this program. You can also do some experimentation using this program. The downside of using this is that it is not capability of creating 3D models. However, the 2D result (the photos and images) gives impressive, realistic and precise and accurate preview of the landscape design.

7. IMSI TurboFLOORPLAN Landscape & Deck

This TurboFLOORPLAN Landscape & Deck from IMSI is a powerful program with great potential for the users. The features and functionalities included in this software can get the job done. However, this one requires users to have a high end and powerful personal computer. This program is also good for those who prefer no superfluities in their approach to landscape designing.

6. Total 3D Home, Landscape & Deck

The Total 3D Home, Landscape & Deck is an impressive landscaping software sold at an affordable price. One of the main strong points of this program is its effectiveness in designing landscapes as well as home. A thorough study of this program is required before you can grasp and harness its full potential. Another thing, this program is specific in terms of what and what not to allow during the design and drawing.

5. HGTV Home & Landscape Platinum Suite

The HGTV Home & Landscape Platinum Suite is one of the outstanding selections for those looking for landscape design software. HGTV is known for home renovations including landscaping and it is not surprising if they come up with their own software. The program contains the essential landscaping tools as well as other functionalities for building, re-modeling or in re-thinking of the design ideas. This program provides fast, effective and efficient work.

4. Landscaping & Deck Designer

The Landscaping & Deck Designer is another landscape designing program designed for the average home user. This program is also intended for the professional in the landscaping field. This program can help landscapers to provide their customers with visual and digital ideas through the videos showing aerial and walkthrough views. The interface of the program is very user-friendly making it possible even for beginners to create and put his/her ideas into motion.

3. Home & Landscape Design

close up. The library includes 470 high-resolution 3D plant models which are ideal for movies and 3D walkthroughs.

Create Swimming Pools and Spas

Design breathtaking swimming pools and spas. Above ground, in-ground, multiple level, and infinity edge pool styles are supported. Create spas that flow into pools, add pools with rockery, diving boards, or waterslides, and add products from national manufacturers such as S.R. Smith, Master Tile, and PebbleTec(tm). Present clients with a surprisingly realistic view of your swimming pool design ideas, complete with flowing water, reflections, ripples, and even nighttime lighting.

Design Irrigation Systems

Design irrigation systems perfectly suited to your client's landscape design. Add sprinklers, piping, and other symbols. Set the coverage angle and radius of each sprinkler head as needed.

Create Cost Estimates and Material Lists

Quickly estimate the cost of each project using the integrated and automatic Project Material List. Simply open the list, enter prices for the different landscaping objects, and print the result. When creating client quotes, you can export the material list to Excel and add labor, excavation, and other custom items as needed.

Deck Design Made Easy

Use the intuitive deck tools to create decks of virtually any size, shape, and style. Create a deck design in as few as five clicks, and then customize your creation until you find the perfect combination of style and function. Select one of our predefined styles to instantly visualize a new

look, or design your own. Help clients visualize your design ideas with realistic deck furniture, outdoor kitchens, and more.

Design Patios, Fencing, Driveways, and More

The possibilities are endless with the wide variety of tools included in Realtime Landscaping Architect 2014. Create metal, vinyl, wood, or chain link fencing with ease. Add patios and driveways by simply drawing their shape and selecting a material. Add realistic paths, hedges, rockery, and much more.

Fencing styles include metal, vinyl, wood, and chain link. Add fencing by simply drawing the fence shape and selecting a material. Add realistic paths, hedges, rockery, and more. **Patios** of any shape and size can be added. Belgard and Unilock materials are included. Have a custom paver? Import your own from a photo using the Wizard. Create **driveways** using powerful tools and detailed vehicles. Both sloped and flat driveways are supported. Landscaping **paths** are easily added and support hundreds of different materials. Border paths with rocks, lighting, garden designs, edging, and more.

Plants from Every Planting Zone

Choose from over 7,200 high quality plants using the built-in search tools. Locate plants that will thrive at your client's location and add them to your landscape design with just a few mouse clicks. Use the Plant Growth tool to help clients visualize what their landscape will look like in the future: anywhere from three months to more than 20 years. This is a great way to determine spacing and other size considerations.

Design over a Photo or in Realistic 3D

Import a photo of your client's property and design the landscape. Or, design their entire landscape in full 3D using powerful design tools. Mix and match methods as needed based on the needs of each client.

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EVENTS OF IMPORTANCE RELATING TO CLIMATE CHANGE IN 2022

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Introduction

2022 saw a resurgence in climate change awareness thanks to the disastrous flood in Pakistan, the heatwave and drought in Europe, and the above-average wildfires in the US. As the year draws to a close, we anticipate the important events in 2022.

Pakistan has seen severe floods.

Pakistan had some of the worst floods in recent memory this year. The floods, which started in July but got worse during the next month, reportedly affected over 110 of the 150 districts in the country. The flood was a direct outcome of this year's abnormally rainy monsoon season, which brought more rain than usual to the nation."Pakistan has never had a monsoon cycle that is continuous. Eight weeks of uninterrupted heavy rain have resulted in vast areas of the country being under water. This season is not like others. Sherry Rehman, Pakistan's Minister for Climate Change, stated on Twitter that this assault affects a population the size of a small country, 33 million plus.According to Pakistan's National Disaster Management Authority (NDMA), the floods affected over 15% of the country's population, or roughly 33 million people. This makes the disaster more severe than the 2010 "superflood," which had an impact on nearly 20 million people. According to Pakistani media, this year, more than half of the country was under water, leaving millions without a place to live.

Drought and heatwave in Europe

Europe had a heatwave this summer that broke several records. For the first time ever, temperatures over 40 degrees Celsius were recorded in several parts of the UK. In a few places, the temperature in France exceeded 45 degrees Celsius, which is a new high for the country.This is an illustration of the more typical pattern of temperature rises brought on by global warming. The last eight years have been the warmest on record for the average annual temperature since the 1880s, according to a NASA study, with 2021 ranking as the sixth warmest year on record. At the same time as the heatwave, Europe simultaneously faced the worst drought in 500 years.

Updated list of India's nationally decided obligations

In contrast to an earlier goal of 33 to 35 percent, the Indian government said in August that it will reduce its emission intensity from 2005 levels by at least 45 percent by 2030. Another improvement was the country's goal of having at least 50% of its total energy output come from renewable sources by 2030, up from the current level of 40%.These words came soon after the news-grabbing ones made by Prime Minister Narendra Modi at the Glasgow climate change meeting in 2021. The NDC is a part of the 2015 Paris Agreement, which instructs every country to set its own climate goals, which will then be gradually updated with more aggressive targets every few years. India filed its first NDC before the Agreement was finalised in 2015.

In the climate change performance indicator, India outperforms wealthier countries.

In the Climate Change Performance Index, which was presented at the COP27 and comprised 59 countries in addition to the European Union, India was rated ninth, moving up two spots from its previous position.The bulk of industrialised countries were ranked below India on the list: the United States was ranked 52, China was ranked 51, the United Kingdom was ranked 11, and Germany was ranked 16. In accordance with evaluations, Denmark and Sweden are once again the top achievers this year."India scores well in terms of GHG emissions and energy consumption, but just averagely in terms of climate policy and renewable energy sources. The country is on track to meet its carbon reduction targets by 2030. (fit with a scenario with a temperature considerably below 2 degrees Celsius). The renewable energy pathway, however, is not on track to meet the 2030 goal, according to a statement that accompanied the index.

Renewable energy and the war in Russia and Ukraine

Vladimir Putin shut off nearly 90% of the gas supplies to Europe as revenge for the sanctions the West had imposed on Russia. Even after the sanctions were put in place as a result of the invasion of Ukraine in February of this year and the accompanying Russia-Ukraine war, gas exports from Russia continued. 40% of the gas utilised in Europe came from Russia. Europe had energy shortages as a result, which also had an impact on inflation.

Fund for Loss and Damage from COP27

This year's COP27 in Sharm el-Sheikh, Egypt, marked a critical turning point in the global response to climate change since it decided to create a loss and damage fund, which was a crucial demand of impoverished nations. Expenses that wealthy, industrialised nations, which are primarily at fault for industrial emissions that have an adverse impact on the environment, should pay for on behalf of poorer nations who have contributed little to pollution but are more vulnerable to catastrophic climatic disasters are referred to as "loss and damage" (for example, the Pakistan floods).This was the one encouraging thing at a poor conference, though. The COP27 was billed as the "implementation COP," or the conference that would speed the actions to combat climate change; however, this expectation was unfulfilled. But India planned to phase out all fuels, not just coal (at various points, India has asserted that it will not phase down coals due to its energy needs). The selective labelling of some energy sources as "green" was also criticised for being dishonest by industrialised nations, according to the report, who said that this was not backed by research.

Paintings are vandalised as a method of protest by "activists" opposed to climate change

One of the weirdest developments in the fight against climate change this year was the vandalization of iconic pieces of art by a group of activists seeking a halt to all new oil and gas consents and licences. On October 14, two activists at London's National Gallery spilled tomato soup upon Vincent van Gogh's Sunflowers to call attention to their activist group. Both the organisation and its protest strategy ultimately grew outside of London.A few weeks later, German police apprehended two people on suspicion of throwing mashed potatoes at a Claude Monet painting in the Barberini Museum in Germany. Late in October, a video that depicts two

men standing close to Johannes Vermeer's Girl with a Pearl Earring, which is housed in The Hague's Mauritshuis museum, surfaced on social media. The first man is shown trying to superglue his bald head to the artwork as another man pours tomato soup over his head. Discussions on activism and civil disobedience in modern society as well as global climate change were raised by these protests.

The wildfire season in America is unusually severe

In 2022, there were 64,835 wildfires in the US, which was a record high since 2017. According to USA Today, they together torched more than 7.4 million acres, which is more than the 10-year average (in both number of fires as well as acres burned).According to scientists, the effects and intensity of wildfires are steadily worsening as a result of climate change. They predict that a variety of factors, such as urbanisation, droughts, storms, and debates over how to manage land to prevent wildfires, will make conditions worse in the following.

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GROW COWPEA FOR MORE INCOME -A SUCCESS STORY

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Introduction

Sh. Patel Vishnubhai M. is a resident of village – Earal, Tal. - Kalol, Dist. -Panchmahal, Gujarat 389 340. He is having 5 acre land, out of which 3.5 acre land is irrigated. He grows maize, pigeon pea, chilli, cowpea, brinjal, cucurbitaceous vegetables, etc with traditional system. He was not satisfied with the income earned from agriculture. The climatic conditions of the area are characterized as hot semi arid. The annual rainfall is mainly confined in the monsoon period (July- September) and actual mean precipitation is about 750-1220 mm and the total number of rainy days about 32-34. The mean summer temperature is 32.9° C while the winter temperature is 21.3° C indicating that the area falls under hyperthermic soil regime. The mean annual maximum and minimum temperatures vary from 42 - 45° C (May) and 6 - 9° C (January), respectively. The soil of area is black to loamy sand with available N (140.25-151.60 kg/ha), P (6.30-8.80 kg/ha) and K (144.50-145.30kg/ha) and organic carbon (0.31%), while EC (0.13-0.17 dSm^{-1}) and *pH* (8.20). The soil depth ranged from 0.78 to 1.19 m derived from mixed alluvial basalt, quartzite, granite and layers of limestone. The available ground water is good. In this area most of the farmers are grow cowpea during rainy (kharif) and summer season with traditional system.

Training programme

They faced problems of poor awareness about high yielding varieties, cultivation practices, low price and infestation of pest and disease. The most of the farmers are not growing cowpea during summer due scarcity of quality irrigation water. The demand of vegetable especially cowpea is high during summer due to short supply. The price of cowpea during summer is high.

He was grown vegetable *viz*. chilli, cowpea, brinjal, cucurbitaceous vegetables, etc. He came in contact with KVK for solving his question how to get higher income from cowpea cultivation. He came in various programmes like as training, meeting, campaigns organized by KVK time to time. Keeping above fact in mind an on farm trial (OFT) was implemented at five farmer's field to find out the most suitable variety of cowpea cultivation especially during summer season. The seed of improved varieties namely Kashi Kanchan, Kashi Unnati, Pusa Komal, Gujarat Vegetable Cowpea-1 and Rashili (local check) were procured reputed centers and distributed to the selected farmers. Before implementation of on farm trial a training programme were conducted and trained the framers about all aspects of cowpea cultivation. The crop was grown under keen supervision of KVK experts and demonstration visited frequently from preparation of land, seed treatment, application of manure and fertilizers, seed rate, sowing of seed, weed management, harvesting, grading and sale of produce. The various programmes *viz*. front line demonstrations (FLDs), training, field day, advisory service, telephonic advisory, method demonstration, deliver lectures were carried out by KVK for at horizontal dissemination of the technology.

This on farm trial was undertaken to get higher income from vegetable especially summer (off season) cowpea cultivation. All the farmers were got very good income by adopting

this simple technology. Among the farmers, he got highest production. The crop yield during summer was slightly low but infestation of pest is also low as compression to kharif season. He

is became a key person and have lot of skill of vegetable cultivation especially in summer (off season) cowpea.

Table 1 Economics of cultivation of cowpea during summer

Variety	Production (q/ha)	Cost of cultivation (₹/ ha)	Gross income (₹ ha)	Net return (₹ ha)	B:C ratio
Kashi Kanchan	125.35	34500	131400	96900	3.80
Local check (Rashili)	95.50	29300	97700	68400	3.33

During the implementation of OFT all the package and practices were used as per suggestions/ guidelines of KVK experts. He grows cowpea in summer regularly from 2015. The production (125.35 and 95.50q/ha), cost of cultivation (₹34500 and ₹29300), gross return (₹131400 and ₹97700), net return (₹96900 and ₹68400) and cost benefit ratio (3.80 and 3.33) were recorded in demonstration and local check, respectively (table -1).

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BIO-DIVERSITY IN TRIBAL HORTICULTURE

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Abstract

Tribes are known for their close proximity with the nature all over the world. They use natural resources as part of their survival while protecting these as part of their duties and obligations. Thus the concept of nature-man-spirit is very ancient as both biological diversity and cultural diversity are directly related to the origin of many tribes in India. The present paper seeks a critical note on the relationship of biodiversity and tribes in India.

Introduction

The tribal population constitutes about 9 percent of the total population in India as per 2011 census. The states of Madhya Pradesh, Chattisgarh, Maharashtra, Odisha, Jharkhand and Gujarat have more than half of the total population of India. Almost 8.6 percent of the total population of India, known as Scheduled Tribes is the grip of numerous catastrophes owning to the prevalence of Vicious circle of Poverty and Unemployment with rapid deteriorating common property resources. The Scheduled Tribe population represents one of the most economically impoverished and marginalized groups in India. The fragile eco-system of the upland tribal regions has also been affected by deforestation and rampant shifting cultivation practice, causing extensive soil erosion, reducing the capacity of land to rejuvenate and affecting natural

vegetation and water resources. In the light of the above, the present paper makes an attempt on the basis of secondary sources of data to know the role of horticultural plantations to conserve bio-diversity and development of tribes.

Traditionally the tribal community practiced subsistence agriculture. They were also dependent on forests for fulfilment of their needs as well as income. Gradually timber logging became a major source of income for them. The imposition of a ban on timber logging resulted in depletion of income of the tribals. With the depletion of source of income, the dependence of tribals on agriculture and horticulture increased. Since the type of agriculture and horticulture practiced by tribals was primitive in nature, the only scope of enhancing income levels was by increasing the area under cultivation. This resulted in increase in area of jhum cultivation. With increasing pressure on land, the cycle of jhum cultivation which was earlier 15-20 years and which provided enough time for rejuvenation of fertility of land stands reduced to 2-3 years cycle. This has resulted in low yields. Hence there is a need to enhance income of the tribals but would do so in a sustainable manner.(Source: CHFLG)

Definition: Biodiversity is defined as, the variety and variability among all groups of living organism and the ecosystem in which they occur.

Classification:

- **Genetic diversity:** Genetic diversity is the diversity within species i.e., variation of genes within the species. Ex. Teak wood trees: Indian teak, burma teak, malasian teak.
- **Species diversity:** Variation in types of organisms present in a community.
  - **Species richness:** Number of species present.
  - **Heterogeneity or Equitability of species:** How equally distributed in the community are the abundances of Individual species.
- **Ecological diversity:** It is the variation in ecosystem found in any region.

Biological diversity and Cultural diversity

There exists a close proximity between the biological diversity and cultural diversity. Biodiversity encompasses the variety of all life form on the earth. India is one of the 17 mega-biodiverse countries in the world and has 45,000 identified plant species, including 15,000 flowering plants and 81,000 faunal species. Though it has only 2.5 % of the land and less than 2

% of the world's forest area but it supports more the 7 % of the global recorded species has aptly remarked on the notion of biodiversity.

Horticulture in Tribal areas

Govt. Of India introduced many schemes like 'Podu Rehabilitation Scheme (PRS)' initiated to improve the economic condition of the tribals by raising fruit plants of low gestation period along with timber and other economic plants. The objective is both to improve the economic condition and stabilize the tribals and to generate forest growth and conserve biodiversity (Ministry of Forest affairs, 2014).

The research studies proved that returns from the horticultural crops are found to be quite encouraging as compared to shifting cultivation. In the hilly areas, horticultural crops are considered to be viable alternative to shifting cultivation practices (Srinivasa Rao et al., 2010).

Role of the Tribal in Bio-diversity Conservation:

- **Conserving Natural Flora:** A wide variety of plants such as crop plants, wild fruits, seeds, bulb, roots and tubers are conserved by the ethnic and indigenous people as they have to depend on these sources for edible purposes. Religious belief of plants tribal communities as a god and goddess habitat leads to their conservation in their natural habitat.
- **Application of Traditional Knowledge:** The rural communities have gathered a pool of indigenous knowledge for the cultivation of the medicinal plants and their propagation. These plants conserved are antidotes to snake bites and scorpion bites or even for broken bones or orthopedic treatments.
- **Conserving the Sacred Groves:**India's ethnic people have played a vital role in preserving the biodiversity of several virgin forests and have conserved flora and fauna in sacred groves of tribals. Otherwise, these flora and fauna might have disappeared from the natural ecosystem.

Recent issues on Biodiversity:

- Some 75 per cent of the genetic diversity of crop plants been lost in the past century.
- Some scientists estimate that as many as 3 species per hour are going extinct and 20,000 extinctions occur each year.

- Roughly one-third of the World's coral reef systems have been destroyed or highly degraded.
- About 24 per cent of mammals and 12 per cent of bird species are currently considered to be globally threatened.
- More than 50 per cent of the world's wetlands have been drained and population of inland water and wetland species have declined by 50 per cent between 1970 and 1999.

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CRISPR/Cas: AN EMERGING AND ADVANCED DIAGNOSTIC TOOL FOR PLANT PATHOGENS

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Introduction

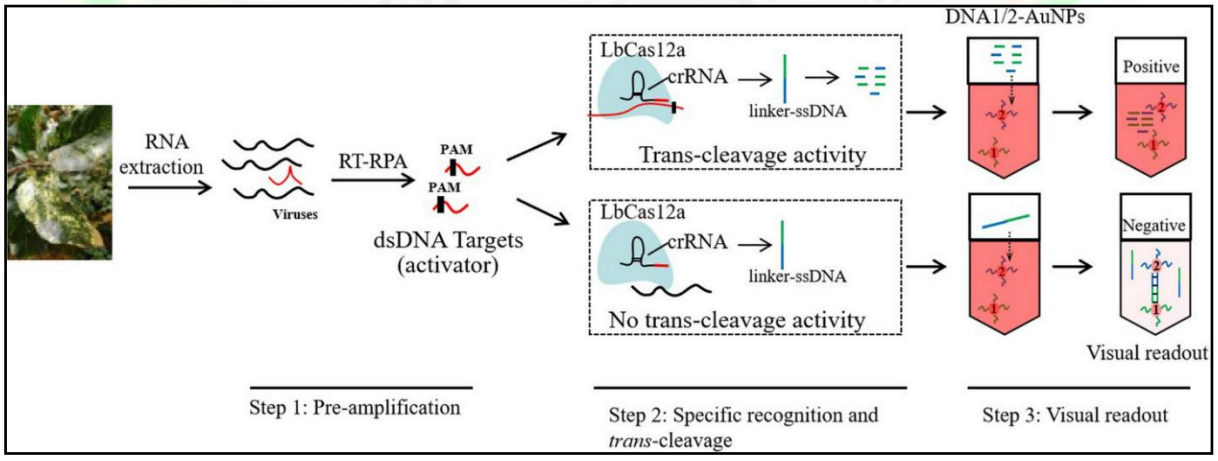
Recently, the CRISPR/Cas (clustered regularly interspaced short palindromic repeats/CRISPR-associated protein) system has emerged as a powerful technology with versatile applications in basic and applied research in agriculture. The CRISPR and CRISPR-associated (Cas) protein systems have been reported to recognize and cleave specific nucleic acid sequences (namely cis-cleavage). Some Cas proteins, including Cas12a, Cas12b, Cas13a and Cas14, have exhibited nonspecific trans-cleavage activity by cleaving non-target sequences when they are activated by recognizing a specific target sequence. This collateral effect has been developed into Cas12a/Cas13a-based nucleic acid detection methods termed HOLMES (one-hour low-cost multipurpose highly efficient system), DETECTR (DNA endonuclease targeted CRISPR trans reporter) and SHERLOCK (specific high-sensitivity enzymatic reporter unlocking) (Gootenberg et al. 2018). In DETECTR, CRISPR RNA (crRNA) is designed specifically to target double-strand DNA (dsDNA) located downstream of a short T-rich protospacer-adjacent motif (PAM); therefore, the target DNA works as an activator to trigger both cis- and trans-cleavage of Cas12a. The fluorophore quencher labelled reporter (FQ Reporter) in the system is then cut, and a fluorescence signal is released and measured. This advanced diagnostic technology is emerging up in India in recent times in all the crops for diagnosis of all disease causing of pathogens.

