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Contents

1. AGRICULTURE

Apomixis and its Implications in Plant Breeding

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Introduction

Apomixis (apo = detached/separate; mixis = union/combination) term was introduced in 1908 by Winkler. It is a phenomenon where seeds are formed but the embryos develop without fertilization. Apomixis is known to exist in about 300 species belonging to 40 families. It is most commonly observed in families likeCompositae, Graminae, Asteraceae, Rosaceae, Orchidaceae and Liliaceae. It is an asexual means of plant reproduction, more frequent in fruit crops than field crops.

Advantages of Apomixis:

1. Rapid production of purelines.
2. Fixation of heterosis
3. Farmers do not have to buy seed every year as they can produce their own seed
4. Hybrid seed production becomes much easier and less time taking
5. No need of male sterile sources for hybrid seed production.
6. Autonomous apomictic crops will not need pollination and hence do not require male system development.
7. Facilitates the survival of hybrids from wide species
8. Allow multiplication of clonal propagation material as seeds in crops such as potato, cassava.
9. Decreased seed production costs
10. Fastens the hybrid variety development process as there is no need of several generations of selfing to reach homozygosity.
11. No need of pollination in autonomous apomictic lines.
12. Reduces the losses due to pollination failure.
13. Higher multiplication rate of superior genotypes, including hybrids, as clones in form of seed.
14. Usage of less seed material
15. Less bearing of diseases with those of propagation by clone (maintaining genetic structure and fixing superior genotypes after crossing).
16. No need of field isolation.

Limitations of Apomixis

1. Apomixis is a very complicated phenomenon.
2. Estimation of the level of facultative apomixis, is tedious and time consuming.
3. In case of facultative apomicts, the proportion of sexual progeny is affected by environmental factors.
4. In case of facultative apomicts, differentiation of apomictic and sexual progeny is a difficult task.
5. In the absence of morphological markers linked with apomictic development, maintenance of apomictic stock becomes difficult.
6. The genetic basis of apomixis is not clear in most cases.
7. Apomixis genes could escape into wild relatives and cause genetic erosion.
8. A dominant apomixis transgene may spread through pollen across populations to a related outcrossing species apomicts becoming invasive when they are introduced in some ecological niches.

Future Prospects

This technology if explored may change the face of plant breeding. Unraveling the genetic mystery of apomixis is the need of the hour. More research on the genetic control of apomixis will expand the potential horizons of apomixis in plant breeding. One of the major concerns of this technology is that it may affect the seed industry as it allows farmers to produce their own seed. But in reality, any seed need to be replaced for every 4-5 years to ensure genetic purity. Apomixis makes hybrid technology more accessible/ feasible that inturn a boon for the

seed industry. Apomixis is a potential breeding tool for allows fixation and rapid propagation of heterozygous genotypes.

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2. ENTOMOLOGY

Entomophagy: Edible Insects for Humans

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Introduction

Entomophagy is the term used to describe the practice of consumption of insects as food. FAO estimates that insects already form part of the traditional diets of at least 2 billion people. World population is increasing; it is expected to hit 9 billion people by 2050. Current food production will need to almost double but land is scarce will have profound implications on food production, therefore UNs has formulated eight Millennium Development Goals among them 2 are important -Eradicating extreme poverty and hunger, and Reducing child mortality (FAO, 2013). FAO is interested in the use of insects as an alternative food source. Edible insects contribute to the diet of a part of the world population such as those living in Africa, Asia, and Latin America, (Banjo *et al.,* 2006). The most commonly consumed insects globally are beetles, caterpillars, bees, wasps and ants, but in some societies, there is a degree of distaste for their consumption. Insect are rich in protein, amino acids, fat, CHO, various vitamins and trace elements. (Chen and Feng, 1999). Insects also have a high feed conversion ratio: on average insects use 2 kg of feed to produce 1 kg of meat compared to cattle that require 8 kg for every 1 kg of meat produced. Insects are cheap and nutritious food for the vulnerable groups. (DeFoliart, 1999). FAO is looking at insects as a food source for the future.

Entomophagy

Is the practice of eating insects - including arachnids (tarantulas) and myriapods

(centipedes). The word "entomophagy" derives from the Greek term éntomos, or éntomon, meaning, "insect(ed)," literally meaning "cut in two," referring to an insect's segmented body, and phăgein, "to eat." Combined, the two terms mean, "insect eating.

Consumption of Insect in Different Countries

Country	Consumption of insect
South America	Butterfly, Grasshoppers, crickets, Cicadas, Ants, Flies, Bees and Wasps
Colombia	Giant queen ants, Palm grubs and Caterpillars. Asia Grasshoppers, Crickets, Silk worm pupa, Dragonflies, Termites, and Beetles
Thailand	Giant water beetle. Africa Caterpillars, Mopane worm, Termites and Locusts
Pacific Islands	Papua, Palm grubs, Grasshoppers, Crickets, Stick insects, Mantids and Locust
Australia	Honey ants, Grubs, Moth, Bardi grubs and Cerambycid beetle
China	Silkworm pupa, Fly larvae, Cricket, Blattaria, Termites and Locusts
India	Termite, Dragonfly, Grasshopper, Ants, Eri and Mulberry silkworm, Honey bee, Cricket

Advantages

- Insects provide high-quality protein and nutrients compared with meat and fish.
- Insects are particularly important as a food supplement for undernourished children because most insect species are high in fatty acids (comparable with fish).
- They are also rich in micronutrients.
- Insects pose a low risk of transmitting zoonotic diseases.
- New efforts and standards are required to assure nutritional quality and safety of insect foods.
- Eating insects is very sustainable and healthy for the environment since raising them does not require large amounts of land or other resources.

Disadvantages

- Pesticide use can make insects unsuitable for human consumption.
- Herbicides can accumulate in insects through bioaccumulation.
- Cases of lead poisoning after consumption of chapulines were reported by the California Department of Health Services in November 2003.
- Adverse allergic reactions are also a possible hazard.