Although several diagnostic methods are available like enzyme-linked immunosorbent assay (ELISA), polymerase chain reaction (PCR), reverse transcription–polymerase chain

reaction (RT-PCR), real-time quantitative RT-PCR each has its own pros and cons. ELISA-based assays have insufficient sensitivity and require high quality antibodies and RT-PCRbased assays need minimum 2-3 hrs and requires expensive thermal cyclers. Recently loop mediated isothermal amplification (LAMP), recombinase polymerase amplification (RPA) have come up in large level for diagnosis but its limits of detection/ sensitivity is not up to the real time PCR and they have a high rate of non-specific amplification besides other limitations of per sample analysis cost . The collateral activities of CRISPR and CRISPRassociated nuclease Cas systems like Cas12 have recently been exploited to develop highly specific, rapid and sensitive diagnostic platforms(Aman et al., 2020). Currently,there is a need for development ofsimple and user friendly on-site diagnostic kits for on field diagnostics of plant pathogens.

CRISPR is a type of bacterial defense system where foreign DNA is incorporated into an array within the host genome (When there is an attack from the invaders, this foreign DNA is transcribed as a short RNA (guide RNA), which then mediates RNA guided endonucleolytic cleavage of the target DNA by Cas proteins(Razzaq et al. 2019). Several classes of CRISPR are found in various bacteria and this natural bacterial defense has been well adapted to various molecular biology applications such as gene editing, imaging, diagnostic, therapeutic etc.

CRISPR-Cas systems have been classified into three major types, type I, type II and type III, and 11 subtypes, based on their genetic content, structural and functional differences.The 11 distinct subtypes include Types I A–F, Types II A–C, and Types III A and B. The core defining



feature of CRISPR-Cas types and subtypes are the Cas genes and the proteins they encode,

which are genetically and functionally diverse, illustrating many biochemical functions that they carry throughout the different steps of CRISPR-mediated immunity. Each of the systems and its specific Cas protein components are referred to by a name derived from a model organism for the system (e.g., Cse or Cas subtype Escherichia coli for Type I-E).

Figure 1: The working principle of the CRISPR/Cas 12a coupled - Recombinase polymerase amplification based on-site diagnostic tools based on the visual readout.

Beyond its conventional applications in genome editing, CRISPR/Cas has recently been harnessed for specific and ultra-sensitive detection of DNA or RNA. The Cas nuclease-based diagnostics is a highly promising technology with potentially broad applications in plant pathogen detection and disease management. The Cas12a and Cas13a-based detection harnesses the targeted specificity of Cas nucleases to detect the presence of a defined target sequence with pathogen DNA or RNA (Gootenberg et al. 2018; Li et al. 2018; Chen et al. 2018). Typically, isothermal amplification in the form of T7-RPA (T7 transcription – recombinase polymerase amplification) (Cas13a specific), RPA, or LAMP (loop-mediated isothermal amplification), is performed prior to the addition of the Cas nuclease. In the cases of SHERLOCK, SHERLOCK v2, HOLMES and DETECTR methods, the Cas nuclease will remain activated upon recognition of the target sequence, allowing for the degradation of a fluorescent reporter oligonucleotide that provides a quantifiable signal (Li et al. 2018). In addition, Cas-based methods are usually compatible with lateral flow assays using immunostrips(Gootenberg et al. 2018).

The first Cas12a endoribonuclease-based detection method, referred to as DNA endonuclease-targeted CRISPR trans reporter (DETECTR), was used to guide dsDNA targets by crRNA triggering collateral cleavage of short ssDNA carrying a quencher and a fluorophore leading to target recognition via generation of fluorescent signal upon target recognition and subsequent reporter cleavage. One Hour Low-cost Multipurpose highly Efficient System (HOLMES) utilizes the Cas-12a effector system combined with loop-mediated isothermal amplification (LAMP) capable of fast and highly sensitive detection of target DNA and RNA. In other approaches, a sample is amplified to enrich the target DNA using recombinase polymerase amplification (RPA) reactions or reverse-transcription-recombinase polymerase amplification (RT-RPA) reactions when the target is RNA. The RPA product is then transcribed into RNA using a T7 RNA polymerase. The transcripts obtained are subjected to collateral cleavage with

Cas12/13 in the presence of a quenchable reporter ssRNA, and fluorescence is quantified. SHERLOCK, DETECTR, and HOLMES are highly specific and provide attomolar sensitivity in detecting viruses, microorganisms, and transgenes.

In comparison with traditional nucleic acid detection techniques such as PCR, qPCR, and digital droplet PCR, the Cas-based detection allows significantly lower inputs with reliable detection at femtomolar (10^{-15}) to zeptomolar sensitivity (10^{-21}) depending upon the methods (Li et al. 2019). Therefore, CRISPR/Cas-based diagnostics is an excellent choice for highly sensitive, specific, rapid, cost-efficient, and multiplex detection of nucleic acids that is capable of supporting point-of-care use. With portable fluorescence signal detector or immunostrip, the Cas based diagnostics can pave a way towards rapid and large scale in-field detection of plant pathogens, which will be valuable for qualitative and quantitative measurements of disease prevalence in plants, insect vectors and soils. The field-deployable detection can help establish quarantine zones of invasive pathogens and/or aid in IPM strategies for mitigating the spread of disease, including informed and precise applications of pesticides in the infected field.

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TALC BASED BIOCONSORTIA FOR THE MANAGEMENT OF *Sclerotium* ROOT ROT

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Abstract

The objective of present study was to assess the efficacy of individual and mixture of talc based bioformulations of Plant Growth Promoting Rhizobacteria and *Trichoderma* in the management of sugarbeet root rot caused by *Sclerotiumrolfsii*. The result from field experiments revealed that next to the chemical treatment, significantly lower root rot incidence of (18.6%) was recorded in the combination of *Pseudomonasfluorescens*(Pf1)and *Trichodermaasperellum* (TTH1) followed by the combination of *P. fluorescens*(Pf1) and*Bacillussubtilis* (EPCO16) with 20.5% as against 28.5% in untreated control. However, the combination effect was not observed while combining TTH1 and EPCO16 as they are incompatible with each other. In the same way, increase in improvement of yield parameters was recorded in Pf1+TTH1 followed by Pf1+EPCO16 under field conditions. The results suggest that the approach of combined application of compatible biocontrol agents may provide improved biocontrol efficiencyin controlling the crop diseases

Key words: Biocontrol agents – Consortia - root rot - *Sclerotiumrolfsii*–Sugarbeet

Introduction

Sugarbeet (*Betavulgaris* L. ssp. *vulgaris* var. *altissima* Doll.**family** Chenopodiaceae) is abiennial sugar producing tuber crop with **white roots of conical shape, growing deep into the soil with only the crown exposed.** Two sugarbeet crops can be grown in a year as compared to 12 months in the case of sugarcane (Chatin*et al.,* 2004).**As i**t can produce 60 to 80 tonnes of beet per ha, it shares about 45% of the world's total sugar productionand provides valuable by-products like

beet tops as cattle feed and molasses for the production of vitamin-B complex through fermentation (Shewate*et al.*, 2009, Lal *et al.*, 2004). Sugarbeetis affected by number of soil borne pathogens such as *Sclerotium*, *Rhizoctonia*, *Phoma*, *Pythium*, *Fusarium* and *Rhizopus*, of whichroot rot caused by *Sclerotiumrolfsii*considered as a serious problem(Eweis*et al.*, 2006; Khattabi*et al.*, 2001). The occurrence of root rot resulted in reducing yield and sugar content (Harveson and Rush, 2002). As the pathogen could survive in the soil for long period in the form of sclerotia, it is very difficult to control solely by the application of fungicides. In this context, biocontrol is advocated in the place of chemical pesticides.

An innovative approach for improving soil-borne disease control could be the development of cocktails containing strains that communicate with each other to maximize biocontrol efficacy (Saravanakumar et al., 2009; Singh and Singh, 2013; Singh and Singh, 2014). Mixtures of biocontrol agents (BCA) can overcome the limitations with single BCA and may have advantages of broad spectrum activity, enhancing the efficacy and reliability of the biological control and it allows the combination of various traits without employing genetic engineering (Janisiewicz, 1996). Palaiah*et al.* (2007) suggested for using more than one type of BCA for the management *S. rolfsii*, as their isolates varied in their sensitivity to the different BCAs, mainly due to inherent variability existing among them. Jetiyanon and Kloepper (2002) proposed a combinational use of different BCAs for improved and stable biocontrol activity against a complex of diseases. Application of compatible mixture of fungal and bacterial biocontrol agents possessing various mechanisms of pathogen suppression is suggested as a reliable and potential means of disease suppression(Mishra *et al.*, 2011).With this background, the current study was carried out to assess the efficacy of individual and mixture of BCAs for the management of sugarbeet root rot caused by *S. rolfsii*.

Materials and methods

Biocontrol agents and their compatibility

The bacterial BCAs such as *P. fluorescens* (Pf1) and *B. subtilis* (EPCO16) were tested for their compatibility with each other following the method of Fukui *et al.* (1994). The compatibility of *T. asperellum* (TTH1) with Pf1 or EPCO16 was tested by dual culture technique (Dennis and Webster, 1971). They were observed for the overgrowth among them without any inhibition zone for compatible strains or for the separation among them with inhibition zone for incompatible strains.

Preparation of bioformulations

The bioformulations were prepared for *P.fluorescens* (Pf1), *B. subtilis* (EPCO16) and *T. asperellum*(TTH1) separately.A loopful of Pf1 and EPCO16 strains were inoculated into the King's B and nutrient broth respectively and incubated on a rotary shaker for three days at 150 rpm at 28±2°C. To 400 ml of bacterial suspensions containing 9 x 10^8 cfu/ml, 1 kg of the carrier material (talc powder), 15 g calcium carbonate (to adjust the pH to neutral) and 5 g Carboxy methyl cellulose (CMC) (adhesive) were added and mixed under sterile conditions to get an inoculum density of 1x10^8cfu g^{-1}(Vidhyasekaran, and Muthamilan, 1995).An actively growing mycelial disc of *T. asperellum* TTH1wasinoculated into yeast molasses broth (30 ml molasses; 5 g yeast; made up to 1000 ml), and incubated for 15 days at 28±2°C. The fungal biomass (containing 3x10^6cfu/ml) along with the spent broth was incorporated into the sterilized talc powder carrier material at the rate of 50 ml suspension per 100g and thoroughly mixed with addition of 500 mg CMC to get an inoculum density of 2 x10^6cfu g^{-1}(Ramakrishnan et al., 1994).

Field study

A field experiment was conducted to assess the efficacy of BCAs against root rot disease in sugarbeet at hot spot locations. The field trial was laid out with seven treatments T_1 (*P. fluorescens* Pf1), T_2 (*B.subtilis* EPCO16), T_3 (*T. asperellum* TTH1), T_4 (T_1 + T_2), T_5 (T_1 + T_3), T_6(Difenoconazole, 0.2% soil drenching), T_7 (Control) and replicated thrice using a plot size of 4x3 m in a randomized block design. A spacing of 45x15 cm was adopted. A total of 525 plants were maintained per treatment. The bioformualtion was applied individually at the rate of 2.5 kg/ha and in combination at the rate of 2.5 kg of each to soil at 0, 30, 60 and 90 days after sowing. Growth parameters such as number of leaves, leaf length, leaf area, top weight, root weight and sugar contentper plant were observed. Top and tuber yield were measured at 150 DAS. Sugar content was measured at 150 DAS using brix meter. Disease incidence (DI) was assessed upto 150 DAS.

Statistical Analysis

The data obtained were subjected to statistical analysis and were tested at five per cent level of significance to interpret the treatment differences following (Gomez and Gomez 1984).

Results

Compatibility

The biocontrol agents *P. fluorescens*(Pf1) and *T. asperellum*(TTH) were compatible with each other, however B. subtilis (EPCO 16) and *T. asperellum*(TTH) were incompatible with each other as they showed inhibition with each other.

Field study

The field experiments recorded the lower root rot incidence in the combined application of *P. fluorescens* Pf1+ *T. asperellum* TTH1 (18.6%) followed by Pf1+ EPCO16 (20.5%) as against 28.5%in untreated control (Table 1b). However, the application of fungicide, Difenoconazole showed the greater reduction in root rot incidence (5.6%) under field conditions. The observations on yield parameters revealed that next to the chemical treatment, enhanced top (6.21 t ha^{-1}) and tuber (58.85 t ha^{-1}) yield were recorded in the combination of Pf1+TTH1 application followed by Pf1+EPCO16 treatment with the top and tuber yield of 5.75 t ha^{-1} and 55.27 t ha^{-1} respectively. Other yield attributing parameters such as number of leaves, leaf length, leaf area, top and tuber yield and sugar content $plant^{-1}$ were extensively increased in Pf1+TTH1 followed by Pf1+EPCO16 than other treatments. Control treatment observed with reduced top and tuber yield of 4.13 t ha^{-1} and 40.80 t ha^{-1} respectively (Table 1a).

Table 1a. Efficacy of talc based bio-formulations on growth parameters of sugarbeet under field conditions

Treatments	No. of Leaves			Leaf length (cm $plant^{-1}$)			Leaf area (cm whole $plant^{-1}$)			Top weight (g $plant^{-1}$)				
	DAS			DAS			DAS			DAS				
	30	60	90	30	60	90	30	60	90	30	60	90	120	150
Pf1	9.8	18.4	22.6	28.18	37.03	40.50	738	2309	2913	22.6	244	332	245	164
EPCO16	9.3	17.6	24.2	23.71	34.46	37.72	701	2175	2661	20.30	227	318	232	147
TTH1	11.2	19.8	24.9	27.33	38.00	39.8	763	2413	2847	24.7	253	340	257	150
Pf1+EPCO 16	11.2	20.5	26.5	27.52	41.23	42.61	801	2746	3005	28.5	259	349	266	168
Pf1+TTH1	11.5	21.7	27.6	28.75	43.35	45.34	836	2912	3202	32.6	265	357	271	176
Difenoconazole	9.3	17.8	23.3	22.56	32.6	36.43	657	2391	2829	19.3	207	280	215	147
Control	9.0	17.6	22.0	21.66	31.47	34.52	549	2105	2515	18.5	186	270	220	136
CD (0.05)	0.35	0.47	0.62	0.90	1.18	1.30	63.46	67.41	59.98	4.32	9.77	8.81	8.03	12.82
SEd	0.17	0.22	0.30	0.43	0.56	0.62	30.21	32.09	28.55	2.06	4.65	1.19	3.82	6.10

*DAS – Days after sowing; Values are mean of two experiments

Discussion

A microbial consortium is a group of different species of microorganisms that act together as a community. The organisms with different modes of actions and survivability can perform better in the environment than single microorganisms (Davelos*et al*., 2004). A combinatory approach has the potential to overcome problems that occur with individual BCA (Meyer and Roberts, 2002). Mixed inoculants that interact synergistically are currently being devised for better disease control. In the present study, mixed application of Pf1+TTH1showed significant increase in sugarbeet yield followed by Pf1+EPCO16 than they were applied alone. Similarly, *Trichoderma*spp. in combination with *P. fluorescens*improved seedling growth in tomato (Rajendraprasad*et al*., 2017), chilli (Manoranjitham*et al*. 2000), black gram (Babu and Seetharaman 2002), green gram (Thilagavathi*et al*. 2007) and Vanilla (Sandheep*et al*., 2013). Plant growth promoting ability of fluorescent pseudomonads and *Bacillus* were observed in tomato and hot pepper (Ramamoorthy*et al*., 2002; Cakmakci*et al*. 2006).

Table 1b. Efficacy of talc based bio-formulations on yield parameters and disease incidence of sugarbeet under field conditions

Treatments	Root weight (g plant^{-1})					Sugar content (%)	Top yield at 150 DAS (t ha^{-1})	Tuber yield at 150 DAS (t ha^{-1})	Percent disease incidence (PDI)
	DAS								
	30	60	90	120	150				
Pf1	3.0	148	423	535	591	18.2	5.38	48.60	21.1
EPCO16	2.7	137	450	505	596	17.4	5.55	48.27	22.5
TTH1	3.6	156	415	493	643	17.5	4.87	44.06	25.5
Pf1+EPCO16	4.3	164	461	574	708	18.6	5.75	55.27	20.5
Pf1+TTH1	5.0	170	518	588	712	20.8	6. 21	58.85	18.6
Difenoconazole	2.4	141	363	475	543	15.5	6.74	63.15	05.6
Control	2.1	132	360	462	535	14.7	4.13	40.80	28.5
CD (0.05)	0.45	8.93	8.62	11.57	10.76	0.70	12.82	11.18	1.90
SEd	0.22	4.25	4.10	5.51	5.12	0.33	6.10	5.32	0.91

*DAS – Days after sowing; Values are mean of two experiments;

In the combined application, certain growth promoting substances and secondary metabolites produced by both fungal and bacterial BCA might be responsible for the better plant growth as reported by Shanmugaiah et al. (2009). In the present study, the combination of Pf1+TTH1, Pf1+EPCO16 performed better in controlling sugarbeet root rot when compared to individual BCA and control treatments under field conditions. Similarly, combined inoculation of *T. harzianum*with *P. fluorescens*recorded maximum wilt suppression on Vanilla (Sandheep *et al.*, 2013).

T.viride with *P. fluorescens* recorded improved biocontrol activity against pre and post emergence damping off(*Pythium debaryanum*) and wilt (*Ralstoniasolanacearum*) in tomato (Rajendraprasadet al., 2017; Yendyo*et al*., 2017), stem rot (*Sclerotiumrolfsii*) in groundnut (Manjula*et al*. 2004) and root rot (*Macrophominaphaseolina*) in green gram (Thilagavathi*et al*. 2007). *Trichoderma virens* in combination with *Burkholderiacepacia* or *B. ambifaria* significantly improved suppression of cucumber damping off (*R. solani*) over individual applications (Roberts *et al*., 2005). A combination of BCA with different mechanisms of disease control will have an additive effect and results in enhanced disease control compared to their individual application (Guetsky*et al*. 2002).

Toxic exoproducts such as HCN, pyrrolnitrin, phenazine, pyoleuterin and 2,4-diacetyl phloroglucinol (Phl), exoproteases and lytic enzymes produced by *P. fluorescens*reported for their deleterious effect against fungal pathogens (Jousset*et al*. 2008; Has and Keel 2003; Ramamoorthy and Samiyappan 2001). An array of antifungal compounds including iturin produced by the *Bacillus* responsible for the inhibitory effect on plant pathogens (Gumede 2008; Bernal *et al*. 2002). Antifungal antibiotics and hydrolytic enzymes of *Trichoderma* strains (Monte 2001; Vizcaíno *et al*. 2005) reported to reduce the growth of fungal pathogens. Therefore, the results of the current study suggested that diverse groups of antimicrobial compounds and multiple mechanisms offered by combination of BCAs could attribute for better disease control than the individual BCA.Therefore, application of microbial consortia might be a useful and potential approach for the management of soil borne diseases.