The roadmap drawn up during the Expert Consultation Meeting on Assessing the Potential of Insects as Food and Feed in Assuring Food Security in Rome in January 2012 summarized the main tasks that lie ahead:

- Further document the nutritional values of insects in order to promote insects more efficiently as a healthy food source.
- Investigate the sustainability and quantify the environmental impacts of harvesting and farming insects compared with traditional farming and livestock-raising practices.
- Clarify and augment the socio-economic benefits that insect gathering and farming can offer, with a focus on improving the food security of the poorest of society.
- Develop a clear and comprehensive legal framework at the (inter-)national level that can pave the way for more investment, leading towards the full development (from the household scale to the industrial scale) of production and trade in insect products for food and feed internationally.

Conclusion

Edible insects are a promising alternative to the conventional production of meat, either for direct human consumption or for indirect use as feedstock. Considering the immense quantities of insect biomass needed to replace current protein-rich ingredients such as meal and oil from fish and soybeans, automated mass rearing facilities that produce stable, reliable and safe products need to be developed. The challenge for this new industry will be to ensure the cost-effective, reliable production of an insect biomass of high and consistent quality. Regulatory frameworks

need to be developed. The close collaboration of government, industry and academia will be essential for success.

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3. ENTOMOLOGY

Cultural and Mechanical Pest Management in Cotton

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Introduction

Cotton occupies 5% of the total cropped area distributed among three different agroclimatic zones in India, and consumes 55% pesticide share accounting for 40% of total production costs. This fact signifies the impact of insect pests and the increased agrochemical use in cotton production. Concern over human health and environmental consequences of agrochemicals besides pest resistance to pesticides has been a corner stone from the eighties.

Major Cotton Insect Pests	
Jassids/ Leaf hopper: Amrasca biguttula biguttula	Spotted & spiny bollworms: Earias vittella & E.insulana
Aphids: Aphis gossypii	American bollworm: Helicoverpa armigera
Thrips: Thrips tabaci	Pink bollworm: Pectinophora gossypiella
Whiteflies: Bemisia tabaci	Red cotton bug: Dysdercus cingulatus F: Pyrrhocoreidae
Cotton mealy bug: Phenococcus solenopsis	Dusky cotton bug: Oxycarenus hyalipennis F: Lygaeidae
Semi-looper: Anomis flava	Grey weevil: Myllocerus subfasciatus
Leaf roller: Syllepte derogata	Grass hopper: Cyrtocanthacris ranacea
Spodoptera leafworm: Spodoptera litura	Stem weevil: Pempherulus affinis

Cultural Practices

- Deep summer ploughing to expose soil inhabiting/ resting stages of insects (*H. armigera* pupae) pathogen and nematode population.
- Adopt proper crop rotation practices to reduce the incidence of mealybugs and soil borne diseases.
- Selection of proper varieties.
- Grow sucking pest resistant genotypes.
- Sowing should be done timely within 10 to 15 days in a village or block in the season.
- Adopt proper spacing, irrigation and fertilizer management as per state govt. recommendations.
- Avoid high doses of nitrogen as it favours the sucking pest population build-up.
- The crop should be maintained weed free for atleast 8-9 weeks after sowing. A hoeing in between crop rows is given 18-20 days after emergence.

- Remove and destroy alternate hosts viz. *Sida* sp., *Abutilon* sp., and other malvaceous members that grow around the field.
- Intercropping with Pigeon pea, Groundnut and Pulses like Cowpea favours the natural enemy population such as *Chrysoperla* and Syrphid population.
- Use of trap crops like Okra (Boll worms), cannabis, castor (*Spodoptera*), Marigold (*Helicoverpa*, Nematodes), Jowar (Sucking pests' barrier) are recommended.
- Avoid ratooning as that may lead to carrying over of pests from one season to next (Pink boll worm and American boll worm)
- Shredding of cotton stalks after harvest and incorporated into the soi.

Mechanical Practices

- Hand picking and destruction of various insect stages viz., egg masses and gregarious larvae of Spodoptera litura, grown up larvae of Helicoverpa armigera, affected plant parts, rosetted flowers due to pink boll worm and rotted bolls.
- Clipping of terminal shoots on 90-110 days in case of conventional hybrids.
- Growing of Setaria as intercrop to serve as live bird perches. Install 8-10 bird perches per ha after 90 days of crop growth for the benefit of predatory birds.
- Monitor pests by using pheromone traps @ 4/acre for different boll worms. The adult monitoring should be supported egg and larval monitoring.
- Keep birds perches @ 10 to 20 per acre for encouraging bird predation on notice of bollworm larvae.
- Hand collection and destruction of egg masses and skeletonised leaves in respect of *spodoptera*.
- Removal of top leaves by topping of cotton plants when maximum egg laying of Helicoverpa armigera is noticed.
- Set up readily available (in market) yellow sticky traps @ 10/acre for monitoring and controlling whitefly incidence.

Conclusion

Cotton is one of the largest consumers of pesticides among other field crops. Due to indiscriminate use of pesticides, there is build-up of toxic residues not only in the environment but also all kinds of food chain. Cultural and mechanical methods to control pests are one of the tactics of IPM (Integrated Pest Management) which are very useful and they help the environment by reducing usage of pesticides. Effects of IPM programs vary because of heterogeneity across regions, time and types of crop growth. Given the fact that in most cotton growing systems pesticide applications are usually required, improved pesticide management must be the starting point for introducing IPM. For judicious use of pesticides on a need basis, developing practical methods of pest monitoring is a priority for biological and social science research.