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ORGANIC CARBON AND ITS IMPROVEMENT IN SOIL

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Introduction

Soil organic matter content is used as an index of soil health, since it influences the soil in three ways, such as, physically, chemically, and biologically. The fibrous portion of organic matter plays an important role in improving soil physical properties. It promotes soil aggregation and improves permeability and aeration of clayey soils. Its high moisture-absorbing capacity and high carbon for growth of microbial mycelia may help in the granulation of sandy soils to improve the nutrient- and water-holding capacity. Organic matter accounts for at least half the cation exchange capacity (CEC) of soils. Thus, it is very important not only in retaining nutrients from fertilizers applied but also in increasing the buffering capacity of soils, besides enabling crops to better cope with such stresses like soil acidity and nutrient excess etc; It helps increase availability of many nutrient elements. By itself, organic matter is a source of nitrogen (N), phosphorus (P), potassium (K), sulfur (S), and other secondary and micro nutrients. Within the organic matter, soil organic carbon forms a major component. Organic carbon constitutes about 58 per cent of the soil organic matter.

The decline in soil organic carbon in the recent times often associated with crop yield loss of about 30 per cent. Further, the depletion of soil organic carbon under intensive cropping system is the key factor in altering biological equilibrium of the soil ecosystem. It is essential to maintain soil organic carbon cycle, where all the soil organisms *viz.*, bacteria, fungi, actinomycetes, protozoa, earthworms etc., and they grow in the presence of sufficient amount of soil organic carbon.

Due to continuous cropping and ever increasing use of fertilizers without adequate organic recycling has not only aggravated multi-nutrient deficiencies in soil and plant systems but also deteriorated soil productivity and created environmental pollution. Tamil Nadu is endowed with enormous potential for plant nutrients locked up in the biological wastes. These wastes can effectively be utilized for sustaining the soil health.

The amount of Organic Carbon in soils at the steady state can vary greatly. Organic Carbon level ranges from approximately 0.32 to 0.51 percent. The difference in Organic Carbon levels between soils are mainly due to variations in climate, soil characteristics, drainage condition, soil parent materials and human activities. The status of the Organic Carbon in Tamil Nadu is given in Table 1. The organic carbon in Tamil Nadu soil has gone down from 0.70 % in 1971 to 0.40 % in 2002, because of less use of organic inputs. The decline in organic carbon content has made undesirable changes in soil biodiversity and disruption in harmony of crop plants, which affects soil fertility and productivity. Considering its importance, the application of Farm Yard Manure, composting of farm wastes, green manures and biofertilizers plays a pivotal role in sustaining soil health.

Enhancement of Soil Organic Carbon

The soil gets organic matter added to them in various ways. The major sources are 1. The roots and stubbles of crops that are left behind after their harvest, 2. Leaves and other plant parts that are shed by the plants, 3. The organic manure like cattle manure and compost added to the soil and 4. The excreta and dead remains of the small soil animal like rodents, soil insects and the soil micro organisms. When fresh organic matter is added to the soil it is acted upon by various organisms; it loses its shape and structure, decomposes and gets merged with the soil as one of the soil ingredients, losing its identity. The organic matter that lost its structure and become part of the soil is called “humus”.

The importance of soil organic carbon for soil fertility means that in agricultural and horticultural systems, soil organic carbon levels should be maintained at levels high enough to ensure its optimum effects on plant nutrition and soil physical conditions. In cropping systems, the amount of organic carbon in soil often declines and in time may reach a level at which soil structural problems may occur. In addition, nutritional problems such as lack of adequate

nitrogen and sulphur may arise. In some areas, such problems have become more evident in recent years. It should be noted that the buildup of organic carbon in soils, by whatever means, is a slow process. However, the following strategies may help to improve the organic carbon content of the soil significantly.

1. **Crop rotation**: It improves soil organic carbon and soil biological activity besides preventing the leaching loss of nutrients. Not only organic carbon, but also nutrient addition is possible due to leaf litter and residues addition.
2. **Crop residues:** When field crops are harvested a significant proportion of their root system is left behind in the soil and becomes a source of organic carbon. Soil incorporation of straw and stubbles by in situ ploughing can be practiced wherever possible. Crop residues are the non-economic plant parts that are left in the field after harvest refuses that include straws, stubble, stover, and haulms of different crops. Crop remains are also from thrashing sheds or that are discarded during crop processing. This includes process wastes like groundnut shell, oil cakes, rice husks, and cobs of maize sorghum and Cumbu. The greatest potential as a biomass resource appears to be from the field residues of sorghum, maize, soybean, cotton, sugarcane etc. In Tamil Nadu 190 lakh tones of crop residues are available for use. These residues will contribute 1.0 lakh ton of nitrogen, 0.5 lakh ton of phosphorous and 2.0 lakh tons of potassium. How ever crop residues needs composting before being used as manure.
3. **Minimal cultivation and direct sowing**: Some agronomic practices like minimal tillage and direct sowing will help to reduce the rate of decomposition of soil native organic matter and sustain the level organic carbon.
4. **Green manuring:** It refers to growing of a green crop, usually a legume, which is not harvested but ploughed back directly into the soil thereby it adds organic carbon. In soils significant benefit may be obtained from such practice if carried out properly.
5. Addition of farm yard manure (including animal and poultry manure), biomanure, and biofertilizers will greatly improves the organic carbon in soil, besides improvement in the soil structure and texture. For example an application of farm yard manure at a rate of 25 t ha^{-1} would increase the organic carbon content of the soil by 0.2 % before decomposition.

6. **Integrated Farming System**: Adoption of IFS components at field levels may help to improve the soil organic carbon mainly through recycling of various IFS components. It will also ensure effective utilization of crop residues and animal manures.
7. **Biocomposts and vermicomposts**: Bio compost is a new concept and can be prepared by using green leaves (nitrogenous materials) and dry leaves (carbonaceous materials) in 8-12 weeks. Addition of optimum levels of biocomposts and vermicomposts improves the organic carbon content in soil markedly. They promote the beneficial activity of microflora and fauna in the rhizosphere and thereby they provide the macro and micro elements and growth promoting substances (IAA, cytokinins and gibberellins) for better crop growth.
8. **Solid waste management**: Domestic, agriculture and industrial activities generate large amount of solid wastes which are rich in organic carbon. They should be properly decomposed with appropriate composting technologies before their land application. The composted solid wastes will enrich the soil organic carbon and nutrients. Solid wastes are perceived as undesirable, useless and unwanted materials and substances that arise from human and animal activities. With increasing industrialization and population, solid waste generation has not only increased but its nature also changed. Municipal solid waste includes commercial and residential wastes generated in municipal or notified areas either in solid or semi-solid form excluding industrial hazardous waste but including treated bio-medical wastes.

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STATUS OF CROP YIELD FORECASTING IN INDIA

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Introduction:

Growing population in India and decrease in availability of lands for agriculture requires to produce more per unit area while in recent decades observed changes in weather patterns poses increased risk to the agricultural production. Crop forecasting at various spatial scale, district, state and national level, is fundamental to provide decision makers with timely information for rapid and sound decisions during the growing season.

Crop yield forecasting in India

Final estimates of production based on complete enumeration of area and yield through crop cutting experiments (CCE) become available much after the crops are actually harvested. In order to supplement these estimates at an early stage of crop growth, a programme called FASAL (Forecasting Agricultural output using Space, Agro-meteorology and Land based observations) was launched by Ministry of Agriculture and Farmers Welfare in 2006, for which the technology was developed by Indian Space Research Organization (ISRO), in collaboration with various national and state level organizations.

Objectives of FASAL programme

- To establish the relation between weather and crop.
- To assess and establish the relationship between weather, field level management practices and land factors for crop yield forecast.

- To determine genetic coefficients for popular varieties of crops to generate estimate of crop yield forecast.
- Development of national / state / district level multiple crop yield forecast models Yield forecast to be issued at mid-season (F2) and pre-harvest stages (F3).

Crops included under FASAL programme

It includes major crops such as kharif and rabi rice, wheat, winter potato, cotton, sugarcane, mustard, jute, kharif and rabi sorghum, kharif maize, kharif bajra, finger millet and kharif and rabi groundnut.

Broad Activities Planned under the Scheme

1. Agricultural Information Group (AIG)
2. Statistical Analysis Group (SAG)
3. Ground Observation and Analysis Group (GOAG)
4. Image Analysis and Pattern Recognition Group (IAPRG)
5. Crop Growth and Yield Modelling Group (CYMG)

Major Components of FASAL

A. Econometric Forecast: Institute of Economic Growth (IEG) has developed and standardized econometric models for crop acreage and production forecasts for different crops *viz.* cereals, pulses,oilseeds and cash crops.

B. Remote Sensing Forecast: This forecast is envisaged at crop stage after flowering and pre-harvest stage of crop growth when crop canopy is visible on the ground and crop coverage is amenable to RS techniques.

C. Agromet Forecast: India Meteorological Department (IMD) has developed crop yield forecasting models based on:(i) Multiple correlation and regression technique**,** (ii) Crop growth simulation.The statistical model based on multiple correlation and regression technique is a linear combination of predictors (both meteorological parameters and technological parameters), which takes into account the influence of weather and technological advances on yield**.** Based on the above methodology, pre-harvest crop yield forecast models have been developed for crops in *Kharif* and *Rabi* season for all the districts where these crops are grown predominantly.

Conclusions:

The yield forecast using statistical model and crop simulation model at state level having the highest accuracy. Crop growth simulation model is found as an effective tool for establishing the crop weather relationship and predict the yield, but the model requires exhaustive input data. Automation of simulation modelling enhanced the efficiency of the system and makes it competent for monitoring and yield forecasting. Despite efficient tools, associated limitation of the crop simulation models restricts its adaptation extensively in field level.

Future considerations

- Improvement in estimation of daily solar radiation, using routine weather data such as minimum temperature, maximum temperature, rain, cloud cover as it is important during monsoon season.
- Also there is a need to use satellite data derived insolation (8 km & 4 km resolutions).
- Linking remote sensing data with Crop model for prediction and re-run crop model with adjusted sowing date to match simulated crop condition.
- Develop methodology to ensemble/ hybridize the multi crop simulation and statistical models' estimates to improve final forecast.

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APPLICATIONS OF SOMACLONAL VARIATIONS IN HORTICULTURAL CROPS

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Introduction

Somaclonal variation is the variation observed in plants that have been produced by plant tissue culture. Somaclonal variation is not restricted to, but is particularly common in plants regenerated from callus. The variations can be genotypic or phenotypic, which in the latter case can be classified as genetic or epigenetic in origin.Typical genetic alterations are: changes in chromosome numbers (polyploidy and aneuploidy), Change in chromosome number may be by Euploidy: whole set change, Aneuploidy (Polyploidy and Monoploidy, Change in chromosome structure (translocations, deletions, insertions and duplications). Change in chromosome structure include Deletions (genes missing, for example 1,2,3,4 now 1,2,4), Inversions (gene order altered, for example 1,2,3,4 now 1,3,2,4), Duplications (1,2,3,4 now 1,2,2,3,4) and Translocations (whole chromosomal segments moved to a new location, for example 1,2,3,4 now 1,2,3,4,A,B,C).Transposable elements are segments of DNA that are mobile and can insert into coding regions of genes, typically results in the lack of gene expression. The culture environment may make the transposable elements more likely to excise and move.

Point mutations are often spontaneous and are more difficult to detect in a DNA sequence (base mutations). Point mutations, if they take place within a coding region of a gene and resulted in the alteration of amino acid, can lead to somaclonal variation. A typical epigenetics-related event would be gene methylation. Most of the mutational events occasioned by tissue culture are directly or indirectly related to alterations in the state of DNA methylation. A

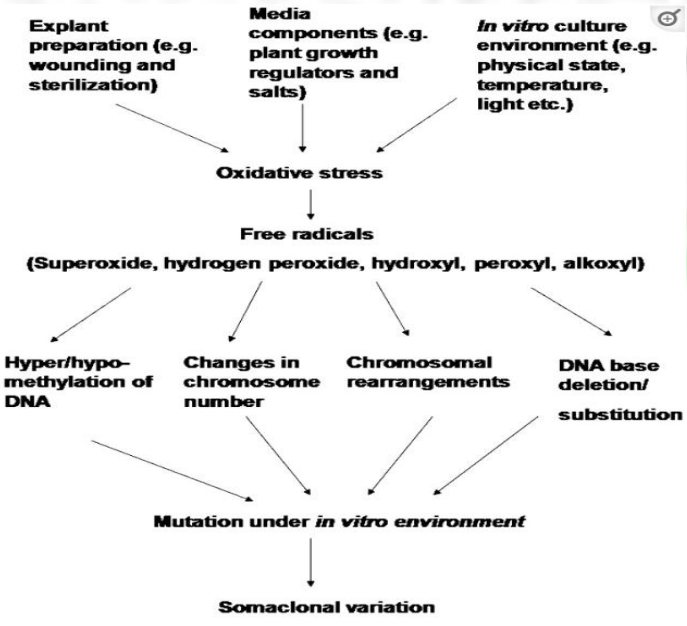
decrease in methylation correlates with increased gene activity. The mutations can occur due to variant stress factors including, hormonal imbalance in culture media, exposure of tissues to chemicals during surface sterilization, and wounding. In many cases, oxidative stress was found to be the main cause of somaclonal variation in tissue culture plants. Explant, Media components, effect of genotype, Regeneration systems, duration and number of culture cycles are the sources of mutations

Explant/explant source :

Differences in both the frequency and nature of somaclonal variation may occur when regeneration is achieved from different tissue sources . Highly differentiated tissues such as roots, leaves, and stems generally produce more variations than explants with pre-existing meristems, such as axillary buds and shoot tips. In general, the older and/or the more specialized the tissue is used for regeneration, the greater the chances that variation will be recovered in the regenerated plants

Mode of regeneration:

Both culture initiation and subsequent subculture expose explants to oxidative stress, which may result in mutations. It seems evident that 'extreme' procedures such as protoplast culture and also callus formation impose stress. Magnitude of this stress depends on the tissue culture technique



Mechanism of somaclonal variation in micropropagated plants as a result of oxidative burst upon in vitro culture

Effect of length of culture period and number of subculture cycles

The longer a culture is maintained in vitro, the greater the somaclonal variations. Variant karyotypes are found to amass with increasing age of callus and as a result the chances of variant plants produced during successive subculture also increases, in general. Furthermore, the rapid multiplication of a tissue, during micropropagation, may affect its genetic stability.

In vitro selection of desirable traits and development of some commercially exploited varieties through somaclonal variation in different horticultural crops

S. no.	Horticultural crop	Characteristic of somaclone	References
1	*Aglaonema*	Cultivar 'Moonlight Bay' and 'Diamond Bay' from 'Silver Bay,' and 'Emerald Bay,' from 'Golden Bay'	Henny et al. (1992, 2003)
2	Apple (*Malus* × *domestica* Borkh.)	Resistance to *Erwinia amylovora*	Chevreau et al. (1998)
3	Apple rootstocks M 26 and MM 106 (*Malus pumila* Mill.)	Resistance to *Phytophthora cactorum*	Rosati et al. (1990)
4	Apple rootstock Malling 7	Resistance to white root rot (*Dematophora necatrix*)	Modgil et al. (2012)
5	*Anthurium* sp.	'Orange Hot' derived from 'Red Hot' clone	Henny and Chen (2011)
6	Banana (*Musa acuminata* L.)	Semi-dwarf and resistant to *Fusarium* wilt TC1-229	Tang et al. (2000)
		Larger bunch size var. TC2-425; Resistant to *Fusarium oxysporum* f. sp. cubense (Foc) race 4; bunch 40 % heavier than cv. Formosana	Hwang (2002)
		Fusarium wilt-resistant somaclonal variants of banana cv. Rasthali	Ghag et al. (2014)
		Var. CIEN-BTA-03, resistant to yellow Sigatoka	Giménez et al. (2001)
		10 somaclones; GCTCV215-1 released for commercial planting	Hwang and Ko (1992, 2004)
		Var. CUDBT-B1, reduced height and early flowering	Martin et al. (2006)
		Var. Tai-Chiao No. 5, superior horticultural traits and resistance to *Fusarium* wilt	Lee et al. (2011)
7	Begonia (*Begonia* × *elatior*)	Plant morphology, number of flowers per plant, and flower size	Jain (1997)
8	Brinjal (*Solanum melongena* L.)	Stress-tolerant somaclone selection	Ferdausi et al. (2009)
9	Blackberry	Thornless var. 'Lincoln Logan'	Hall et al. (1986)
10	Capsicum (*Capsicum annuum* L.)	Yellow fruited var. Bell sweet	Morrison et al. (1989)
11	*Calthea roseopicta*	Developed common cultivars like Angela, Cora, Dottie, Eclipse and Saturn	Chao et al. (2005)
12	Carrot (*Daucus carota* L.)	Resistance to leaf spot (*Alternaria dauci*)	Dugdale et al. (2000)
		Resistant to drought	Rabiei et al. (2011)
13	Carnation (*Dianthus caryoplyllus* L.)	Resistant to *Fusarium oxysporum* f. sp. *dianthi*	Esmaiel et al. (2012)
14	Celery (*Apium graveolens* L.)	*Fusarium* resistant var. UC-TC	Heath-Pagliuso and Rappaport (1990)

Culture environment

External factors like growth regulators, temperature, light, osmolarity and agitation rate of the culture medium are known to influence the cell cycle in vivo in plants, considerably, which indicates that inadequate control of cell cycle in vitro is one of the causes of somaclonal variation. Several growth regulators, such as 2,4-dichlorophenoxy acetic acid (2,4-D), naphthalene acetic acid (NAA) and BAP (6-benzylaminopurine), synthetic phenylurea derivatives (4-CPPU, PBU and 2,3-MDPU) have been most frequently considered to be Though, the in vitro morphogenesis seems to be highly dependent on plant growth regulators and media used for culture, it is again genotype specific . Among factors affecting somaclonal variation, plant genotype is probably the most important determinant of variation responsible for genetic variability.

Advantages:

it is cheaper than other methods of genetic manipulation and does not require 'containment' procedures The major likely benefit of somaclonal variation is plant/crop improvement. Somaclonal variation leads to the creation of additional genetic variability. It can be useful approach to breeding new species. The variation can be a useful approach to introducing new varieties in plants, especially in the case of growing ornamental plant species. Characteristics for which somaclonal mutants can be enriched during *in vitro* culture includes resistance to disease pathotoxins, herbicides, high salt concentration, mineral toxicity and tolerance to environmental or chemical stress, as well as for increased production of secondary metabolites.

Disadvantages:

A serious disadvantage of somaclonal variation occurs when clonal uniformity is required, as in the horticulture and forestry industries where tissue culture is employed for rapid propagation of elite genotypes. Sometimes it can produce undesirable results. Selected variants are random and genetically unstable and require extensive and extended field trials. Not suitable for complex agronomic traits like yield, quality. May develop variants with pleiotropic effects (one variation can effect more than one characteristic in plants).

Conclusion:

Different steps can be used to reduce somaclonal variation. It is well known that increasing numbers of subculture increases the likelihood of somaclonal variation, so the number of subcultures in micropropagation protocols should be kept to a minimum. Regular reinitiation of clones from new explants might reduce variability over the time. Another way of reducing somaclonal variation is to avoid 2,4-D in the culture medium, as this hormone is known to introduce variation.

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APPLICATIONS OF DRONES IN INDIAN AGRICULTURE

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Abstract

Drone use is not a new technology. It can be used for military and security purposes before being sprayed in India. Currently, drone uses gives permission in spraying operation in India. Due to labor shortage and shift of village population to city drone use in agriculture is the need for future prospects. Drone cane be used such as pest, livestock, horticulture, yield, insect and other various operations in agriculture. The use of mechatronics, sensors, IoT, etc. in agriculture has become unavoidable in recent years. Drones can be one of the possible methods for properly applying agricultural inputs and mapping variability across agricultural landscapes.

Keywords: Drone, Agriculture, Remote sensing, and land use mapping.

Introduction:

By 2050, the world's population will need to develop innovative methods to increase food production by 70%, according to the International Telecommunication Union (ITU) and the Food and Agriculture Organization (FAO) of the United Nations (Sylvester et al., 2018). Providing food for the increasing population, which is expected to increase from the present 7.0 billion people to almost 9.0 billion by 2050, is the biggest problem facing the world's agriculture. Recent research indicates that in order to meet the projected global food demand by 2050, current yield improvement trends would not be sufficient, requiring the expansion of agricultural land. India's population, which is now estimated at 1.34 billion, is also expected to increase to 1.51 billion by 2030 and 1.66 billion by 2050. A significant difficulty of our day is sustaining the

planet's limited population of growing and increasingly rich individuals (Anonymous, 2020). A shortage of labor, a lack of arable land, and an increase in the need for irrigation water are some issues that Indian agriculture is dealing with.

Application of Drone in Agriculture and Allied Sector:

Drones, or unmanned aerial vehicles, have been around for a long time. They have previously been employed for military and security objectives. However, with the development of information technology, the Internet of Things, and electronic boards, their application has rapidly increased in various fields, including business, research, and agriculture. Agricultural drones are drones used in agriculture to increase productivity and production through site-specific crop management. Drone use in agricultural production systems has rapidly grown in recent years. Farmers may now gather comprehensive data on the health of their soil and crops thanks to advancements in multi-spectral imaging methods and electronic sensors. By lowering the need for labor and agricultural inputs, it has also raised per capita income.

Agricultural drones are regarded as a promising precision agriculture technology with a great deal of promise to solve the age-old problem of obtaining real-time agricultural data for real-time monitoring of agricultural areas. Drones are now frequently used in agriculture for yield estimation, plant health management, and precise input application as shown in Figure 1. Drone usage in agriculture will rank second in the next ten years, according to Goldman Sachs. By acquiring, analysing, and improving the effectiveness of monitoring systems, drones open up a huge potential for greater adaptation in agriculture.

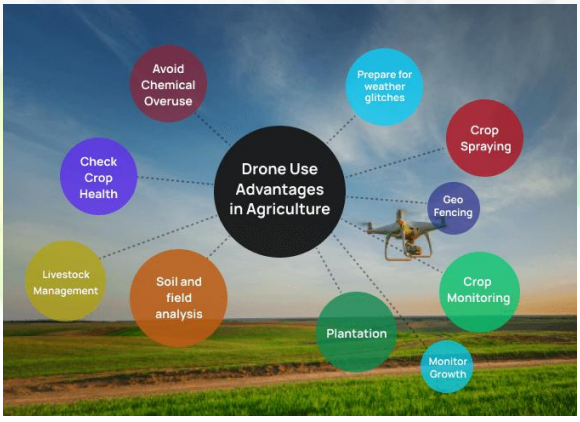

Fig. 1: Application of drone in agriculture.

In addition, compared to traditional techniques, drones are simple to use, inexpensive, and take the least amount of time to collect field data. In order to capture photographs with

extremely high spatial resolution, a drone with a high-resolution camera may fly at low altitudes. Compared to ground-based devices, a drone offers a quick and non-destructive approach to covering a bigger field.Drones are widely viewed as the future of smart farming because of their wide-ranging versatility and rising acceptance in PA applications in recent years. As a result, several studies for real-time site-specific management and plant health monitoring have been carried out all over the world. Even though there have been studies on the use of drones for various agricultural activities, there are still numerous unexplored opportunities in the agricultural and associated industries. The usage of drones in agriculture and related fields is briefly described here.

Agriculture:

Lack of instruments for regularly evaluating farming innovations is one of the biggest barriers to increasing agricultural output and quality. Weather change, which modifies the microclimate of crops and jeopardizes agricultural productivity, exacerbates this problem. To identify geographical heterogeneity in the field and increase agricultural productivity, sensor data from drones is combined with real-time data analytics. Drone operations provide a lot of raw data that may be used to activate agricultural analysis tools. Drones may carry out soil health scans, check crop health, help plan irrigation schedules, administer chemicals and fertilizers, estimate production statistics, and provide vital information for weather analysis as part of precision agriculture. Admissible information is generated when data from drones is integrated with data from other sources and analytical tools. Drones can apply liquid herbicides, fertilizers, and insecticides at exact, changeable rates. Additionally, drones may be used to analyze several plant phenotyping features (Fig. 2). Drone surveys are becoming increasingly popular and affordable.

Drones can gather information and monitor crops, providing farmers with new ways to track changes in a field and monitor crop development. The assessment of crop biomass, nitrogen status, and agricultural production has been the subject of several recent studies. The most significant aspect of a crop is its biomass, which, along with knowledge of its nitrogen content, may be used to determine if further fertilizer or other measures are necessary. Drones have the capacity to gather crop data consistently, giving farmers the ability to manage crops, use inputs, schedule harvesting times, monitor soil and yields, and pinpoint management errors in a controlled manner. The following are some advantages of using drones in agriculture.

• Increased production - Produce output and productivity may be increased by farmers through thorough irrigation planning, sufficient crop health monitoring and surveillance, and adapting to environmental changes.

Effective and durable agricultural methods: Using drones, farmers may get regular updates on their crops and help create more efficient farming methods. They can use resources effectively and adapt to shifting weather conditions.

• Improved safety of farmers - Farmers can spray pesticides in challenging terrain, polluted places, and higher crops more safely and conveniently by using drones. Additionally, it helps farmers spray crops without using a manual sprayer, which reduces soil contamination and chemical influx.

• Faster data collection for swift decision-making - Drone surveys are 10 times quicker and 10 times more accurate than traditional surveying and mapping methods. This facilitates accurate forecasting and effective management of agricultural resources. Additionally, it promotes efficient use of agricultural inputs and minimizes resource waste.

• Insurance claims - Agri-drones are used by agricultural insurance companies to gather reliable and efficient data. For the purpose of calculating the appropriate monetary compensation, they keep track of the farmers' crop losses. Farmers may use drone data to submit crop insurance claims in the case of crop loss.

Survey of farm lands and land use mapping

Drones may perform a variety of activities and can help with real-time mapping of agricultural areas when they are equipped with different controllers and sensors, such as control systems and radio remote controls. A drone can provide far better spatial and temporal information when inspecting a larger area of agricultural land. Orchard fields may be surveyed and observed using drones with LIDAR sensors. Drones can also be used to survey soil nutrition at various soil types, nutrient ranges, and nutrient requirements within and across fields. In India, where illegal stubble burning is a significant problem and a threat to the environment, drones can help eliminate it. Drones may be used to analyze soil and fields. They may be used to produce accurate 3-D maps that can be used to analyze soil for soil characteristics, moisture content, and erosion. This has implications for seed sowing patterns. These data are helpful for managing nitrogen and irrigation even after planting. One of the major difficulties in farming large areas is keeping track of the crops.

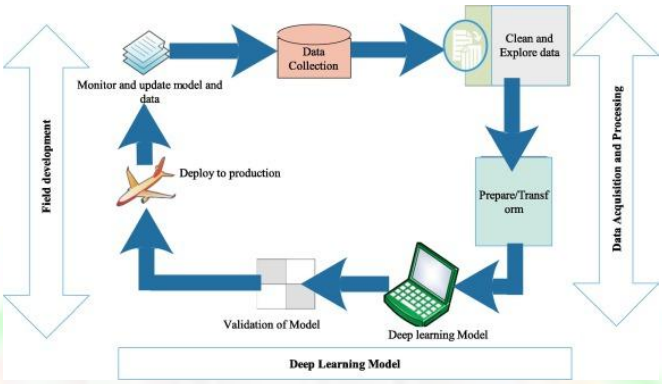

Fig. 2: Deep learning model.

Drones may be used to produce time-series animations that accurately portray agricultural development, exposing production inefficiencies and producing better harvests. Fig. 3 illustrates the use of drones in crop health monitoring and picture data processing. Drones can be used to collect data for crop monitoring, yield prediction, and other purposes. Data interpretation for crop damage, yield, and coverage can then be made with the help of the drones, which can also be used to support efficient crop management practices that boost productivity and enhance crop quality. The entire process is made easier using GCS and GPS imaging.

Remote sensing and field mapping:

Low-flying drones are used for field mapping and crop phenotyping, utilising a variety of remote sensing techniques. Research has shown that drone-based airborne remote sensing is an efficient way to measure breeding plots' NDVI and plant canopy temperature. In addition, drones are increasingly helpful for high-yield agricultural phenotyping and the real-time phenotyping of several test plots. Multi-spectral cameras, digital cameras, infrared thermal imagers, hyper-spectral sensors, and light detection and ranging (LIDAR) sensors are all installed in aerial remote sensing systems like drones. Growers may easily and affordably acquire information on crop and soil health parameters at different phases of agricultural development using drones fitted with remote sensing devices.

Weed management:

One of the most popular applications of drones in precision agriculture is weed mapping. In addition to generating issues with crop development, weeds can complicate harvesting (Subeesh et al., 2022). Drones can be employed for site-specific weed control to address these issues (SSWM). High-resolution images taken by drones in agriculture have been used to identify

specific crops and weeds on a microscopic scale. They have already attempted to spray pesticides in specific areas based on weed density measurements made from hyper-spectral photos obtained by drones. The field is separated into management zones, each of which receives its own treatment because weed plants often only grow in a few specific areas of the field as shown in Figure 3.

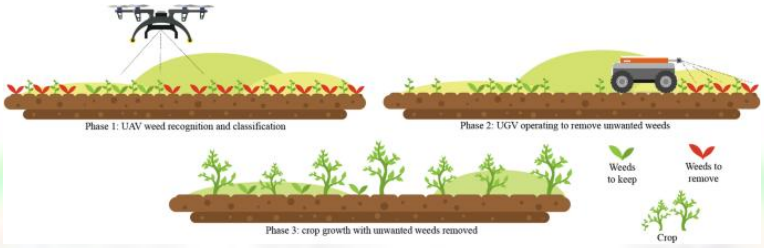

Fig. 3: Weed management by using Drone.

Pest management:

Crop health is an important factor that must be examined since infection in crops may cause significant financial losses due to decreased yields and worse quality. Crops need to be carefully watched in order to spot illnesses early and stop them from spreading. This responsibility has often been handled by local human specialists. However, this can be exceedingly time-consuming and preclude the advantages of "continuous" monitoring because checking a whole crop might take months. Another common strategy for disease prevention is the application of pesticides on designated days. Pesticide residues in the crops raise the risk of groundwater pollution, and this operation is costly. Because infections alter the biophysical and biochemical characteristics of the crops, disease detection is feasible. Drone-based data can employ cropped imagery data. Because infections alter the biophysical and biochemical characteristics of the crops, disease detection is feasible. Drone-based data processing techniques may use crop image data to evaluate plant health and biomass variance. Because of this, infections may be identified early, enabling farmers to take action and reduce losses.

Globally, drones have been used to combat pest and disease assaults. Drones fitted with multi-spectral photography systems can assist in the timely spraying of agricultural herbicides and minimize crop loss by quickly identifying pests, insects, locusts, and armyworm infestations. Drones have recently been used to spray insecticides to manage both solitary and gregarious locust swarms. Drone spraying can decrease operator exposure while increasing the efficiency with which chemicals are distributed in both time and space (Fig. 4).

Fig. 4: Application of drone in pest management.

Drones keep their height constant while following the contours of the ground. Depending on the crop location, they may adjust the height of the spray as well as the volume that has to be applied. Consequently, using drones to combat pests, insects, locusts, and armyworms is an efficient, safe, and useful approach.

Irrigation management:

Precision irrigation is crucial since 70% of the water used on Earth is for crop irrigation. Finding regions that require considerable irrigation can save farmers time and money. On the other side, precision agricultural methods can increase crop yield and quality. To effectively manage the resources, precision agriculture splits the land into several irrigation zones. In precision agriculture, drone technology may be utilized to control irrigation water. Drones with the necessary sensors can be used to locate agricultural areas that are under water and nutrient stress and need more fertigation..

Fig. 5: Application of drone in irrigation management.

In addition, the aforementioned technologies enable the creation of a specific map that shows the soil moisture content in real-time, facilitating more effective irrigation planning.

Additionally, by providing irrigation monitoring, drone surveys assist in enhancing water usage efficiency and identifying potential irrigation leaks. Drones equipped with thermal, hyperspectral, or multispectral sensors may identify regions that require irrigation by farmers (Fig. 5)

Horticulture:

Drones may provide a range of horticultural solutions, such as crop characterization, crop growth dynamics retrieval, yield estimation, and many more (Fig. 6). Below are a few significant uses of drones in the horticultural industry:

Fig. 6: Application of drone in horticulture.

- For determining plant health (biotic and abiotic stressors), tree density, etc., use crop-based leaf area indexing.
- Imaging of horticulture crops in difficult conditions, such as shifting weather, topography, the impact of sunshine, fog, etc.
- Ascertaining the land surface temperature, assessing spatial variability in crop yields, taking a water inventory of groundwater, retrieving kinds of irrigation, etc. are all examples.
- Plant yield monitoring, scouting, and bird scaring.

Livestock Management and Animal Husbandry:

In livestock management, drones have become highly popular for sanitizing farmlands and animal shelters with sanitizer sprays, performing behavior studies and phonemics, and delivering semen, vaccinations, medications, and viable eggs on-site. Drones may be used to transport essential supplies to remote locations, collect data, and record management procedures for livestock and poultry. Additionally, it may be used to count animals and/or poultry, especially for nomadic and pastoralist people, track the home range and movement of livestock, and map

the locations of feed and fodder grasses. Drones are also very useful for tracking the movement of the cow herd as well as their home tract. This is especially true for nomadic and pastoralist cultures as shown in Figure 7.

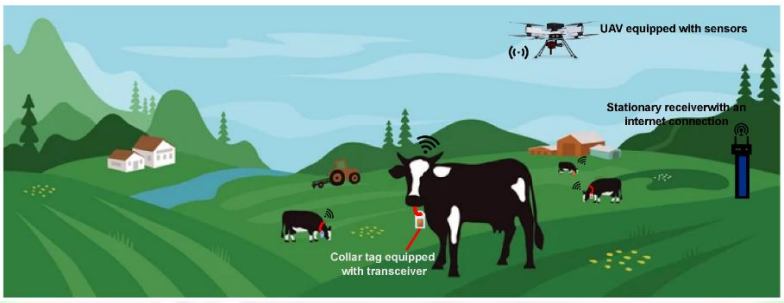

Fig. 7: Application of drone in livestock management and animal husbandry.

Fisheries:

Drones are now being used by the governments of many nations, including the Republic of Palau, Belize, Jamaica, and the Republic of Costa Rica, to identify illicit fishing and assist in the prosecution of fisheries criminals. In water troughs where moving humans is challenging, drones have also been used to feed fish as shown in Figure 8.

Fig. 8: Application of drone in fisheries..

Forestry:

Drones can be used in the forestry industry to create an integrated information system for forest protection. Large-scale, high-resolution ortho-maps are produced using a combination of drone pictures. Following that, these ortho-maps may be used to plan, organize, and analyze data in GIS systems. Drone technology is being used to monitor illegal activity and encroachment, assist in planning forest activities, and manage forests as shown in Figure 9. Additionally, it aids in gathering data on other aspects of the forest's ecology, including carbon sequestration, tree canopy analysis, conservation features, native species tracking, biodiversity monitoring, and ecological landscape elements, to name a few

Fig. 9: Application of drone in forestry.

Conclusion:

The use of mechatronics, sensors, IoT, etc. in agriculture has become unavoidable in recent years. Drones can be one of the possible methods for properly applying agricultural inputs and mapping variability across agricultural landscapes. Drones offer a wide range of uses in agricultural and related industries, including forestry, horticulture, fisheries, and livestock management. It may be used for all phases of plant development, from seed germination through harvest. A farmer may use a drone to watch his field from the air and spot a particular stand of plants that aren't developing properly. It gives the farmer a better overall picture and enables him to make wiser judgements about various agricultural operations.

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ANTIMICROBIAL STEWARDSHIP IN VETERINARY MEDICINE

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Abstract

Antimicrobial resistance (AMR) is the ability of the microorganisms to resist the effect of antimicrobial agentsmainly due to overuse or misuse of drugs. The increasing level of antimicrobial resistance threaten their ability to treat diseases in all living species. Antimicrobial resistant determinants spread between people and animals and can be pass through food chains and indirectly through environment making it One Health issue. The best way to combat is bycollaborative effort from all the sectors of medicine including the veterinary field by implementing the Antimicrobial stewardship practices to aid in preservation of antibiotic efficacy, to promote the health of the animals and to ensure safe food supplyand minimizing the unnecessary antimicrobial use through implementation of guidelines and protocols.

Introduction

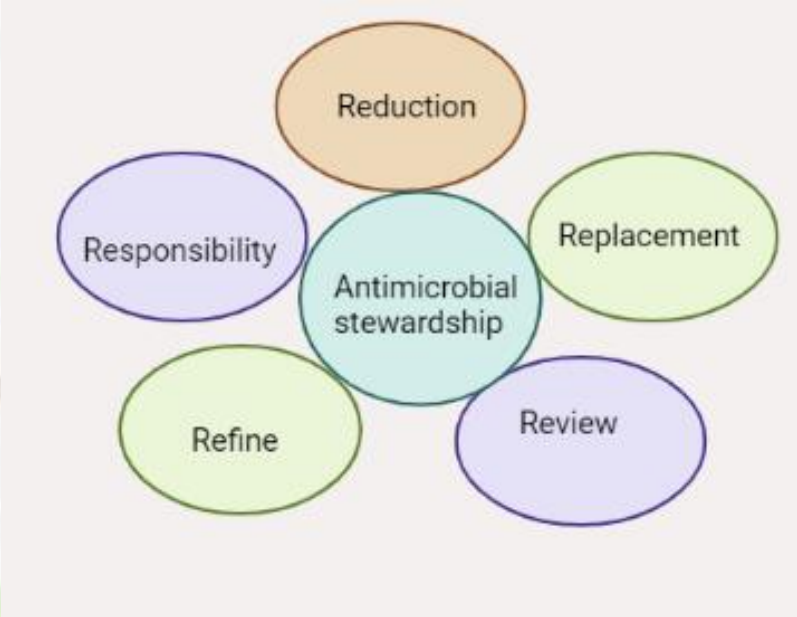
Stewardship is defined as “the careful and responsible management of something entrusted to one’s care” It was first utilised in the health-care sector as a method for optimising antibiotic usage, termed "antimicrobial stewardship.” (AMS).

Antimicrobial stewardship is set of strategies designed to promote appropriate usage of antimicrobials to reduce antimicrobial resistance and to improve the patient outcomes and to minimize the adverse effects. It involves optimizing the selection , dosage, duration and route of administration of the antimicrobial agents and minimizing the unnecessary antimicrobial use through implementation of guidelines and protocols.

The American Veterinary Medical Association (**AVMA**) **defines antimicrobial stewardship** for veterinarians as, "The actions veterinarians take individually and as a profession to preserve the effectiveness and availability of antimicrobial drugs through conscientious oversight and responsible medical decision-making while safeguarding animal, public, and environmental health.

The principles of antimicrobial stewardship in veterinary medicine include

The framework of Veterinary stewardship is customized to meet the varying requirements across the veterinary profession, which encompasses everything from single animal treatment to herd and flock health management. It involves the application of 5 core Rs - responsibility, reduce, replace, refine, review.



Responsibility –

It is the fundamental requirement for successful AMS.Antimicrobials can damage animals in addition to the one they are treating, and this is acknowledged by everyone who uses them. The benefit should always outweigh the danger whenever we use these medications. When we do use an antibiotic, we should take precautions to lower the danger to the health of current and future animals.

Reduction

Implementing better infection prevention and control strategies has been a recurring subject in veterinary research for more than a century and is still essential to reducing antibiotic resistance. Whenever we can, we need to look for ways to reduce our reliance on antimicrobials.

Replacement

Replacement of the use of antimicrobials with alternative, nonantimicrobial measures, wherever possible and appropriate, is another critical AMS tenet.In specific situations, a number of alternatives have been shown to improve animal health, and their usage in livestock production is rising. The use of probiotic yeasts and probiotic bacteria in fish, monogastric, and ruminant species; the use of prebiotics (nondigestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon); and the use of dietary acidifiers or organic acids in broilers and pigs are some of these alternatives.

Two antimicrobial replacement treatments have already acquired regulatory clearance in important markets throughout the world and are having a substantial influence on replacing antimicrobial usage in dairy cattle, where mastitis is a prominent indication for antimicrobial therapy. Teat-sealing pastes containing an inert heavy metal, such as bismuth subnitrate, are available for use at the conclusion of each lactation in adequately chosen dairy calves, where they establish a physical barrier that inhibits new infections from climbing the teat canal during the dry season. Pegbovigrastim, a modified form of the naturally occurring immunoregulatory cytokine bovine granulocyte colony-stimulating factor, has recently become available, restoring normal neutrophil function in cattle during the periparturient period and reducing susceptibility to clinical mastitis infections.

Review

Review of the AMS program is a fundamental core principle. Everyone on the farm management team (owners, herdspeople, nutritionists, veterinarians, and other consultants) must sit down on a regular basis and review farm records. When doing so, we should be critical of every situation in which an antibiotic was used and devise a clear approach for making additional improvements and reducing utilisation.