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4. POST HARVEST TECHNOLOGY

Edible Flowers – Blooming Concept in Post Harvest

Technology

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Introduction

Since ancient times, edible flowers have been used in the human diet (He *et al.,* 2015) and being in practice world wide from Middle Eastern region to Asian countries where edible flowers consumption has been reported for thousands of years. In recent era, awareness and globalization of people have contributed in improvement and lead them to make significant role. Edible flowers have been long used in folk medicine to treat diseases, but recent studies have supported these traditional health benefits, revealing their rich composition in bioactive compounds, which have been correlated to functional properties (Lu *et al.,* 2015). There are numerous edible flowers all over the world and detailed information is much needed in order to increase their acceptability as food ingredients and to avoid potential risks

Edible flowers

- **Garden anchusa and Italian bugloss (*Anchusa azurea* P. Mill.):** Flowers are in violet light-blue colouration and belongs to boraginaceae and used in preparation of soups, boil, fries and salad and it is also depurative, antitussive, diaphoretic, and diuretic (Loizzo *et al.,* 2016)
- **Cotton tree (*Bombax malabaricum* L.):** Flowers are in orange and red colours and belongs to bombacaceae family. Those are cooked and accompanied with meat and rice and also used in treatment of chronic inflammation, fever, diarrhoea, hepatitis, and contused wounds (Zhang *et al.,* 2015)
- **Snapdragon (*Antirrhinum majus* L.):** Flowers are in red, rose, white colours and belongs to plantaginaceae. It is mostly used as salad and widely used in antiphlogistic, resolvent and stimulant; liver disorders, treatment of scurvy, tumours and also used as detergent, astringent and diuretic (Loizzo *et al.,* 2016)
- **Orchid Tree, Purple Butterfly Tree (*Bauhinia purpurea* L.):** Flowers are purple in colour and belongs to leguminosae. It is used in salads and also nephroprotective and thyroid hormone regulating; antibacterial, antidiabetic, analgesic, anti-inflammatory, antidiarrheal and antitumor activities (Lai *et al.,* 2010)
- **Marigold or Scotch marigold (*Calendula officinalis* L.):** Flowers are orange in colour and belongs to asteraceae. It is used in salads, omelettes or as an accompaniment cheese. It has antioxidant, antiinflammatory, antitumor, anti-edematous, anti-HIV, antibacterial and antifungal activities, immunomodulatory and immuno-stimulating, spasmolytic, spasmogenic and gastroprotective, insecticidal, heart rate decrease, cardioprotective, genotoxic and antigenotoxic dose dependent (Benvenuti *et al.,* 2016;)
- **Flinders rose (*Capparis spinosa* L.):** Flowers are white-violet in colour and belongs to capparaceae. It is preserved in vinegar and salt and salad. It is antiseptic, diuretic, and protective of capillary vessels (Loizzo *et al.,* 2016).
- **Safflower (*Carthamus tinctorius* L.):** Flowers are red in colour and belongs to asteraceae. It is used in infusions and cakes and restoring menstrual flow and promoting blood circulation (Wang *et al.,* 2016).
- **Cornflower and bachelor's button (*Centaurea cyanus* L.):** Flowers are blue in colour and belongs to asteraceae. It is used to make infusions, garnish and natural food colorant. It has antioxidant activity, soothing, and used in ocular inflammation (Fernandes *et al.,* 2017)

- **Florist's daisy and hardy garden mum (*Chrysanthemum morifolium* Ramat):** Flowers are yellow-white in colour and belongs to asteraceae. It is used to make infusions and cakes. It has detoxifying and heat clearing effects (Wang *et al.,* 2016).
- **Chicory (*Cichorium intybus* L.):** Flowers are light blue in colour and belongs to asteraceae. It is used in soup, boil, potage and salad and it has depurative, diuretic, laxative, hypoglycaemic, disinfectant of urinary tract and hepatoprotective (Loizzo *et al.,* 2016)
- **Gardenia, cape jasmine, cape jessamine, danhdanh and jasmin (*Gardenia jasminoides*):** Flowers are white in colour and belongs to rubiaceae. It is used in infusions and soup and promoting diuresis and heat-clearing (Wang *et al.,* 2016).
- **Sweetvetch (*Hedysarum coronarium* L.):** Flowers are purple in colour and belongs to fabaceae. It is used in soups, fries with eggs, and salad and hypocholesterolemic and laxative effects (Loizzo *et al.,* 2016)
- **Chinese hibiscus (*Hibiscus rosa sinensis* L.):** Flowers are rose in colour and belongs to malvaceae. It is used as infusions and food
- supplement and cures genito-urinary troubles, bronchial catarrh, fever and cough (Lu *et al.,* 2015)
- **Roselle (*Hibiscus sabdariffa* L.):** Flowers are red in colour and belongs to malvaceae. It has Flavouring agents, beverage (hot and cold), jams preparation of herbal drinks, fermented drinks, wine, ice cream, chocolates, puddings and cakes and it cures hypertension, abscesses, dysuria, fever and scurvy (Lu *et al.,* 2015)
- **Arabian jasmine and Sambac jasmine (*Jasminum sambac* L.):** Flowers are white in colour and belongs to oleaceae. It is used as infusions and also in porridge and it cures skin diseases, cancer, uterine bleeding, ulceration, leprosy and wound healing.
- **Japanese honeysuckle (*Lonicera japonica* Thunb.):** Flowers are yellow-green in colour and belongs to caprifoliaceae. It is used as infusions and in soup and its also heat-clearing and detoxifying (Wang *et al.,* 2016)
- **China rose and Chinese rose (*Rosa chinensis* Jacq):** Flowers are red in colour and belongs to rosaceae. It is used as flavour extract, jams and infusions and also cures homeostasis, menstruation disorders, trauma and diarrheal (Lu *et al.,* 2015)
- **Garden nasturtium (*Tropaeolum majus* L.):** Flowers are yellow. orange, red in colour and belongs to tropaeolaceae. Used as ingredients in meals, salads, foodstuffs and drinks. Antibacterial, antitumor and antithrombotic activities, diuretic and hypotensive effects are medicinal uses (Benvenuti *et al.,* 2016)
- **Johnny Jump up and heartsease (*Viola tricolor* L.):** Flowers are yellow, orange, purple, violet in colouration and belongs to violaceae. It is used in food colorants, sweets, salads, soups, vinegars and drinks and also used in prevention in Alzheimer, Parkinson, atherosclerosis and various cancers; antiallergenic, antiatherogenic, antiinflammatory, antimicrobial, antioxidant, antithrombotic, cardioprotective and vasodilator effects (Navarro-González *et al.,* 2015).