Refine

When we utilise antimicrobials, we must verify that we are taking the proper antibiotic, at the correct dose, at the correct time, for the specific pathogen, and for the required time**.**

Conclusion

Veterinarians have a pivotal role in Antimicriobial stewardship (AWS) and main efforts should be focussed on avoidance of antimicrobials that are critically important of human helath , selection of most appropriate antimicrobial for particular infection while considering the risk of selecting for resistance, optimization of dose regimes and duration of therapy, education and communication with animal owners, health care providers prevention of infection through vaccination , biosecurity and regular monitoring of antimicrobial use and resistance patterns, using electronic health record to facilitate steward interventions.

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BIOTECHNOLOGY IN PLANT DISEASE MANAGEMENT

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Introduction

From the anicent days of farming, plant diseass and pests have been a critical challenge for farmers, they causes major losses to the farmers. Estimates of average global losses to diseases and pests range from 11–30% (Oerke and Dehne, 2004; Savary et al., 2019). Importantly, crop losses are highest in regions that already suffer from food insecurity (Savary et al., 2019). Losses from diseases would be far worse without past steady advances in agricultural practices, including cultural, chemical, physical and biological methods. In addition, chemical control is potentially harmful to the environment and subsequently to human beings through the consumption of pesticide contaminated food (Tarola et al., 2010) Many pesticides are poisonous to humans. Hence, resistant varieties has to be increased in farming to combat pest and diseases and also protect the environment and human health. It plays an important role in controlling the losses caused by diseases and insects in crop plants. Moreover, genetic resistance protects natural enemies of the insect pest which are killed through the use of insecticides. For development of resistant varieties, biotechnological techniques are very essential to improve the genetic resistance of the plants.

Biotechnology is defined as the manipulation, genetic modification and multiplication of living organisms through novel technologies, such as tissue culture and genetic engineering, resulting in the production of improved or new organisms and products that can be used in a variety of ways.

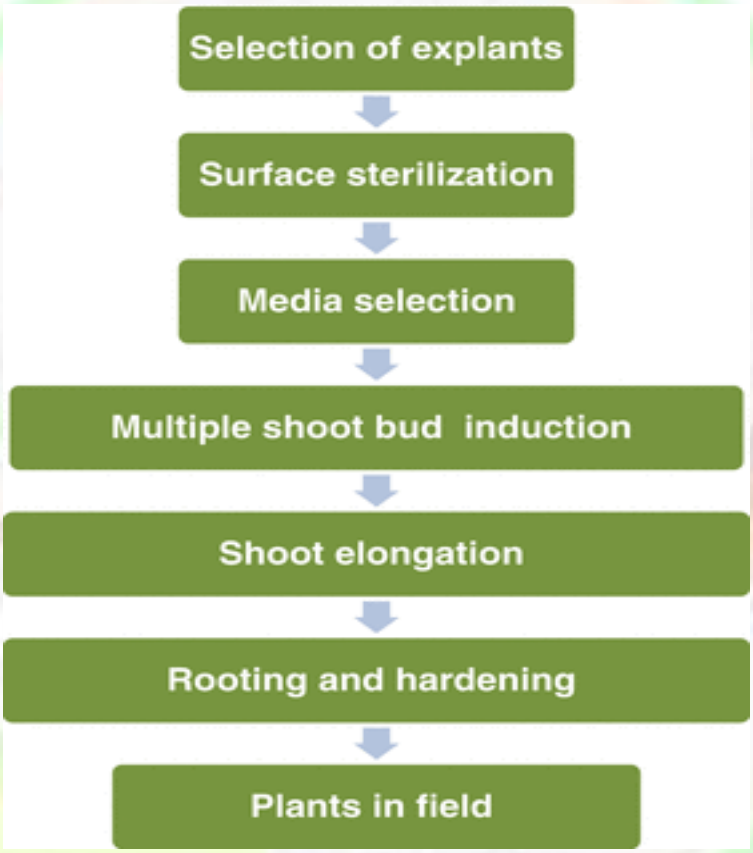
Plant tissue culture

Important tissue culture techniques of importance to Plant Pathology

1. Meristem tip culture
2. Protoplast culture

Production of virus free plants through plant tissue culture:

1. Meristem tip culture: Cultivation of axillary or apical meristems, particularly of shoot apical meristem is known as meristem culture.



Flowchart1: Steps in meristem tip culture

Every steps is explained below in brief

i. Explants:

The explants must consist of the meristematic dome of cells together with at least one leaf primordial. Meristem tips varying in size from 0.1 to 2.0 mm in diameter (usually 0.3-1.5 mm) can be used for meristem tip culture. The infected parent plant or organ of the plant from which

explant is excised is generally subjected to thermotherapy in a temperature controlled cabinet at 30^0C to 40^0C for six to twelve weeks to inactivate the virus.

ii. Culture initiation on suitable medium:

In general Murashige and Skoog medium has been found satisfactory for most plant species. But for some species, a much lower salt concentration may be adequate or even necessary since the high salt concentration of MS medium may be deleterious or even toxic. Culture initiation consists of surface sterilization of explants and establishing them *in vitro* on culture medium. Culture initiation often involves anti-metabolite chemicals such as ribavirin (virazole) in the tissue culture medium.

iii. Shoot multiplication:

After 2-3 weeks, the cultures are transferred to a shoot multiplication medium designed to promote axillary branching. This medium generally contains cytokinins, either alone or in combination with an auxin. Higher concentration of cytokinins induces adventitious buds. During culture initiation and shoot multiplication phases, the cultures are generally kept at 25^0C.

iv. Rooting of shoots:

In general, the rooting medium has low salt (1/2 or even ¼ salts of MS medium) and reduced sugar levels. But in most species, 0.1-1 mg/l Naphthalene Acetic Acid (NAA) or Indole-3-Butyric acid (IBA) is required for rooting. Rooting takes about 10-15 days depending on species.

v. Transfer of plantlets to soil:

Rooted shoots are removed from the medium, agar sticking to roots is washed with tap water, and they are transplanted into plastic cups containing a suitable potting mix. Plants are kept in high (>90%) humidity and initially low light intensities. The humidity is generally decreased to the ambient level after about 7-15 days, and the light intensity is increased. The plants are finally exposed to greenhouse conditions (**hardening**).

vi. Indexing, clone selection and stock maintenance:

Virus indexing is done several times during first year and the virus free plantlet is used as a nuclear stock material for commercial multiplication. Virus indexing is generally made by Enzyme Linked Immuno-Sorbent Assay (ELISA) or Immuno Sorbent Electron Microscopy (ISEM).

Resistant varieties through meristem tip culture:

S. No	Crop	Against diseases	References
1	Apple (Apple cultivar 'Oregon Spur-II)	Chlorotic leaf spot virus, apple mosaic virus, apple stem grooving virus and apple stem pitting virus	Manu Vivek and Manju Modgil., 2018
2	Sweet potato	Internal cork virus Rugouse mosaic virus Feathery mottle virus	Kanichi Mori. 1971
3	Potato	Potato Y virus Potato leaf roll virus Patato X virus Potato G virus Potato S virus	Kanichi Mori. 1971
4	Lily	CMV and lily mosaic	Kanichi Mori. 1971
5	Strawberry	Complex of viruses	Kanichi Mori. 1971
6	Carnation	Complex of viruses	Kanichi Mori. 1971
7	Petunia	Tobacco mosaic virus	Kanichi Mori. 1971
8	Dahlia	Dahlia mosaic virus	Kanichi Mori. 1971
9	Sugar cane	mosaic	Kanichi Mori. 1971
10	Garlic	mosaic	Kanichi Mori. 1971
11	Chrysanthemum	Complex of viruses	Kanichi Mori. 1971
12	Horse radish	Turnip mosaic virus	Kanichi Mori. 1971

2. Protoplast culture:

Fungal protoplasts are important tools in physiological and genetic research. Interspecific, intraspecific and intrageneric hybridization could be done by this technique for strain improvement of biocontrol agents to enhance the biocontrol potential for the management of pathogenic fungi. Isolation and self-fusion of protoplasts were achieved in *Trichoderma harzianum* and *T. viride*

Steps in protoplast fusion:

i. Isolation of protoplasts is achieved by treating cells with a suitable mixture of cell wall degrading enzymes.

ii. The pH of enzyme solution is adjusted between 4.7 and 6.0 and temperature is kept around 25-30^{0}C. The osmotic concentration of enzyme mixture and of subsequent media is elevated to stabilize the protoplasts and to prevent them from bursting. Usually, 50-100 m mol/l $CaCl_2$ is added to the osmoticum as it improves plasma membrane stability.

iii. The protoplasts of different strains are treated with 28-50% Poly Ethylene Glycol (fusogen) for 15-30 min followed by gradual washing of the protoplasts to remove PEG. The washing medium may be alkaline and contain high calcium ion concentration (50 m mol/l). Protoplast fusion occurs during washing step.

vi. Selection of hybrid cells and culturing on suitable medium.

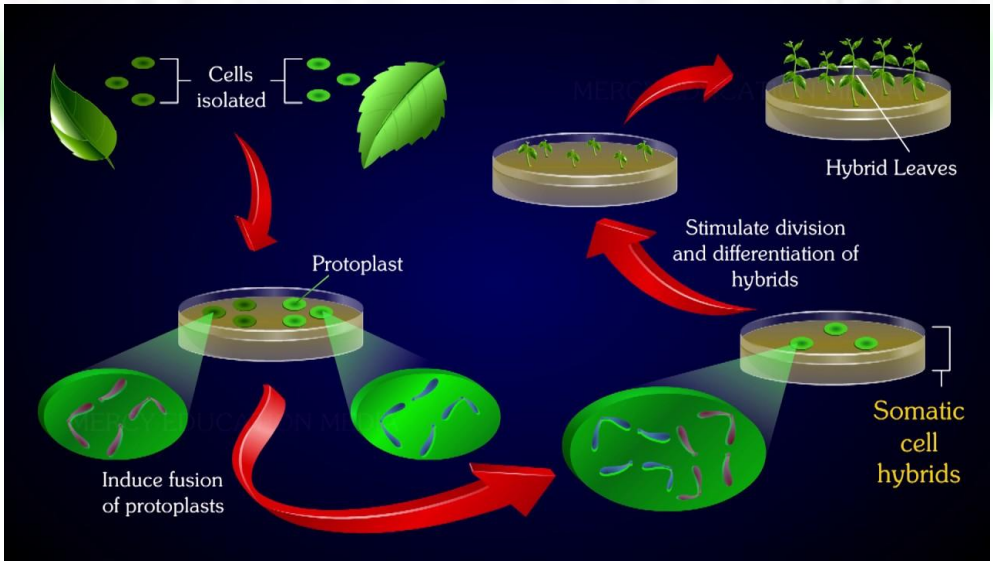


Fig1: Protoplast fusion

Genetic engineering technology:

Integration of specific fragment of foreign DNA into a cell through a suitable vector in such a way that the inserted DNA replicate independently and transferred to progenies as a result of cell division. Recombinant DNA molecule is a vector into which the desired DNA fragment has been inserted to enable its cloning in an appropriate host. Recombinant DNA molecule is produced by joining together two or more DNA segments usually originated from different organisms.

Steps in gene cloning:

1. Identification and isolation of the desired gene or DNA fragment to be cloned (Restriction digestion and electrophoresis)

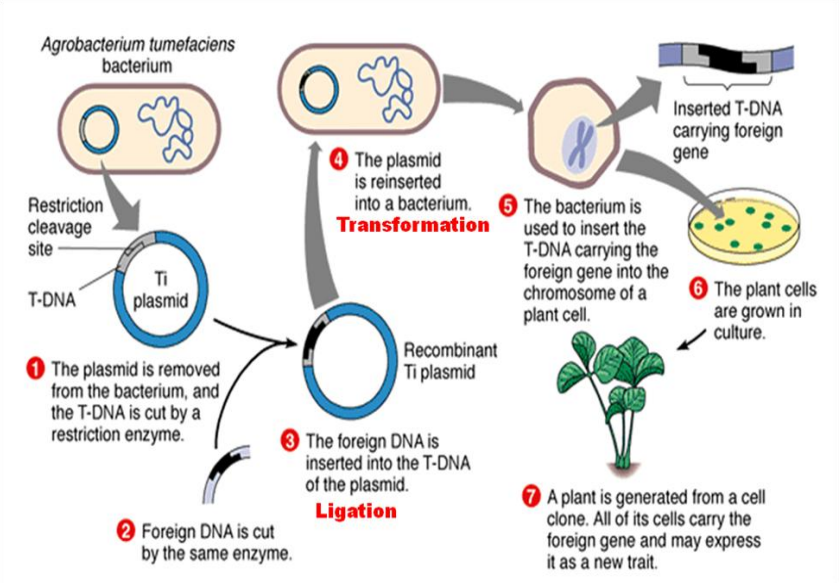
2. Insertion of the isolated gene in a suitable vector (ligation)

3. Introduction of this vector into a suitable organism or cell called host (transformation)

4. Selection of transformed host cells (selectable markers)

5. Multiplication / integration followed by expression of the introduced gene in the host

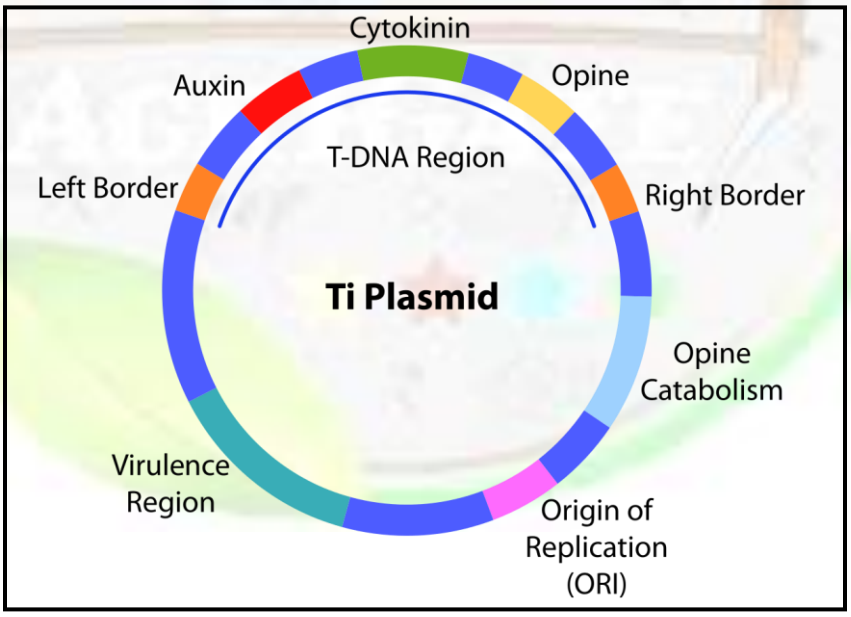
Enzymes involved: Restriction endonucleases, DNA ligases, DNA polymerases, RNA polymerases and reverse transcriptases.



Vectors used in gene cloning: A vector is a DNA molecule that has the ability to replicate in an appropriate host cell, and into which the DNA fragment to tbe cloned (called DNA insert) is integrated for cloning. Ex: Tumor inducing (Ti) plasmid of *Agrobacterium tumefaciens*, pBR322, Bacteriophages, cosmid vectors (derived from phage λ).

Ti plasmid of *Agrobacterium tumefaciens*:

- Ti plasmid is a large conjugative plasmid or megaplasmid of about 200 kb.
- Ti plasmid has a T-DNA region (15-24 kb) which is bounded by a pair of 24 bp repeats. T-DNA carries genes for auxin, cytokinins and opine synthesis which are responsible for tumor formation (tumorigenesis).
- Transfer of T-DNA depends on 35 kb virulence (vir) region of the Ti plasmid. This region has 7 operons ranging from *vir* A to *vir* H (*vir* A, *vir* B, *vir* C, *vir* D, *vir* E, *vir* G and *vir* H). The protein products of these genes respond to phenolics to generate a copy of T-DNA and mediate its transfer into the cell.
- The T-DNA when transferred from the *Agrobacterium* to the plant cell integrates with the chromosome, and the plant cells which are affected begin to synthesize opines, auxins and cytokinins.



- Opines are tumor specific compounds formed by the condensation of aminoacid, ketoacid and sugar. The opines (octopine, nopaline, succinamopine or leucinopine) can be metabolized only by Agrobacteria

- The IAA (auxin) and Isopentenyl-AMP (cytokinins) are phytohormones which cause the proliferation of plant cells and induction of the gall.
- Plant wound exudates contain phenolics, which attract *Agrobacterium* and induce *vir* genes. The strong *vir* gene inducers are syringic acid, ferulic acid, acetosyringone and sinapinic acid. Only Agrobacterium with Ti plasmid are attracted by these compounds.
- The exogenous DNA is inserted into the T-DNA region of the Ti plasmid by homologous recombination using an intermediate vector system or directly using binary vectors.

Procedure for development of resistant varieties through gentic engineering technology:

1. The appropriate gene construct is inserted within the T-DNA of a disarmed Ti plasmid either a co-integrate or binary vector is used. The recombinant vector is placed in *Agrobacterium*, which is co-cultured with the plant cells or tissues to be transformed for about 2 days.

2. In case of many plant species, small (a few mm diameter) leaf discs are excised from surface sterilized leaves and used for co-cultivation. In general the transgene construct involves a selectable reporter gene (Bacterial *neo* gene), the presence of which confers resistance to kanamycin.

3. During the leaf disc-Agrobacterium co-culture, acetosyringone released by plant cells induces the *vir* genes which bring about the transfer of recombinant T-DNA into many of the plant cells. The T-DNA would become integrated into the plant genome, and the transgene would be expressed. As a result, the transformed plant cells would become resistant to kanamycin.

4. After 2 days, the leaf discs are transferred onto a regeneration medium containing appropriate concentrations of kanamycin and carbenicillin. Kanamycin allows only transformed plant cells to divide and regenerate shoots in about 3-4 weeks, while carbenicilin kills *Agrobacterium* cells. The shoots are separated, rooted and finally transferred into soil.

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BIOFORTIFIED MILLETS: SUSTAINABLE APPROACH FOR MALNUTRITION

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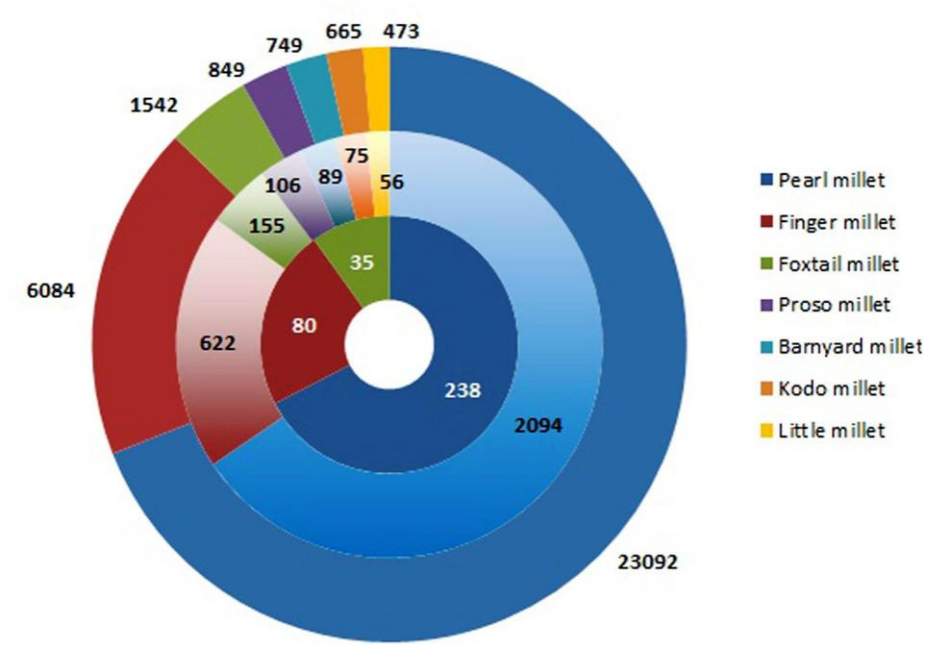
Introduction

Biofortification is a Greek word "bios" means life and Latin word "fortificare" means make strong. Biofortification is a food-based approach to overcome the nutrient starvation. Millets are nutritionally superior as their grains contain high number of proteins, essential amino acids, minerals, and vitamins. Nutritional insecurity is a major threat to the world's population that is highly dependent on cereals-based diet, deficient in micronutrients. Next to cereals, millets are the important sources of energy in the semiarid tropics and drought-prone regions of Asia and Africa.