Conclusion

Edible flowers are increasingly used to colour and enhance the visual appearance of various dishes, having special interest in culinary and for the food industry. They are receiving more and more attention by consumers in the search for more attractive and healthier alternatives, with less environmental impact in terms of production and processing. Besides, edible flowers are also appreciated by their nutritional characteristics, associated to a low content in fat and energetic

value, and can also be sought as a natural source of bioactive compounds, such as phenolic compounds, which may play an important role in health promotion and disease prevention. There are numerous species of plants all over the world whose flowers can be used with edible purposes and only a small part of them have been explored.

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5. PLANT BREEDING

Breeding for Disease Resistance in Gourds

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World population presently now is 780 crores, in 2050 it is expected to be increase to 980 crores. Production of food should be increase upto 25-70 % than the preset production, according to Global hunger index 2019 published by The International Food Policy Research Institute (IFPRI) India is at 102 place which is at very bad position.

In India cucurbits are one of the important family of vegetable which are grown across the country for different purposes of utility, it may be culinary, medicine and therapeutic. The family cucurbitaceae majorly comprises 118 genera and 825 species (Joffrey, 1990), mainly cultivable are cucumber, gourds, melons, squashes and pumpkins. In that gourds having its own importance .Cucurbits are favorable host to many diseases because of their succulence nature, among the various diseases the most devastating are downy mildew, powdery mildew and mosaics and other diseases are given in Table.1.

Some of the major cultivated gourds in India includes Bitter gourd (*Momordica charantia*), Ridge gourd (*Luffa acutangula*), Bottle gourd (*Lagenaria siceraria*), Sponge gourd (*Luffa cylindrica*), Ash gourd (*Benincasa hispida*), Little gourd (*Coccinia indica*), Pointed gourd

(*Trichosanthus dioca*), Snake gourd (*Trichosanthus angunia*).

Total availability of land for agriculture is only 11 % and it's decreasing day by day due to various reasons like deforestation, urbanization, soil degradation etc., Chemicals causes so much of negative impact on human and environmental health. The world is spending on an average 40 billion USD on plant chemicals on 3 million tonnes of chemicals.in order to tackle all these problem there is need to develop host resistance in plants, so breeding for these is utmost need (Olsson *et al*, .2019).

The major common steps in developing any crop for disease resistance have following steps namely

Step: 1: Identify the sources of resistance (it may be)

- **A known variety:** Sources of resistance & good agronomic characters
- **Germplasm collection:** Potential sources of resistance in cultivated crops.
- **Related species:** Resistance to a disease may not be concerned crop species
- **Mutants:** Artificial mutants may use in hybridization
- **Soma clonal variants:** variation in the tissue culture can be used as the one of the source for the breeding of disease development.

Some of the important sources of resistance for disease in gourds are listed in Table 2

Step: 2: choose the methods of breeding for disease resistance:

Some of the important methods for developing disease resistance in gourds. Which included from selection to advanced methods like markers and genetic engineering. According to source of material and availability of resource the method of breeding may be chosen

1. **Selection**: If we have any resistance source we can directly select from the population
2. **Introduction**: from other country or state where the resistance variety or germplasm is being cultivated.
3. **Hybridization**: have the following methods
   a. Pedigree method
   b. Backcross method: to transfer resistance gene from donor parent to popular high yielding recurrent parent
   c. Bulk method
4. **Marker assisted selection**: Molecular marker linked to the disease resistance gene or QTL can be used as indirect selection for the particular trait.
5. **Genetic engineering**: to introduce genes of resistance from the other organism source and by genome editing tool like ZFN, TALEN, CRISPR-CAS-9.

Some of the variety/hybrid developed by using these methods from different institutions are given in table 3.

Step: 3: Testing for disease resistance (screening)

- **Soil borne diseases:** Like root rots, collar rots, wilts, etc. the screening is done in disease sick plots
- **Air borne diseases:** Like rusts, smuts, mildews, blights, leaf spots, etc., The screening is done either by dusting the spores or by spraying spore
- **Seed borne diseases:** Seed borne disease like smuts and bunts, dry spores are dusted on the seeds
- **Insect transmitted diseases**: The insect from susceptible varieties are collected and released on healthy plants.

Conclusion:

At the present scenario due to ever-increasing population and decreasing in the area of availability for the agriculture.simultaneosly there is attach of various pest and diseases to the plant, spraying or applying chemicals to the crop leads various hazardous effect to both humans and plants. Being important nutrition sources for human diet and having medicinal importance like anti-diabetic in bittergourd, it is not to be neglected for not being commercially cultivated. So there is need for developing varieties with good agronomical character and resistance to major diseases.

Table: 1. Some of the Major Diseases of Gourds:

1.Viral diseases		3.Bacterial diseases	
Common name	Causal organisms		
Cucumber green mottle	Cucumber green mottle mosaic virus (CGMMV)	Angular leaf spot	*Pseudomonas syringae* pv. *lachrymans*
Sponge gourd yellow mosaic	Tomato leaf curl New Delhi virus	Bacterial leaf spot	*Xanthomonas campestris* pv. *cucurbitae*
Cucumber mosaic	Cucumber mosaic virus (CMV)	Bacterial wilt	*Erwinia tracheiphila*
Cucumber vein yellowing	Cucumber vein yellowing virus (CVYV)	Stem and soft rot	*Erwinia carotovora* pv. *carotovora*
Squash leaf curl	Squash leaf curl virus (SqLCV)	Angular leaf spot	*Pseudomonas syringae* pv. *lachrymans*
Watermelon mosaic	Watermelon mosaic virus(WMV)		
Zucchini yellows	Zucchini yellows mosaic virus (ZYMV)		
2.FUNGAL DISEASES			
Anthracnose	*Colletotrichum lagenarium*		
Cercospora leaf spot	*Cercospora citrullina*		
Damping off	*Phytopthora* spp.		
Downy mildew	*Pseudoperonospora cubensis*		
Powdery mildew	*Sphaerotheca fuliginea* *Podospaera xanthii*		
Gummy stem blight	*Didymella bryoniae*		

Table: 2. Sources of Resistance for Different Diseases in Cucurbits.

Crop	Diseases	Sources
Bottle gourd	CMV, SqMV, WMV	PI 271353 (India), cow leg variety of Taiwan
	Fusarium wilt	Taiwan variety Renshi (Highly resistance)
	Powdery mildew	PI 271375, PI 273663, PI 642039
Bitter gourd	Downy mildew	NIC-12285,VRBT-39
	Fusarium wilt race 1 & 2	Koganenaski
	WMV-1	PI 391544, PI 391545
	WMV-2	PI 391544, PI391545

Table: 3.Achievements

Bitter gourd		
Downey mildew	Phule green gold (T)	MPKV,Rahuri
Powdery mildew	Priyanka (R)	KAU
Ridge gourd		
Leaf spot	PKM 1 (1980)	TNAU
Powdery mildew	Pant Sankar Lauki (F_1) PKM 1 (Induced mutation)	GBPAU TNAU
Bottle gourd		
Anthracnose	Kashi Ganga(T)	IIVR
Anthracnose, Downy mildew and Cercospora leaf spot	Kashi Bahar (F_1)(T)	IIVR

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6. AGRICULTURE: SOIL SCIENCE

Secondary and Micronutrient Nutrient Deficiency in Banana Crops and their Management Practices

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Introduction

Banana (*Musa* sp.) is the second most important fruit crop in India next to mango. Its year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favourite fruit among all classes of people. It has also good export potential. It requires high quantity of nutrients that must be supplied through balanced fertilization to obtain optimum yields.

Calcium deficiency symptoms

Calcium deficiencies are common in both acid and alkaline soils even when exchangeable soil calcium levels are high. This is largely due to the low mobility of soil calcium and competition with other nutrients such as ammonium nitrogen, potassium and magnesium . Calcium deficiency causes the banana leaves to become chlorotic and later light brown necrosis appears from the top of the leaves. Symptoms start on younger leaves, but growth is not restricted. The lower part of the leaves shows deformations in its shape, the margins are torn and parts of the leaves tend to curl inwards. The fruit quality is inferior and the peel splits during ripening

Necrosis

Leaf blade curl inwards symptoms

Management Practices

- Dehydrated lime 50 g per plant should be added followed by irrigation.
- Application of gypsum @ 250 kg ha^{-1}.

Sulphur Deficiency Symptoms

Sulphur plays important roles in banana plants. Sulphur is necessary for chlorophyll formation and helps to efficiently use inorganic forms of nitrogen. Sulphur deficiency causes the banana leaves to become chlorosis on young leaves and sometimes symptoms resembles like nitrogen deficiency that is the leaves become pale yellow or light green colour ,reduced leaf size and stunted growth is observed in banana plants and Heart leaf becomes white and leaf blades becomes very soft and tear easily and small fruits are produced .

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Yellow colouring of leaves symptoms

Management Practices

- Foliar spray of 0.5 % potassium sulphate (5 gram / litre) thrice at 10 days interval
- Application of ammonium sulphate @ 100g/plant.

Boron Deficiency Symptoms

The occurrence of boron deficiency is rare in banana. In B deficient plants, the veins are very close, raised above the lamina and leaves are brittle in the early stage. In the later stage, chlorotic spots parallel to midrib and corrugation and laddering symptoms also appear and unfolding of leaf is delayed in addition to the yield reduction. Breaking of leaf tip and browning at the end. Severe boron deficiency may be confused with the symptoms of Ca deficiency.

Fruit splitting and hard core symptom

Bunch Deformation symptoms

Management practices

- Application of borax at 10-20 g plant $^{-1}$at the time of planting
- Foliar spray of Borax (or) Boric acid @ 0.2 % (2 gram / litre) at 15 days interval for 3 times.

Iron Deficiency Symptoms

Interveinal chlorosis

Deficiency symptoms

Iron deficiency has been recorded in alkaline soils and is identified by interveinal chlorosis of young leaves and leaves turn yellowish white under severe deficiency of iron

Management Practices

- Foliar spray of iron sulphate @ 0.5 % (5 gram / litre) thrice at weekly interval

Zinc deficiency symptoms

Zinc is the most important trace element in bananas and the most reported micronutrient deficiency in banana plantations. Zinc is important for leaf expansion and growth , increases fruit length and diameter , increases bunch stem elongation and bunch expansion.

Zinc deficiency typically shows as smaller, thinner, young leaves appearing with a spearhead shape. As the deficiency progresses, emerging leaves appear with a reddish coloration on the back of the leaves. Bunches produced on zinc deficient plants are small and deformed .Limited zinc availability shortens the distance between hands, giving the bunch a compact appearance. A red pigment, called anthocyanin, can be seen on the back of young, zinc deficient leaves. Zinc availability is reduced with increasing soil alkalinity. High soil phosphorus can induce zinc deficiency.

Rosette appearance of leaves Symptoms

Bushy leaves Symptoms

Management Practices

- Foliar spray of zinc sulphate @ 0.5 % (3 gram / litre) + urea @ 0.5 % (5 gram / litre) twice at 15 days interval.The prepared solution is sprayed at 45 and 60 day after planting.
- Basal application of zinc sulphate @ 50 gram/plant for subsequent planting.

Conclusion

Secondary and micronutrient application in banana crops is very important and plays important role in crop yield. Application of Secondary nutrients and micronutrients fertilizers along with recommended dose of fertilizers not only alters the yield of crops and quality of crops but also maintain soil health.

7. SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Role of Biochar in Improving Crop Performance

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Introduction

The atmospheric carbon dioxide concentration has been increasing over the years due to many reasons including industrialization and inappropriate agricultural practices such as deforestation. There is likely possibility that atmospheric CO_2 concentration will further increase in near future. Hence, it is inviting the attention of scientific community to make soil a possible sink for atmospheric CO_2. There is growing interest in the use of charcoal or 'biochar' to sequester carbon in soil and improve soil fertility (Lehmann and Joseph 2009). There are many types of soil additives and fertilizers used to improve the structure and functions of soil. Biochar has re-emerged an issue in the last five to ten years. Interest in biochar has increased recently as everyone is looking for sustainable ways to improve soils and decrease use of chemical fertilizers. Our history has been well documented with practices like deforestation for fuel, cremation, celebrations in mass, slash and burn (zoom cultivation) agriculture etc. that has already generated some amount of biochar. The potentials might have been overlooked or unattended due to low amount and poor quality of biochar for want of any research information. In the 1970s and 80s, soil scientists starting looking at these unique soils, but it was the late 1990s before they understood that it was a type of charcoal that enriched the soils.