Nutritional security is the key to improve the health status of the world's population as mankind is primarily dependent on plant-based diets. Plants are the major source of nutrients essential for normal growth and development. However, half of the global population, especially people from Asia and Africa suffer from nutrition deficiency as they rely on cereal crops for food . Biofortification is a food-based approach to overcome the nutrient starvation by delivering nutrient-dense crops at the door steps of poor populations. Biofortification Challenge Program (BCP) under HarvestPlus-Consultative Group for International Agricultural Research (CGIAR) Micronutrients project has focused primarily on seven major staple crops (rice, beans, cassava, maize, sweet potato, pearl millet, and wheat) targeting three important micronutrients (Fe, Zn, and vitamin A). In resource-poor countries of Asia and Africa, millets provide 75% of total calorie intake next to cereal grains with an average annual production of 14.2 and 12.4 million

tons. India is the leading producer of millets accounting for about 80% of the global millet production (Food and Agricultural Organization [FAO], 2015).

Millets are commonly referred as "small seeded grasses" which include pearl millet [*Pennisetum glaucum* (L.) R. Br.], finger millet [*Eleusine coracana* (L.) Gaertn], foxtail millet [*Setaria italica* (L.) Beauv], proso millet (*Panicum miliaceum* L.), barnyard millet (*Echinochloa* spp.), kodo millet (*Paspalum scrobiculatum*), and little millet (*Panicum sumatrense*). Among the millets, pearl millet occupies 95% of the production (Agricultural Statistics, Government of India, 2014;). Foxtail millet [*S. italica* (L.) P. Beauv] is the second largest crop among the millets, cultivated for food in semi-arid tropics of Asia and as forage in Europe, North America, Australia, and North Africa. Finger millet is the sixth largest crop under cultivation serving as the primary food for rural populations of East and Central Africa and southern India. Proso millet is a short-season crop cultivated in drier regions of Asia, Africa, Europe, Australia, and North America. Barnyard millet is the fastest growing among the millets with a harvesting period of 6 weeks. It is predominantly cultivated in India, China, Japan, and Korea for food as well as fodder.



Kodo millet is native to the tropical and sub-tropical regions of South America and domesticated in India 3,000 years ago . Little millet was domesticated in the Eastern Ghats of

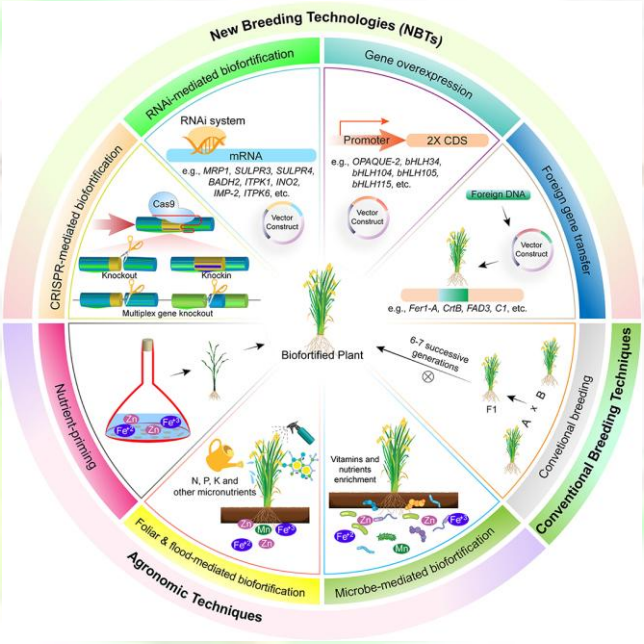
India occupying a major portion of diet amongst the tribal people and spread to Sri Lanka, Nepal, and Myanmar .Millets are nutritionally superior to rice and wheat as they contain a high amount of proteins, dietary fibers, iron, zinc, calcium, phosphorus, potassium, vitamin B, and essential amino acids. But the presence of antinutrients like phytates, polyphenols, and tannins reduce the mineral bioavailability by chelating multivalent cations like Fe^{2+}, Zn^{2+}, Ca^{2+}, Mg^{2+}, and K^{+}. In addition, high amounts of protease and amylase inhibitors affect the digestibility of millet grains. The predominance of the antinutritional factors has thus rendered the orphan status to millets in terms of global economic importance.

Biofortified crops have been primarily developed through conventional breeding exploiting the natural genetic variation, with the exception of Golden rice. Millets exhibit vast genetic variability for key mineral elements like, iron, zinc, and calcium when compared to other cereal crops (Muthamilarasan and Prasad, 2015). Moreover, millets are drought tolerant crops, resistant to pests and diseases offering good insurance against crop failure in developing countries. In spite of the superior quality of millets, only pearl millet has been prioritized as crop of choice for iron biofortification in India. Therefore, vast potential exists to utilize the minor millets for biofortification. Biofortification in millets can be achieved through two strategies: (1) by enhancing the accumulation of nutrients in milled grains and (2) by reducing the antinutrients to increase the bioavailability of minerals. This review highlights the importance of germplasm characterization of millets to develop biofortified varieties and the use of omics approaches to enhance grain-nutrient density. Taking the leads from other cereal crops, we emphasize the application of genetic engineering and genome editing tools to facilitate nutrient accumulation in edible portions and to block the biosynthesis of antinutrients.

Macronutrients

1. Starch: Millets are the primary source of carbohydrates in tropics and semi-arid tropics of India. Grain starch typically comprises of two polymers, amylose (15–30%) and amylopectin (70–85%). Based on the amylose content, millet accessions are classified into two major phenotypes, waxy and non-waxy. Waxy grains containing 0% amylose and nearly 100% amylopectin are glutinous in nature, easily digestible and therefore recommended as food for infants under 6 years of age. Amylose synthesis in millets is controlled by a single dominant

waxy allele (Wx), while the recessive loss-of-function allele (Wx) leads to the waxy phenotype with near 0% amylose content. The waxy gene product named as granule-bound starch synthase 1 (GBSS 1) is the key enzyme catalyzing the formation of amylose. Mutations in GBSS 1 result from insertions/deletions (InDels), transposable elements, and single base pair mutations. In millets, Wx gene was found to contain 14 exons and 13 introns. 2. Proteins and Amino Acids: Cereal proteins contain 1.5–2% lysine and 0.25–0.5% tryptophan while estimated average requirement is 5% and 1.1% for lysine and tryptophan. Finger millet on the other hand is high in essential amino acids than cereals.High lysine and tryptophan in finger millet is attributed to the transcriptional regulation of amino acid catabolism genes by Opaque2 (o2), a basic leucine zipper (bZIP) transcription factor. o2 modifiers (Opm) downregulate lysine ketoglutarate reductase dehydrogenase and upregulate aspartate kinase resulting in free lysine and tryptophan in endosperm. Molecular characterization of Opm alleles using SSRs and SNPs can effectively identify quantitative trait loci (QTLs) influencing amino acid content.



Micronutrients

1. **Iron (Fe):** Iron (Fe) deficiency is reported in 79%of pre-school children of India and 56% of Indian women are reported to be anaemic. Fe supplementation program in India since 1970 failed to address the issue of iron deficiency. Recognizing biofortification as a feasible alternative for Fe delivery, HarvestPlus has developed high Fe pearl millet by conventional

breeding. The first step in breeding crops for better nutrition is to evaluate the genetic diversity of available germplasm for target nutritional trait. ICRISAT, a member of Harvest Plus undertook the process of screening pearl millet germplasm for sources of high Fe density. High Fe bio fortified pearl millet provides twofolds higher iron than modern wheat varieties. This led to increase in iron absorption by 5–10% in around 35 million people consuming biofortified pearl millet. Feeding trial conducted in 2013 revealed that consumption of 232 g iron biofortified pearl millet flour/day resolved 65% more iron deficiency in Indian school children.

2. **Zinc (Zn):** Genetic enhancement of grain Zn content is possible by modulating the metal transporters that facilitate their uptake, translocation, and storage. Members of Zn-regulated transporters and Iron (Fe) regulated transporter-like protein (ZIP) family contribute to Zn homeostasis by either uptake or remobilization in intracellular compartments (Figure 2).Cereals and millets with high Zn seeds can be engineered by seed-specific expression of ZIP transporters. Initial success in transgenic development for seed Zn accumulation was recorded in rice. Recently, high zinc accumulating finger millet transgenic plants were produced by over expression of OsZIP1 driven by constitutive (35S) and endosperm-specific promoters (Bx17).

3. Calcium: Elucidation of role of calcium transporters in plants favours the development of Ca biofortified cereals. Finger millet containing about 5–30 times higher Ca than wheat and rice serves as a model system to understand seed calcium accumulation. Transcriptomics approach characterized calcium sensor gene family from the developing spikes of finger millet using Illumina paired-end sequencing methods which included characterization, identification, classification, phylogeny, and pathway analysis of calcium sensor genes of two genotypes, GP-1(low calcium) and GP-45 (high calcium). In total, 82 calcium sensor proteins identified in the transcriptome of finger millet spikes were grouped into 25-calmodulin (CaM) and calmodulin-like proteins (CaML), 9-CDPK-related protein kinases (CRK), 9- calcineurin B-like protein (CBL), 23-CBL interacting protein kinases (CIPK), and 14-Ca2+- dependent and CaM-independent protein kinases (CDPK) genes. Comparative phylogenetic analysis of calcium sensor gene family in finger millet identified 12 calcium sensor genes.

Potential Source of Nutrition

Millets are commonly called as "small seeded grasses" which include Pearl Millet, Finger millet, Foxtail millet, Proso millet, Barn yard millet, Kodo millet and little millet. Among the millets, pearl Millet to occupies 95% of the production. More than 80% of millet grains are used as a food, while the rest is used as animal fodder and in brewing industry for making alcoholic products. The grains are ground into flour and consumed as cakes or porridges. Millets are recommended for well-being of infants, lactating mothers, elderly, and convalescents. Millet grains is considered "gluten-free" because grains release sugar slowly into the blood stream. With high fiber and protein content, millets are preferred as dietary foods for people with diabetes and cardiovascular disease.

Pearl millet is rich in Fe, Zn, and lysine (17–65 mg/g of protein) compared to other millets (Hadimani et al.,2001). Foxtail millet contains a high amount of protein (11%) and fat (4%). The protein fractions are represented by albumins and globulins (13%), prolamins (39.4%), and glutelins (9.9%). It is thus recommended as an ideal food for diabetics. It also contains highest amounts of antioxidants i.e phenols, phenolic acids and carotenoids (Saleh et al., 2013). Finger millet grains contain significant amount of minerals like Ca, Mg, and K (Devi et al., 2014). Positive calcium content maintains healthy bones, while potassium prevents the onset of diabetes, renal and cardiovascular diseases. It also has high levels of amino acids like methionine, lysine and tryptophan (Bhatt et al., 2011), and polyphenols (Devi et al., 2014). Prosomillet contains the highest number of proteins (12.5%) while barnyard milletis the richest source of crude fiber (13.6%) and Fe (186mg/kg dry matter) (Saleh et al., 2013). Barnyard millet grains have own other important functional constituents viz. g-amino butyric acid (GABA) and b-glucan, used as antioxidants and it also help to reducing blood lipid levels. Among the millets, barnyard millet content lowest carbohydrate, hence is recommended as an ideal food for type II diabetics.

Needs of Biofortification in Millets

Cereals being a staple food in Indian diet with cost effective and single largest source of energy reaching to every person via daily diet. Cereal grains are considered as potential source of micronutrients for mitigating malnutrition due to their highest consumption and availability per person. Millet crops are treated as nutricereals considering their nutritional status Millets offer abundant micronutrients like vitamins, beta carotene, which are being consumed like

pharmaceutical pills in present day. In the current situation, all the millets are extraordinarily superior and are therefore, the solution for the malnutrition and obesity that affects a vast majority of the Indian population.

Conclusion

Millets are highly nutritious crops feeding poor populations. As millets exhibit cross-genera transferability, introgression of nutrient-linked genes into other cereals can become feasible by the use of molecular breeding or genetic engineering. Advent of next-generation sequencing platforms favours rapid sequencing of millet genome biofortification most economical approach for overcoming hidden hunger. Highly nutritious millet crops to fight against the micronutrient malnutrition with good grain qualities and significant amounts of essential amino acids, minerals, and vitamins

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GUT MICROBIOTA OF HONEY BEE AND ITS ROLE IN BIOTIC STRESS MITIGATION

Article ID: AG-VO3-I03-19

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Introduction:

A larger organism or microbial community living in an intensive environment is called the "microbiota". Animals that live as a community and have social relationships often use a characteristic microbiotawhich plays a critical role in a variety of metabolic functions like

- Modulation of glucose and lipid homeostasis,
- Safety regulation
- Management of energy
- Production of vitamins
- Regulation of various biochemical and physiological mechanisms by means of the production of metabolitesexerts anti carcinogenetic and anti-inflammatory activities
- The host immune system maintains a mutualistic relationship with the microbiota

Honeybees are eusocial insects with close interaction with their surrounding environment hence have been identified with different group of microorganisms because of their wider foraging range. The diversity in composition of the gut microbiota is influenced by topographical and short-term shifts in the microbial communities

Location of gut biota in Honey bees

The microbiota of honey bees consists of microbial communities in different intestinal sections, also called the stomach, which is located between the esophagus and the ventriculus,

which is used to store and transport nectar to the hive. Different microbial communities in the hindgut, ileum, lumen, and in the distal rectum form the honeybee microbiome

Predominant Gut microbiota in honey bees

The honeybee gut microbiota is dominated by 8 bacterial species namely

1. *Lactobacillus sppFirm 2*

2. *Lactobacillus sppFirm 4*

3. *Bifido bacterium spp*

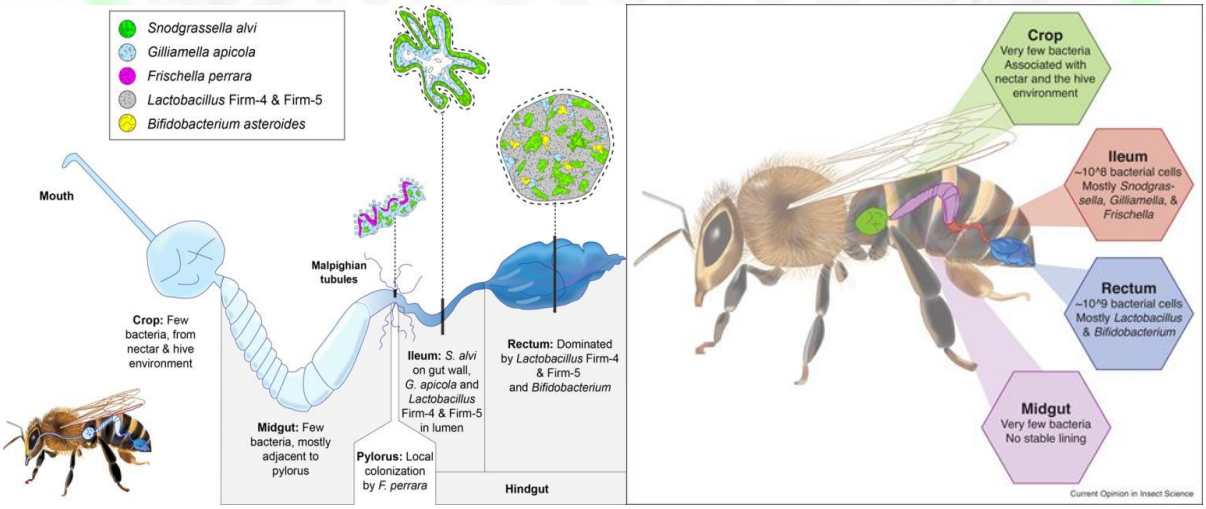
4. *Snodgrassellaalvi*

5. *Gilliamellaapicola*

6. *Frischellaperrara*

7. *Bertonellaapis.*

The intestinal microbiota of *Apismellifera* worker bees were investigated within 0-40 days after hatching. It was determined that *Snodgrassella, Gilliamella*and *Frischella* species were colonized in the honey bee intestine from the 1st day. *Bifidobacterium, Commensalibacter,* and *Lactobacillus* colonize within 3 days, while *Gilliamella* is reduced simultaneously *Lactobacillus kunkeei* and *Bartonella sp*., colonize significantly in 12 days. *Shigella sp., Escherichia sp., Bacteroides sp*., and *Porphyromonadaceaesp.* 19 to 25 days, *Commensalibacter sp.* and *Bifidobacterium sp*. decreased at 25 days (Dong et al., 2020).



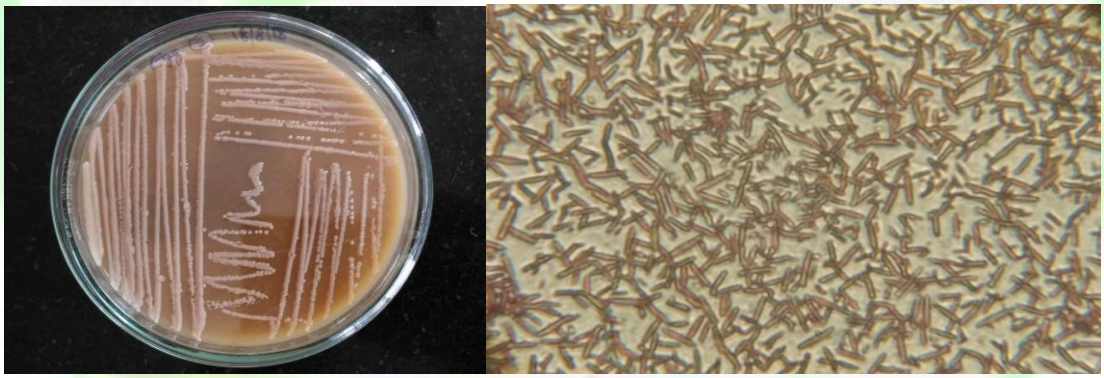
Presence of Microflora in Honey bees

- *A. mellifera* is a useful model organism with a microbial community that displays high host adaptation. Newly emerged workers have a reduced core gut micro biota or may lack it entirely.
- Honey bee bodies are colonized by microbial communities orally by means of social interactions with nurse bees within a few days of emergence
- During metamorphosis into pupae, the gut bacteria are excreted via defecation along with the gut epithelium, and the next colonization starts due to trophallaxis, contact with other bees, as well as from the hive
- The abundance of bacteria in the whole gut reaches its peak 3–5 days post-adult emergence
- The ileum is more variable, with its final structure emerging after eight days
- The workers are involved in age-associated tasks, and newly emerged bees are usually associated with hive maintenance and cleaning tasks.
- Therefore, the interactions with adult bees, contact with the comb, and consumption of bee bread are all potential routes of inoculation
- Using 16S rDNA community surveys and metagenomics of the total DNA, it was determined that guts of worker honeybees are inhabited by nine bacterial species clusters that account for 95–99.9% of the bacteria in almost all individuals
- Two ubiquitous Gram-negative species—*Snodgrasellasp*and *Gilliamellaapicola*
- Two Gram-positive species belonging to phylum Firmicutes that are ubiquitous and abundant; namely, *Lactobacillus* which inhabit the distal rectum
- The core member *Lactobacillus* Firm-4 was detectable in 98.4% of all analyzed bees in the study.

Lactic Acid Bacteria

- Lactic acid bacteria (LAB) are an important part of the microbiome in honeybees as in other animals.
- The microaerophilic environment of the honey bee digestive system is an ideal environment for sugars from nectar and lactic acid bacteria with a temperature of 35°C).

- LAB plays a role in many different functions that have positive effects on the host.
- LAB in the microbiota prevents the colonization and invasion of the intestine by competing with the pathogens for the food in the environment.
- Metabolism products such as carbon dioxide, organic acids, hydrogen peroxide or ethanol produced by the microbiota play an important role in defense against pathogens.
- LAB also produces bacteriocins. They can biosynthesize many different types of antagonistic molecules.
- As a component of the microbiota, LAB participates in important interactions in immunomodulation. LAB increases anti-inflammatory and pro-inflammatory cytokines.
- LAB components can directly induce the immune system. It has been determined that LAB also affects lipid metabolism.