Biochar:

Biochar is the charred biomass produced by slow pyrolysis, whereby organic material is heated under controlled temperatures (300-500 ^oC) in the absence of oxygen. The charred product has a high carbon content (>60% C), making it a potential tool for long-term soil carbon storage as it is largely resistant to decay. However, biochar is a highly variable material, depending on the quality of the original feedstock and pyrolysis conditions, and many questions arise on the value of biochar to modern farming, and importantly, on its impacts on soil functions. Biochar is prepared by different methods. For instance, the Amerindians dug trenches or pits up to 6 feet deep and fill them with the cleared

"slash" (biomass). The soil that is excavated to create the hole, is then placed on top and set on fire. Because of the high moisture content and lack of oxygen in the biomass, these fires smolder for hours and sometimes days. The biomass thus undergo pyrolysis and become biochar or black charcoal. Biochar can be prepared at field level also by making shallow pits and filling them with feed stock and igniting them from one side while keeping passage for smoke on the other side.

Biochar recovery and composition:

Conversion of biomass carbon to biochar carbon leads to sequestration of about 50% of the initial carbon compared to the low amounts retained after burning (3%) and biological decomposition (<10-20% after 5-10 years), thereby yielding more stable soil carbon than burning or direct land application of biomass. This efficiency of carbon conversion of biomass to biochar is highly dependent on the type of feedstock, but is not significantly affected by the pyrolysis temperature (within 350-500°C common for pyrolysis). The amount of material obtained after pyrolysis must not be too little so that the process remain viable with respect to carbon sequestration. There is always decline in recovery of biomass after pyrolysis with increase in temperature and duration. Biochar is an excellent soil amendment for sequestering carbon (increasing SOC content) and water retention as well as providing a habitat for microbes. Biochar also adds some macro (P, K, N, Ca, Mg) and micronutrients (Cu, Zn, Fe, Mn) which are needed for sustainable agriculture. Black carbon may significantly affect nutrient retention and play a key role in a wide range of biogeochemical processes in the soil, especially for nutrient cycling.

Biochar in climate change scenario:

Biochar can hold carbon in the soil for hundreds and even thousands of years. Biochar also improves soil fertility, stimulating plant growth, which then consumes more CO_2 in a feedback effect. Additional effects from adding biochar to soil can further reduce greenhouse gas emissions and enhance carbon storage in soil. These include: biochar reduces the need for fertilizer, resulting in reduced emissions from fertilizer production. It increases soil microbial life, resulting in more carbon storage in soil. It retains nitrogen and emissions of nitrous oxide (a potent greenhouse gas) may be reduced. Turning agricultural waste into biochar reduces methane (another potent greenhouse gas) generated by the natural decomposition of the waste. Humus has this same ability to store nutrients but humus can take hundreds of years to form and there is no practical way we can speed up that process. Biochar on the other hand, can be made very quickly, making it like 'instant humus'. The indirect effect of biochar is that it prevents loss of nutrients from soil through leaching and release to plants slowly as per their need. Biochar does not affect the soil C:N ratio. Microorganisms will release varying amounts of CO_2 depending on the availability of nitrogen in the soil. When the C/N ratio moves too far towards carbon, microorganisms will increase the amount of CO_2 they give off in their respiration in an attempt to restore their preferred C/N ratio. This means that putting lots of carbon-rich matter in the soil will result in more carbon being returned to the atmosphere as CO_2 sooner than would happen otherwise.

Effects on soil properties and crop improvement:

There is no side effect reported on micro-organisms and other fauna in soil There are lots of positive influences reported on varying soil type on soil properties. It is reported that black C can produce significant benefits when applied to agricultural soils in combination with some fertilizers. Apart from positive effects in both reducing emissions and increasing the sequestration of greenhouse gases, the production of biochar and its application to soil will deliver immediate benefits through improved soil fertility and increased crop production. Leaching of applied N fertilizer was significantly reduced by charcoal, and Ca and Mg leaching was delayed. Significant changes in soil quality, including increase in pH, organic carbon and exchangeable cations as well as reduction in tensile strength were observed at higher rates of biochar application, i.e. > 50 t ha^{-1} Reduction in tensile strength and increase in field capacity of hard-setting soil were the most significant. In a green house study, two soil types (sandy loam

and silt loam soils) with different combinations of biochar, cattle manure and N fertilizer in maize resulted in highest shoot dry weight possibly due to improved nutrient retention from the biochar. Shoot dry weight ranged from 41 to 45 g pot-1 at the sandy loam soil and 28 to 35 g pot-1 at the silt loam soil. Shoot dry weight was significantly higher at the sandy loam soil compared to the silt loam soil. Biochar resulted in N recovery of 4 and 5% in maize shoot and root respectively on the sandy loam soil but caused less N recovery at the silt loam soil. The results showed that N recovery can be improved by biochar application to sandy loam soil but not silt loam soil suggesting soil textural effect in the effectiveness of biochar application for soil productivity.

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8. AGRICULTURE SCIENCE

Nutritional and Therapeutic Uses of Green Gram [*vigna radiata* (L.): A Potential Interventional Dietary Component

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Introduction

In recent years, there is a sharp rise in the incidence of a variety of lifestyle disorders. Certain conditions such as cardio vascular diseases, diabetes mellitus etc. are threatening lives and have turned out to be major causes of death. Prevention of occurrence of such diseases has been a major global concern. Green gram, a principle pulse used as a daily food article, exhibits a potential to act against this. In this regard, Ayurveda recommends its use in daily diet and modern research also directs towards the same recommendation.