Streaked culture of LAB isolated from *A.cerana*bees LAB in 3rd instar larva of *A.cerana* bees

Functions of gut microbiome

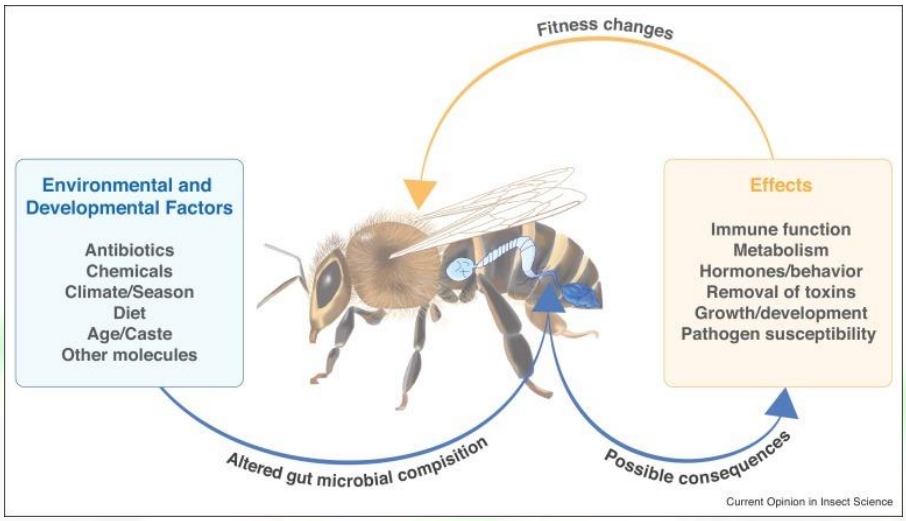
- Considering an ecological perspective, gut microorganisms play a critical role in the process ofcodevelopment of insect-symbiotic interactions by means of secondary metabolites
- Gut microbes take part in insects growth, development, reproduction, and above all they contribute significantly to their metabolism
- Gut microorganisms synthesize essential nutritional compounds, increase the efficiency of digestion, and support insects in absorption of nutrients

- Gut microorganisms significantly contribute to the digestion of lipids and proteins, as well as the detoxification of secondary plant compounds
- One of the possible mechanisms through which microbes support insects against parasites is through modification of the gut environment to constrain parasite development or induce an immune response of the host
- Primary role of gut microbiota in the functioning of mucosal immunity is not surprising, considering that the intestinal mucosa comprises the largest surface area in contact with antigens coming from the external environment
- The dense layer of microbiota covering the mucosa constitutes the greatest proportion of antigens presented to the resident immune cells
- It must tolerate microbiota inhabiting the gut to prevent the induction of harmful systemic immune responses, while controlling the number of microorganisms to avoid overgrowth and translocation the host immune system controls the composition of microbes by releasing molecules like defensins, lectins, reactive oxygen species, and bacteriocins, which effectively constrain the expansion of pathogenic microorganisms
- Peptides are crucial components of innate immunity aimed at defense against the invasion of pathogens,They are determinants of the microbiota composition,as their role is to damage pathogenic microorganisms cells by means of membrane perforation
- Four families of antimicrobial peptides (abaecin, apidaecin, defensin, and hymenoptaecin) are evoked within the honeybee hemolymph during immune challenge
- It was observed that apidaecin and hymenoptaecin expression was upregulated in bees inoculated with gut microbiota, which indicates that the gut microbiota induces immune responses in bees
- Microbes can also affect host behavior by alteration of the levels of biogenic amines such as serotonin, octopamine, and dopamine

Factors Affecting Honeybee Microbiota

- Many pesticides (e.g., chlorothalonil, imidacloprid, and coumaphos) contribute to important adverse health effects and unfavourable changes in the structure and function of the honeybee microbiome

- Sublethal doses of insecticides, such as fipronil, imidacloprid, thiamethoxam, andinduced significant decreases in the quantity of *Lactobacillus sp.* and *Bifidobacterium sp.*



- High and very high concentrations of thiacloprid (a neonicotinoid insecticide)led to dysbiosis in the gut microbial community of honeybees
- neonicotinoid insecticidecontributes to key alterations in the microbiota community, leading to metabolic changes and a decrease in effectivenessof the immune system
- The honeybee microbiome changes seasonally
- It was found that bees were more susceptible to infections by *Nosemaceranae* due to its negative influence on the immune system, which was illustrated by the depletion of the expression of genes that encode antimicrobial peptides
- Gut microbiota is disturbed with **tetracycline** decreased honeybee survival, which was associated with an elevated susceptibility to the oopportunistic pathogen *Serratia sp.*

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BIOLOGICAL DIVERSITY ACT

Article ID: AG-VO3-I03-20

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Introduction

Biological diversity is the variability among all living organisms existing on earth in various ecosystems and ecological complexes. This diversity is the basis of continuous evolution of life forms and in turn maintaining the life-sustaining systems of the biosphere. The conservation of all biological diversity is a common concern of human kind and it is vital to anticipate, prevent and tackle the causes of loss or reduction of biological resources. The dependence of human beings on biological diversity is undoubted, as evident in everyday life. The food, fibre, fuel, fodder, shelter, health and other needs of the growing world population are dependent on various components of biodiversity. It is also recognized that plant genetic resources for food and agriculture are a common concern of all countries and most countries depend largely on plant genetic resources that have originated elsewhere.

Therefore, the sustainable use of biological diversity at the national as well as international level is of critical importance. For the same reason, the access to and sharing of both genetic resources and technologies for their sustainable use among nations are essential. A legally binding agreement, Convention on Biological Diversity (CBD), was adopted by the United Nations Conference on Environment and Development, held at Rio de Janeiro in June 1992. The objectives of the CBD are 'the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization

of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

The Convention reaffirmed that states have sovereign rights over their biological resources and that the states are responsible for conserving these resources and using the same in a sustainable manner. The contracting parties to the CBD are, therefore, required to integrate considerations of conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans programmes and polices. The Biological Diversity Act (BDA) was formulated after India became signatory to the CBD. The draft legislation was developed through an intensive consultation process involving all stakeholders such as the Central Government, State Governments, institutions of local selfgovernment, scientific and technical institutions, experts, non-governmental organizations, industry, etc. The Act was passed by the Parliament in December 2002 (ref. 2). The objectives of the Act are 'to provide for conservation of biological diversity, sustainable use of its components and equitable sharing of the benefits arising out of the use of biological resources and for matters connected therewith or incidental thereto'.

THE BIOLOGICAL DIVERSITY ACT, 2002

- An Act to provide for conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of

biological resources, knowledge and for matters connected therewith or incidental thereto.

- Whereas India is rich in biological diversity and associated traditional and contemporary knowledge system relating thereto; And whereas India is a party to the United Nations Convention on Biological Diversity signed at Rio Janerio on the 5th day of June, 1992;
- And whereas the said Convention came into force on the 29th December, 1993;
- And whereas the said Convention reaffirms the sovereign rights of the States over their biological resources;
- And whereas the said Convention has the main objective of conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of utilization of genetic resources;
- And whereas it is considered necessary to provide for conservation, sustainable utilization and equitable sharing of the benefits arising out of utilization of genetic resources and also to give effect to the said Convention.

Salient provisions

Some of the salient provisions made in the BDA for regulation of access to biological diversity, its conservation and sustainable use are:

(i) Conservation and sustainable use of biological diversity.

(ii) Conservation and development of areas important from the standpoint of biological diversity by declaring them as biological diversity heritage sites.

(iii) Protection and rehabilitation of threatened species.

(iv) To respect and protect knowledge of local communities related to biodiversity.

(v) Regulation of access to biological resources of the country with the purpose of securing equitable share in benefits arising out of the use of biological resources, and associated knowledge relating to biological resources.

(vi) To secure sharing of benefits with local people as conservers of biological resources and olders of knowledge and information relating to the use of biological resources.

(vii) Involvement of institutions of self-government in the broad scheme of the implementation of the Act through constitution of committees.

Relevant definitions

Some of the definitions in the context of the Act are:

Benefit claimers means the conservers of biological resources, their by-products, creators and holders of knowledge and information relating to the use of such biological resources, innovations and practices associated with such use and application.

Biological diversity means the variability among living organisms from all sources and the ecological complexes of which they are part and includes diversity within species or between species and of ecosystems.

Biological resources means plants, animals and microorganisms or parts thereof, their genetic material and by-products with actual or potential use or value but does not include human genetic material.

Bio-survey and bio-utilization means survey or collection of species, subspecies, genes, components and extracts of biological resources for any purpose and includes characterization, inventorization and bioassay.

Equitable benefit sharing means sharing of benefits as determined by the National Biodiversity Authority under section 21 of the Act.

National Biodiversity Authority means the National Biodiversity Authority established under section 8 of the Act.

State Biodiversity Board means the State Biodiversity Board established under section 22 of the Act.

Biodiversity Management Committee means a committee established by each local body (panchayat) under section 41 of the Act.

Sustainable use **means** the use of components of biological diversity in such manner and at such rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

Proposed institutional mechanisms

For the effective implementation of the BDA, the Central Government would undertake activities to develop national strategies, plans and programmes for conservation and sustainable use of biological resources, with the following proposed institutional mechanisms. It would take measures for identification and monitoring biodiversity-rich areas and notify threatened species. It would also undertake promotion of incentives for research, training, public awareness and education with respect to biodiversity, and make assessment of environment impact of any activity likely to have adverse impact on biological diversity. It would regulate, manage or control the risks associated with use and release of living modified organisms resulting from biotechnology, likely to have adverse impact on conservation and sustainable use of biodiversity and human health. It may also declare some resources to be exempted from the provisions of this Act, including resources normally traded as commodities.It is proposed to have National Biodiversity Authority (NBA), State Biodiversity Boards (SBB) and Biodiversity Management Committees (BMC) for effective implementation of the Act.

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COMPOSTING OF AGRICULTURAL WASTE

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Introduction:

Composting is the natural process of decomposition and recycling of organic material into a humus rich soil amendment known as compost.In traditional small-scale farm operations most solid waste is composted and recycled as fertilizer. Composting is simply an acceleration of natural process or organic matter mineralization. Composting accomplishes several beneficial goals for it practioners.

- It reduces the bulk of waste.
- It lowers the biological oxygen demand (BOD) of waste.
- It improves waste's physical characteristics and makes it easier to handle.
- It reduces pathogens and eliminates weed seeds.
- It reduces the land use for land filling and for surface application o waste.

Composting is accomplished in windrows, aerated piles and continuous feed reactors.

The windrow process is simple but slow. It is the large-scale version of the backyard compost pile. Windrow composting requires mixing at intervals for even composting and for several months for stabilization. Soil or compost covering controls odour.

The aerated pile method composts wastes faster than does the windrow system. Perforated pipes are buried in a pile or window and air is either pumped inside or drawn through the piles by vacuum. The air stream oxygenates the composts and cools the compost. This is important, since composting is an aerobic rather an anaerobic process. The heat generated by a compost pile can be used to dry the final product.

Factors affecting the composting process:

The type and composition of the organic waste, The availability of microorganism, Aeration, The C, N and P ratios, Moisture content, Temperature, pH, time,

Type and Composition of the Organic Waste

Organic waste varies considerably in terms of their chemical and physical characteristics. The surface area, hydrophobic and type and complexity of chemical bonds in the waste are key issues. The decomposition rate is proportional to the surface area and inversely proportional to size. So the particle size decreases, surface area increases and decomposition rate increases. A particle size that varies from 0.65 –2.54 cm is recommended as the optimal range for decomposition. Smaller particle interfere with aeration; large particles are too unreactive.

The availability of microorganisms

It is assumed that microorganisms are in the compost. Rapid composting presupposes that a large, active microbial population is present. The microbial population consists of a mixed group of mesophilic and thermophilic bacteria, actinomycetes and fungi. Inoculating compost with material from a previous compost pile can be beneficial because it adds representative mix of microorganisms in high numbers. Bacillus is the predominant genus species include B.brewis, B.circulans, B.coagulans and B. subtilis this account for 10% of the decomposition. The filamentous bacteria representing the actinomycetes account for 15-30%. Thermo tolerant actinomycetes are the most numerous organisms at 2 stages of composting. Nocardia, Streptomyces rectus, S.thermofuscus, Themoactinomyces vulgaris, Thermomonospora spp. Fungi identified in the compost include Mucor, Chetomium, Thermophilum, Penicillium and Aspergillus. Fungi are responsible for 30 –40 % of the weight loss.

Aeration

Microbial decomposition of organic compounds proceeds faster under aerobic conditions. More energy is available from aerobic respiration than from fermentation. This means that for the same amount of C, higher microbial populations can develop and henceforth waste decomposition can be accelerated. The oxygen concentration of the compost air space should be kept at 5% or above. The porosity of composting mix should be about 30%.

The C, N and P ratios

A C: N ration of 30:1-40:1 is appropriate for the initial compost material, but ratios as low as 20:1 have been recommended. High ratios cause immobilization of N. the C: N ratio

should not be lower than 20:1 because it could cause N loss through leaching and volatilization as the organic N mineralizes. C: P ratio of 100:1 –150:1 of recommended. C: N ratio can be lowered by mixing high C: N material with low C: N material.

Moisture Content

Adequate moisture is critical for composting; 50% to 60% water content about right. The compost should be moist but not soggy. Water helps cool the compost .Microbial growth and activity also require enough moisture to keep water films on solid surface for movement and metabolism and also diffusion of soluble compounds . Too much water impedes O_2 diffusion, creates anaerobic condition and slow decomposition rates.

Temperatures

Composting occurs in two temperature ranges; a mesophilic range varying from 10° to 43° and thermophilic ranges varying from 55° to 60°. Temperature control is one of the critical aspects of composting that is distinctly different from the way in which decomposing occurs in soil. It accounts for one of the reasons why decomposing in compost is much faster than decomposition in soil .During early stages of composting, mesophilc microorganisms are responsible for decomposition. The rising temperature allows thermometer bacteria, actinomycetes and fungi to grow and metabolize. An optimal temperature is around 60° to 65°C. Composing at this temperature supports a large thermophilic population. Aerating and watering compost are ways to maintain optimum temperatures. Frequent turning also helps to cool the compost. When readily decomposable material is used up, metabolism slows and the temperature fall allowing mesophilic populations to redevelop. Turning the compost at this stage causes a second temperature increases as UN decomposed material is metabolized.

pH

Optimum pH is near neutral for most microorganisms and slightly alkaline for actinomycetes important in composting. This translates into a range of about 5.5 to 8.5, but the pH extremes should be avoided. A pH of 6.5 to 7.2 is ideal.

Time

One final consideration is time, which will be a function of all these other factors and the mechanical manipulation of the compost. Curing is the slow maturation of compost after active composting is done. It allows volatile compound to escape, some additional decomposition to occur and the moisture of the composted material to decline. Compost is a good soil conditioner

because it is humus like. Thus it promotes aggregation and improved aeration in the soil to which it is applied.

Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil. As a result of these improvements, the soil (i) becomes more resistant to stresses such as drought, diseases and toxicity, (ii) helps the crop in improved uptake of plant nutrients and (iii) possesses an active nutrient cycling capacity because of vigorous microbial activity.

These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers.

Advantages of Composting

Volume reduction of waste, Composting temperature kill pathogen, weed seeds and seeds, Excellent soil conditioner, Saleable product, Improves manure handling, Reduces the risk of pollution, Pathogen reduction, Additional revenue, Suppress plant diseases and pests, Reduce or eliminate the need for chemical fertilizers, Promote higher yields of agricultural crops, Facilitate reforestation, wetlands restoration, and habitat revitalization efforts by amending contaminated, compacted, and marginal soils, Cost-effectively remediate soils contaminated by hazardous waste. Remove solids, oil, grease, and heavy metals from storm water runoff.

The Benefits of Using Composts to Agriculture

Improves the Physical Properties of Soils

Reduces the soil bulk density and improves the soil structure. Increases the water-holding capacity of the soil directly by binding water to organic matter. Protects the surface soil from water and wind erosion by reducing the soil-dispersion action

Enhances the Chemical Properties of Soils

Enables soils to hold more plant nutrients and increases the cation exchange capacity (CEC), anion exchange capacity (AEC), and buffering capacity of soils for longer periods of time after composts are applied to soils. This is important mainly for soils containing little clay and organic matter. Builds up nutrients in the soil. Composts contain the major nutrients required by all plants [N,P,K, calcium (Ca), magnesium(Mg), and S] plus essential micronutrients or trace

elements, such as copper (Cu), zinc (Zn), iron (Fe), manganese (Mn), boron (B), and molybdenum (Mb). Adds organic matter and humus to regenerate poor soils. Buffers the soil against rapid changes due to acidity, alkalinity, salinity, pesticides, and toxic heavy metals.

Improves the Biological Properties of Soils

Supplies food and encourages the growth of beneficial microorganisms and earthworms. Helps suppress certain plant diseases, soil borne diseases, and parasites. Research has shown that composts can help control plant diseases (e.g. Pythium root rot, Rhizoctonia root rot, chili wilt, and parasitic nematode) and reduce crop losses

Economic and Social Benefits of Composting

It Brings higher prices for organically grown crops. Composting can offer several potential economic benefits to communities. Extends current landfill longevity and delays the construction of a more expensive replacement landfill or incinerator. Reduces or avoids landfill or combustor tipping fees, and reduces waste disposal fees and long-distance transportation costs. Offers environmental benefits from reduced landfill and combustion use.

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APPLICATION OF NANO DIAGNOSTIC TOOLS IN PLANT DISEASE DIAGNOSIS

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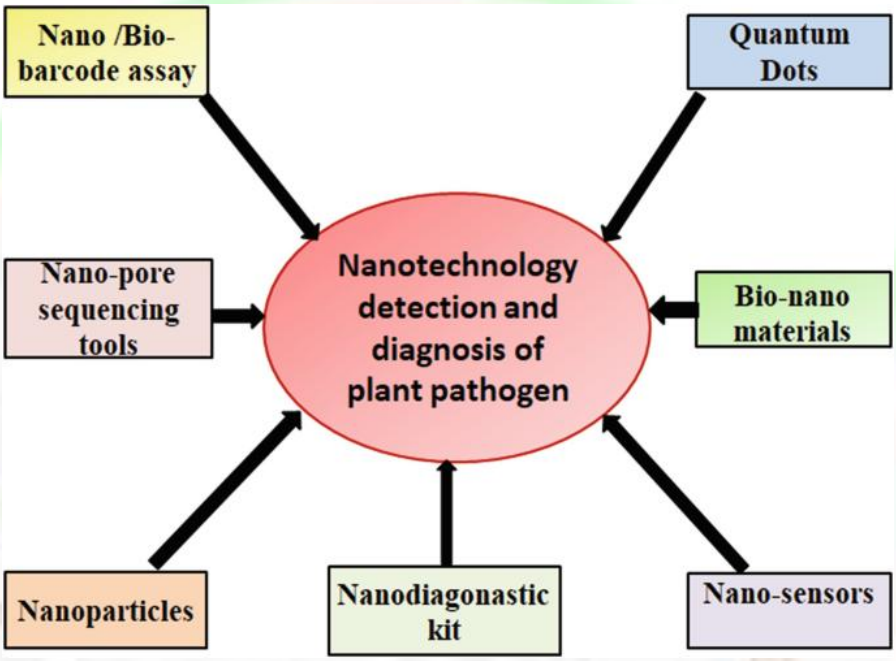
Introduction

Globally, Plant Pathology is one of the major disciplines under the Agriculture sciences. It is the study of plant diseases caused by different microorganisms, various disease symptoms caused by these pathogens, favourable climatic factors responsible for the disease development and spread, plant disease diagnosis by identifying the causal organisms, yield loss estimation and developing proper management methods to control or minimize the disease incidences. Among the several sub areas in plant pathology, research in plant disease diagnosis is always been advancing thus paving ways for development of several quick precision detection techniques.

Identification of Plant diseases

The microorganisms such as fungi, bacteria, viruses and phytoplasma are the major plant disease causing organisms amongst, identification of the fungi and bacteria are quite easy whereas, the viruses and phytoplasmas are very difficult due to their obligate nature in the host and could be seen only through electron microscopy. Although scanning and transmission electron microscopy are available, sample preparation for the analysis is tedious and time consuming. Hence, immuno and molecular diagnostic tools such as Enzyme linked immune sorbent assay (ELISA), Double antibody sandwich (DAS)/ Direct antigen coating (DAC)-ELISA, Tissue blot immuno assay (TBIA), Polymerase chain reaction (PCR), Reverse transcriptase PCR (RT-PCR), multiplex PCR, real time quantitative –PCR (qPCR),Immuno capture RT-PCR (IC-RT-PC), nested PCR,Loop mediated isothermal amplification(LAMP)

(Notomi et al. 2000) , RT-LAMP, Rolling circle amplification (RCA) (Sukal et al. 2019), Recombinase polymerase assay (RPA) (Londono et al.2016) and Next generation sequencing (NGS) based diagnostics have been developed for diagnosing all the disease causing pathogens. However, major limitation for all these techniques is it could be done under laboratory conditions only and lengthy protocol is to be followed which is laborious, time consuming and costly.