Green gram - An Ayurvedic Perspective

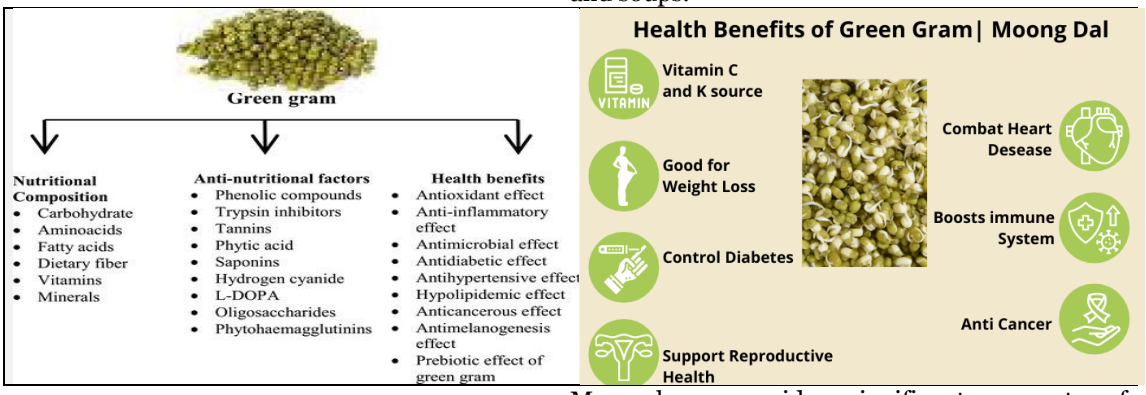
The word Green gram (Mung bean) in Sanskrit means “that which brings joy, delight and gladness”. 1 All the pulses are known to produce flatulence with an exception of Mung bean. This property makes Mung bean complementary to health. There are evidences to show that Mung bean was used as a measurement parameter in Ayurvedic practice. It has been used to explain the size of a mass of haemorrhoids. 2. It has been also referred to, in determining the outlet lumen of an enema nozzle for children. 3. (Used in basti or enema therapy) or a horn used in bloodletting therapy. 4. Further Mung bean has been used as a reference to describe the shapes of lesions of certain skin diseases [for e.g., Ajagallika. 5. (Diaper dermatitis), Upadamsha. 6.(Chancroid) and Masurika. 7. (Measles)]. These evidences show the familiarity of Mung bean to people at large.

In Ayurveda, the pharmacokinetics and pharmacodynamics of a drug are explained in terms of certain attributes viz., Rasa (Taste of the drug), Guna (Properties and effect it has on the body following consumption), Veerya (Potency of the drug, whether it has a catabolic or anabolic effect on the body), Vipaka (Post digestive effect on metabolism). Based on the above, the probable action of the drug can be understood in terms of its effect on the Doshas (Bioforces governing the body whose balance and imbalance determines health and ill health). The pharmacodynamics of mung in Ayurveda has been explained to be that as Madhura (Sweet) and Kashaya8 (astringent) in taste, Laghu8 (light for digestion), ruksha (Dry), sheetaveerya (cold in potency), katu vipaka8 (post digestive

transformation into pungency) and it exhibits Kaphapittahara Vatakaratva 8 (pacifies kapha and pitta whereas aggrevates Vata). It is known to be drushtiprasadaka9 (improves quality of vision).

Botanical Illustration of Mung Bean

The mung bean (Vigna radiata) is a member of the legume family Fabaceae and commonly called as green gram (Figure 1). Mungbean originated in the plains of Peninsular India with its botanical origin, area of maximum genetic diversity and location of domestication being South India. 13 Mung bean is an annual, deep rooted herb, 25-100 cm tall with trifoliate leaves and short fine brownish hairs on the stem branches. Planted in early June, the crop begins to flower in 50 to 60 days which continues for few weeks and is ready to be harvested in early to mid-September. The matured pods are glabrous and consist of 8-20 globose seeds per pod. 14 Green gram is cultivated in several countries of Asia, Africa and the America. It grows best at an altitude of 0-1600 m above sea level and under warm climatic conditions (28-30°C). They are well adapted to red sandy loam soils and are drought tolerant giving reasonable yields with as little as 650 mm of yearly rainfall. Heavy rainfall results in increased vegetative growth with reduced pod setting and development. 15 The most important part of mungbean is the seed used in several food products, both as whole seed and in processed form. Like most legumes they are relatively high in proteins, around 25 % of the seed weight. The principal domestic use of mungbean is the production of bean sprouts which is seen commonly in Asian cooking and is used for dhals and soups.



Nutritional Facts of Mung bean

Green gram is known for its high nutritional value. 100 g of it produces 334 Kcal of energy. 17 It is rich in carbohydrates (56.7 g/100 g) and is a very good source for minerals like Potassium (843 mg/100 g), Magnesium (127 mg/100 g), Calcium (124 mg/100 g), Phosphorus (326 mg/100 g) and Iron (4.4 mg/100 g). Vitamins like Carotene, Thiamine, Niacin, Riboflavin, Ascorbic acid and Folic acid are also present in Mung. It is considered one of the best sources for proteins and constitutes a number of essential amino acids such as Arginine, Histidine, Lysine, Tryptophan, Phenylalanine, Leucine, Isoleucine, Tyrosine, Valine, Threonine, Cystine and Methionine. Mung hence is considered to be a substantive source of dietary proteins and carbohydrates. Mung bean provides significant amounts of dietary iron to plant based diets in developing countries where Mung bean is consumed. 18 Certain chemical components such as flavanoids (Flavones, isoflavones and isoflavonoids), phenolic acids (Gallic acid, Vanillic acid, Caffeic acid, Cinnamic acid, protocatechuic acid, Shikimic acid, p- hydroxybenzoic acid etc), and organic acids isolated from Mung in recent years, supports its health promoting action as mentioned in the classics.