Hence, there is a need for a quick, on site, sensitive and reliable diagnostic kits for effective field diagnosisof the disease causing pathogens mainly, the viruses and phytoplasma. Recently, usage of nano materials in plant disease diagnosis have been increasing throughout the world due to their unique and advantageous properties, simple process of synthesis and long shelf life for more precise and low cost onsite diagnosis. Nano diagnostics can be developed by using different nano materialssuch as carbon nanotubes, silver Nanoparticles (AgNPs), Grapheneoxide (GO), Nanocomposites, Silica nano particles (SiNPs), Up conversion NPs, Dendrimers, Colloidal semiconductor fluorescent nanocrystals (Quantum dots- QDs), Nanofibers, Polymeric NPs, gold nanoparticle (AuNPs) etc. (Garcia and Merkoci, 2016). Although nano diagnosis based research is been advancing around the world, it has been in the start-up stage in India especially in Agricultural and Horticultural crops. The recent development of nanoparticle enabled lateral flow immnochromatographic field diagnostic kit is

one such technique successfully developed in India for the detection of *Large cardamom chirke virus* (*Macluravirus*) (Maheshwari et al. 2018) affecting spice crop cardamom from ICAR-Indian Agricultural Research Institute, New Delhi. Developing onsite -field handy and portable nano diagnostic tools would be very helpful to select the healthy planting material especially in vegetatively propagative crops like Sugarcane, Banana, Potato, Tapioca, Turmeric, Ginger, Elephant foot Yam etc. thereby the viral and phytoplasma diseases spread into new areas can be prevented, and it also reduces the plant protection costs to the Indian farmers.

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MILLETS: THE NUTRI - CEREALS

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Introduction

Millets, a type of ancient grain, have been farmed and eaten on the Indian subcontinent for more than 5000 years. One of the most significant cereal grains is nutri-cereal. More than one-third of people in the planet eat them. It is the sixth cereal crop grown globally. Millets are annual cereals from the grass family with small grains that are best suited for warm regions. Compared to other common cereals, they are resilient, rain-fed grains with minimal water and fertility requirements (Mall and Tripathi, 2016). Sorghum, Pearl Millet, Foxtail Millet (Korra), Proso Millet (Variga), Kodo Millet (Arika), Barnyard Millet (Ooda), and Brown Top Millet are among the nutritious grains (Andukorra). Nutri-cereals, an economically advantageous crop, have traits including resistance to drought, photosensitivity, and climate change, among others. Nutri-cereals are cultivated in dry and semi-arid regions with little precipitation (200–600 mm). In many places, millets are an important part of traditional meals.

Nutri-Cereals – Nutrition

Considering their great nutritional value, nutri-cereals significantly contribute to food and nutritional security. Dryland conditions suit millet crops well, and they have outstanding nutritional qualities with high micronutrient concentrations and low glycemic indices. A very good source of carbs, minerals, and phytochemicals with potential health benefits is millets. The millets are high in protein (7–12%), fat (2–5%), carbs (65–75%), and dietary fibre (15–20%).

(DayakarRao et al., 2018). Hunger's main symptom is malnutrition. Due to the preventive effects of health-promoting phytonutrients, epidemiological studies have demonstrated that diets high in plant foods, especially whole grains, are protective against noncommunicable illnesses including diabetes, cancer, and cardiovascular diseases. Millets are enticing, tasting like nuts, and rich in fibre and B-complex vitamins including Niacin, Thiamine, Riboflavin, and Vitamin E. (Shadang and Jaganathan, 2014). With the exception of lysine and threonine, millets are rich providers of essential amino acids; nevertheless, they are also high in amino acids that include sulphur, such as methionine and cystine (Singh et al., 2012).

Millet – the best vehicle for fortification

The main issue in India is micronutrient shortages, and fortification is the cheapest, easiest, and best solution. Because millet is less expensive than other cereals and a staple diet for underprivileged people, millets fortified foods may be the finest supplements. Millets utilised in a variety of culinary products include finger millet, pearl millet, and barnyard millet. Millets may also be used to make bread goods, and they are more nutrient-dense than refined flour. According to a study, finger millet flour may be successfully utilised as a vehicle for zinc fortification to obtain extra levels of bioavailable zinc, with high storage stability, and to address zinc insufficiency(Shadang*et al*., 2014).

Millets for health benefit

Millets are incredibly nutrient-dense, gluten-free, and high in dietary fibre. Calcium, iron, phosphorus, and other micronutrients are abundant in them. They have a low Glycemic Index (GI), which means that their blood sugar levels don't significantly increase. The best diet for us should include millets regularly. Millets provide dietary fibre that can bulk up and absorb water (Chaturvedi et al., 2022). In addition to acting as a cleansing agent for the body, it lengthens the time that food spends in the gut, lowering the risk of inflammatory bowel disease.

International Year of Millets (IYoM)-2023

Government of India had proposed to United Nations for declaring 2023 as International Year of Millets (IYOM). The proposal of India was supported by 72 countries and United Nation's General Assembly (UNGA) declared 2023 as International Year of Millets on 5 th March, 2021. Now, Government of India has decided to celebrate IYOM, 2023 to make it peoples' movement so that the Indian millets, recipes, value added products are accepted globally.

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PRADHAN MANTRI KISAN SAMMAN NIDHI (PM-KISAN)

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Introduction

The Government with a view to augment the income of the farm families is implementing a Central Sector Scheme, namely "**Pradhan Mantri Kisan Samman Nidhi (PM-KISAN)**". The Scheme is in effect from 01.12.2018.

Objective:

- With a view to provide income support to all land holding eligible farmer families, the Government has launched PM-KISAN.
- The scheme aims to supplement the financial needs of the farmers in procuring various inputs to ensure proper crop health and appropriate yields, commensurate with the anticipated farm income.

Benefits and Eligibility criteria:

- All land holding eligible farmer families (subject to the prevalent exclusion criteria) are to avail of the benefits under this scheme, as per the recent cabinet decision taken during May 2019.
- The revised Scheme is expected to cover around 2 crore more farmers, increasing the coverage of PM-KISAN to around 14.5 crore beneficiaries, with cash transfer of 2.2 lakh crore by Central Government for year 2021-22.
- Earlier, under the scheme, financial benefit has been provided to all Small and Marginal landholder farmer families with total cultivable holding up to 2 hectares

with a benefit of ₹ 6000 per annum per family payable in three equal installments, every four months.

Exclusion Categories:

The following categories of beneficiaries of higher economic status shall not be eligible for benefit under the scheme.

- All Institutional Landholders
- Farmer families in which one or more of its members belong to the following categories
  - ✓ Former and present holders of constitutional posts
  - ✓ Former and present Ministers/ State Ministers and former/present Members of LokSabha/ RajyaSabha/ State Legislative Assemblies/ State Legislative Councils, former and present Mayors of Municipal Corporations, former and present Chairpersons of District Panchayats
  - ✓ All serving or retired officers and employees of Central/ State Government Ministries /Offices/Departments and its field units Central or State PSEs and Attached offices /Autonomous Institutions under Government as well as regular employees of the Local Bodies (Excluding Multi Tasking Staff /Class IV/Group D employees)
  - ✓ All superannuated/retired pensioners whose monthly pension is ₹ 10,000/-or more (Excluding Multi Tasking Staff / Class IV/Group D employees) of above category
  - ✓ All Persons who paid Income Tax in last assessment year
  - ✓ Professionals like Doctors, Engineers, Lawyers, Chartered Accountants, and Architects registered with Professional bodies and carrying out profession by undertaking practices

Details required from the beneficiary:

- The States shall prepare database of eligible beneficiary landholder farmer families in the villages capturing the Name, Age, Gender, Category(SC/ST), Aadhaar Number (in case Aadhaar Number has not been issued then Aadhaar Enrollment Number together with any other prescribed documents for purposes of the identification such as Driving Licence, Voters' ID Card, NREGA Job Card, or any other identification

documents issued by Central/State/UT Governments or their authorities, etc.), Bank Account Number and the Mobile Number of the beneficiaries.

- In case of beneficiaries in states of Assam, Meghalaya, J&K where Aadhaar number has not been issued to most of the citizens, Aadhaar number shall be collected for those beneficiaries where it is available and for others alternate prescribed documents can be collected for identity verification purposes.
- Responsibility of identifying the landholder farmer family eligible for benefit under the scheme shall be of the State/UT Government.

Similar programmes by state governments:

- Bhavantar Bhugtan Yojana in Madhya Pradesh was sought to provide relief to farmers by providing the differential between MSPs and market prices.
- The Rythu Bandhu scheme of the Telangana government provides ₹4,000 per acre for every season to all the farmers of the state. Similar initiatives have also be framed in Jharkhand and Odisha.
- In December 2018, Odisha launched the Krushak Assistance for Livelihood and Income augmentation (KALIA). KALIA is more complicated in design and implementation. It commits to give ₹ 5,000 per SMF, twice a year that is ₹ 10,000 in a year.
- The state Government of Karnataka has been providing additional financial assistance of ₹ 4,000 / - in two installments under the PM Kisan-Karnataka Scheme to all eligible farmers of the Central Government's PM KISAN scheme directly to the farmers' account through the Aadhaar based Direct Benefit Transfer.

Twin Factors Aiding Success of PM-KISAN:

- **Enabling Direct Transfers to Farmers:** Direct benefit transfer is now possible, as banking infrastructure created through Pradhan Mantri Jan Dhan Yojana (PMJDY) plays a key role in the fund disbursal.
- **Digitization of Records:** State governments have digitised the complete database of farmers who were now registered in the system with their credentials.

The significant efforts made by the government machinery have revolutionized the welfare framework.

Advantages of PM-KISAN:

Given below are the advantages and the impact of the PM-KISAN schemes:

- The direct transfer of funds is one of the biggest advantages of this scheme. On August 31, 2022, in the presence of PM Narendra Modi, ₹ 2 lakh crores were directly transferred to the bank accounts of 11.37 crore farmers
- All the records related to farmers are registered officially on a digital platform which has made the registration and fund transfer easy. The digitalised records have brought about a new start to this welfare scheme
- This scheme eases liquidity constraints of farmers
- PM-KISAN yojana is a big step towards the Government's initiatives of modernisation of agriculture
- There is no discrimination in choosing the PM-KISAN beneficiaries
- Turning Farmers Competitive: Cash transfer increases the net income of farmers and thus, in turn, may enhance farmers' risks-taking capacity, leading to undertaking riskier but comparatively productive investments.

Efforts Made to Improve the Implementation of PM-KISAN:

Since, the inception of this scheme, a set of technological and process advancements have been done in the scheme so that maximum number of beneficiaries can take the advantage of the same in an efficient way:

- **Self-registration Mechanism:** Process of self-registration of beneficiaries has been made simple and easy through a Mobile App, PM KISAN portal and walkins via Common Service Centres in order to give the maximum benefit to the farmers.
- **Enhanced Recovery Mechanism:** In case of an ineligible beneficiary, recovery mechanism has been made very smooth and transparent which does not require a demand draft or a physical cheque to be submitted by the state. The process includes auto transfer from state nodal department's account to Central Government account which made this process very efficient and less time consuming.
- **Grievance Redressal & Helpdesk:** In order to address the issues and problems faced by the beneficiaries, a holistic grievance redressal mechanism has been envisaged which involves

setting up of a central Project Management Unit of PM-KISAN at the Centre. A centralized helpdesk has also been introduced in order to support the beneficiaries regarding any issues faced during the registration process or for any other query.

- **Physical Verification Module:** In order to maintain the authenticity and validity of the scheme, a mandatory physical verification of 5% beneficiary every year is being done as per the provisions laid down in the scheme. With the help of Physical Verification Module, now the selection of a beneficiary for physical verification has been totally automated and no manual intervention is required.
- **Income Tax verification:** The beneficiary database in this scheme is being regularly validated with income tax payee database in order to have an audited and authenticated user base.
- **Demographic Aadhaar authentication:** To make this whole process more transparent and authenticated, Aadhaar validation has been made compulsory. As of February 24, 2022, the data of 11.20 crore beneficiaries is Aadhaar-seeded in the scheme.

Way Forward:

- **Raising economic support**: The impact of a welfare measure such as PM-KISAN can only be realised through financial support that provides farmers with adequate purchasing power to meet their daily basic necessities.
  - ✓ Therefore, to be effective, any cash transfer scheme should first ensure that there is enough cash provided to help bring an affected community out of poverty.
  - ✓ For instance, the Rythu Bandhu in Telangana provides ₹4,000 per acre to each farmer in each season, and the Krushak Assistance for Livelihood and Income Augmentation scheme (KALIA) in Odisha offers a direct cash transfer of ₹5,000 for a farm family over five seasons, among other benefits.
- **Technology choices for farmers**: It is realised that the adoption of technology for resolving liquidity issues is just one cog in the wheel.
  - ✓ Knowledge and extension support is also needed to bring about adoption.
  - ✓ Investing more in agricultural advisory services, the government can encourage farmers to invest some or all part of the income support in productive assets for achieving the multiplier effect of PM-KISAN.

- **Back-end support**: The scheme needs back-end infrastructure and institutions in place to be effective.
  - ✓ Adoption of modern technologies is one of the most promising strategies to increase farm incomes.
  - ✓ Also, an alternative bottom-up strategy and well-planned implementation mechanism should be identified and implemented at the local level.
  - ✓ The most effective modalities can then are scaled nationally and ensure success.

Conclusion:

A direct transfer scheme like PM-KISAN is a game-changer and can have significant effects if it is timely, not transaction cost heavy and is provided with complementary inputs such as extension services.

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A BRIEF INSIGHT INTO PLANT STEM CELLS

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Introduction

Stem Cells (SC) are undifferentiated cells capable of differentiating into specialized cells (asymmetric division) or more stem cells (symmetric division). SCs have two key characteristics *viz.*, the ability to form many differentiated cell types and the ability to self-renew such that one daughter cell remains a stem cell. SCs are found both in plants and animals.

Plant Stem Cells

Unlike animals, plants are immobile. As plants cannot escape from danger by taking motion, they need a special mechanism to withstand various and sometimes unforeseen environmental stress. It is the stem cells, which empowers them to withstand harsh external influence and preserve life.

Plant stem cells are innately undifferentiated cells, which occupy a small region or niche in larger zones of mitotic activity called meristems. These provide an almost unlimited supply of undifferentiated, immature cells that later differentiate depending on the need. Stem cells act as precursors for differentiating cells; therefore they are essential for normal development and growth in plants.

Two primary meristems, the shoot apical meristem (SAM) and the root apical meristem (RAM) are responsible for plant longitudinal growth and are located at the tip of the stem and root respectively. In addition, plants develop a secondary meristem, the cambium, that allows them to grow radially, and which contributes cells to their vasculature and for mechanical support structures (Jouannet *et al.*, 2015). The control of meristematic activity is therefore crucial

for allowing plants to establish their body plan, maintain tissue homeostasis and adapt their development to fluctuating environments.

Stem cells in both root and shoot system are maintained by the intracellular signals provided by the specialized tissue microenvironment the niche, located within the meristems of the shoot and root tips. Radial and bilateral patterning information helps to position the stem cell niche. The stem cells of the stem are maintained by the signals from the organizing centre (OC) located immediately beneath the stem cells; whereas in the root the signals originate from the quiescent centre (QC) found in the meristematic zone in the centre of the root tip (Williams et al., 2005).

Nature of Plant Stem Cells

Plant stem cells tend to be either pluripotent or totipotent. Plant stem cells never undergo aging process but immortally give rise to new specialized and unspecialized cells, and they have the potential to grow into any organ, tissue, or cell in the body. Thus they are totipotent cells equipped with regenerative powers that facilitate plant growth and production of new organs throughout lifetime. Embryogenic cells can be considered totipotent stem cells based on their aptitude to regenerate or develop into an embryo and then a complete organism (Verdeil *et al.*, 2007*).*

Whereas, pluripotent is ability of a single stem cell to give rise to most but not all the various cell types that make up the body. These pluripotent stem cells give rise to the cells and tissues but do not have the ability to form an embryo. They develop in to all organs except the placenta. Stem cells in plants are highly localized in specific niches. According to Steeves and Sussex, the SAM stem cell niche found in the shoot tips harbours pluripotent cells within the central zone (CZ). It has a stark difference from totipotent cells in that its initiation and development occurs at the post-embryonic stages. Totipotent cells do not possess strong interactions with the stem cell niche cells, unlike the pluripotent cells which do.

Maintenance of Plant Stem Cells

There are number of genes involved in maintaining the stemness of the stem cells. Cells surrounding the plant SCs in the meristem provide signals to maintain niche in an undifferentiated state. A complex pathway of transcription factors and regulatory elements overlap to exert a precise control over the niche and the stem cells. Post embryonic plant

development depends on the maintenance of tissue specific stem cells in the shoot and root meristems. Phytohormones also play an important role in deciding the stem cell fate. The cross talk between auxin and cytokinin plays a significant role in maintaining stem cell populations.

Plant stem cells Vs Animal stem cells

Plant and animal stem cells may show functional similarity, but have marked differences. While animals have a small population of stem cells present in every tissue, plant SCs are generally found in the meristematic region. The plastic nature of the progeny of the meristems is equivalent to the transit amplifying cells present in animals. The plant SCs can develop complete organs based on their position, but animal SCs are restricted to regenerating cells of only one tissue type due to their complexity.

Both plant and animal stem cells maintain the SC population through short range intracellular signals, the niche. Although both SC populations require niches, the niches themselves have no homology. The plant SCs capacity to develop whole organs from the daughter stem cells is influenced by environmental factors, unlike the animal SCs, which are more rigidly locked in their state. The biggest drawback of stem cells in animals is that specialized cells are unable to return to their original undifferentiated state. This limitation is overcome in case of plant stem cells which are capable of reverting to their original state without any external manipulation.

Applications of Plant Stem Cells

Stem cells are becoming increasingly popular owing to their prospective applications in the biomedical and therapeutic domains. Significant advantages of plant stem cells over animal stem cells in commercial applications are depicted in (Fig. 1). Extensive research has found various independent stem cell systems fulfilling specific needs of plant development. The regenerative property of plants has grabbed the interest of dermatology researchers and the cosmetics industry, wherein cosmetic manufacture involving stem cell derivatives is the most promising field at present. Scientific evidence suggests anti-oxidant and anti-inflammatory properties possessed by various plants such as grapes (*Vitis vinifera*), lilacs (*Syringa vulgaris*), Swiss apples (*Uttwiler spatlauber*) etc. are of great importance in terms of cosmetic applications of plant stem cells. There are widespread uses of plant stem cells and their extracts. The products so formulated have a varied range of applications which included skin whitening, de-tanning, moisturizing, cleansing etc.

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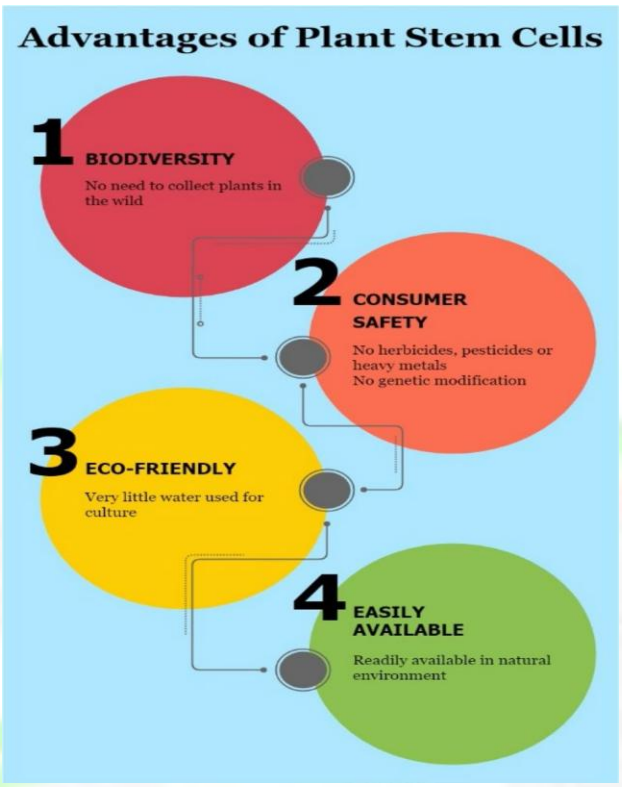

Fig. 1 Advantages possessed by plant stem cells over animal derived counterparts (Picture courtesy: Aggarwal *et al.*, 2020)

Thus, Plants use stem cells as a reservoir to continuously produce new tissues/organs during development and initiate *de novo* organogenesis in regeneration. Cellular plasticity has evolved in plants as an adaptive trait providing plant cells with developmental flexibilities and with the capacity for dedifferentiation and acquisition of pluripotent state.

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