Mode of Action of Mung Bean as per Ayurveda (Pharmacological Effects)

This property makes it a highly beneficial candidate for daily diet in the present scenario where in numerous lifestyle disorders are affecting people worldwide. Cardio vascular diseases and allied conditions (causal and risk

factors) like Diabetes mellitus, Obesity, Dyslipidemia are leading threats to mankind globally. Dietary supplementation both preventive and supportive can help in combating these and usage of Green gram as staple will account for a valuable step. Mungbeans have been tested for several pharmacological activities worldwide. The Mung bean extracts were also found to have a potent scavenging activity against pro-oxidant species, including reactive oxygen species and reactive nitrogen species as well as an inhibitory effect on low-density lipoprotein oxidation. Regular consumption of Mung beans can regulate flora of entero bacteria, decrease absorption of toxic substances, reduce risk of hypercholestraemia and coronary heart disease, and prevent cancer.

Mung bean protein isolates improved the plasma lipid profile by normalizing insulin sensitivity and significantly reduced plasma triglyceride level. Mung bean (*Vigna radiata*) has been traditionally used in China both as nutritional food and herbal medicine against a number of inflammatory conditions since the 1050s. This when experimentally tested showed that Mung bean extract is protective against lethal sepsis by stimulating autophagic HMGB1 degradation. In the ant glycation assays, vitexin and isovitexin showed significant inhibitory activities against the formation of Advanced Glycation end products induced by glucose or methylglyoxal with efficacies of over 85 %. . It was found that the Mung extracts lowered blood glucose, plasma C-peptide, glucagon, total cholesterol, triglyceride, and BUN levels and at the same time markedly improved glucose tolerance and increased insulin immunoreactive levels suggesting a potent antidiabetic effect. 28 The above mentioned researches establish the potential of Mung bean in preventing the occurrence of certain chronic and life threatening disease conditions on daily consumption and also as a therapy in several diseased conditions.

Conclusion

Mung bean or *V. radiata,* one of the most commonly used components of Indian cuisine, is mentioned as the best among Shimbidhanyas (legumes) in Ayurveda. It is mentioned in both treatment and dietary aspects of life threatening conditions like cardiovascular diseases. Some of the researches of recent years have provided evidence on the validity and authenticity of the classical viewpoints about Mung bean. Hence Mung bean can be considered a potential interventional diet in lifestyle disorders. Further research is necessary for better understanding about Mung bean so as to throw more light on its pharmacological efficacy.

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9. AGRICULTURAL SCIENCE

Moringa: The Herbal Green Gold to Combat Malnutrition

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Introduction

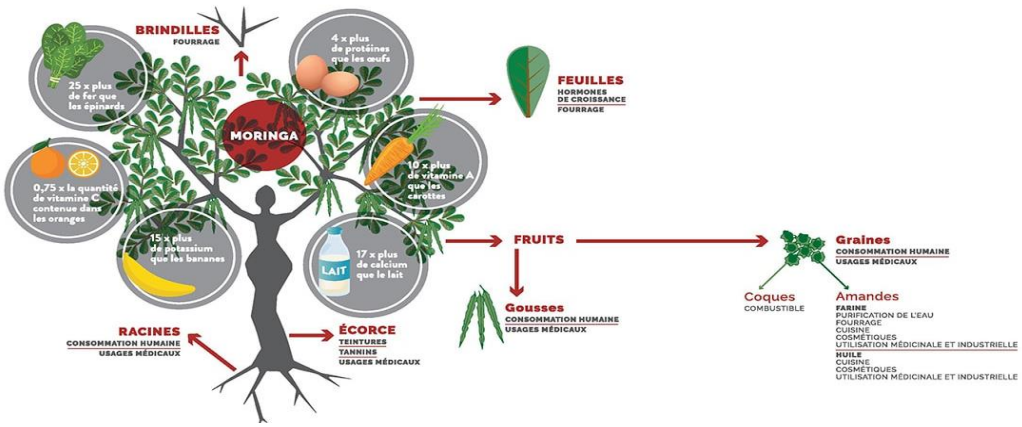
Moringa oleifera is the most widely cultivated pan-tropical species of a monogeneric family, the *Moringaceae*, which is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. *Moringa oleifera* is known by such regional names as benzolive, drumstick tree, kelor, marango, mlonge, mulangay, nébéday, saijhan, and sajna. The history of Moringa dates back to 150 B.C. Historical proofs reveal that ancient kings and queens used Moringa leaves and fruit in their diet to maintain mental alertness and healthy skin. There are 13 varieties of Moringa.

Moringa as a nutrient source

In developing tropical countries, Moringa trees have been used to combat malnutrition, especially among infants and nursing mothers. The pods are extremely nutritious, containing all the essential amino acids along with many vitamins and other nutrients. The immature pod can be eaten raw or prepared like green peas or green beans, while the mature pods are usually fried and possess a peanut-like flavor. The pods also yield 38 to 40% of non-drying, edible oil known as Ben Oil. This oil is clear, sweet and odorless, and never becomes rancid. Overall, its nutritional value most closely resembles olive oil. The thickened root is used as a substitute for horseradish although this is now discouraged as it contains alkaloids, especially moriginine, and a bactericide, spirochin, both of which can prove fatal following ingestion. The leaves are eaten as greens, in salads, in vegetable curries, as pickles and for seasoning. They can be pounded up and used for scrubbing utensils and for cleaning walls. Leaves and young branches are relished by livestock. The Bark can be used for tanning and also yields a coarse fiber. The flowers, which must be cooked, are eaten either mixed with other foods or fried in batter and have been shown to be rich in potassium and calcium.

Treating malnutrition with Moringa

Ideally, good nutrition should be assured by a varied diet rich in meat, root, grain, fruit and vegetable foods. In reality, for a majority of the world's population such variety in food is unaffordable or seasonally unavailable. Malnutrition is frequently characterized by this kind of restricted diet wherein a child consumes the same weaning pap every day. In this context, Moringa is a very simple and readily available solution to the problem of malnutrition. The edible leaves of the Moringa oleifera tree are already an occasional food source throughout West Africa and other regions of the tropics and sub-tropics. Micronutrient deficiencies are now recognized as an important contributor to the global burden of disease. Iodine deficiency in pregnancy has long been linked to intra-uterine brain damage and possible fetal wastage. Currently, although more than two billion people live in areas that used to be iodine-deficient, it is estimated that iodine deficiency is the cause of only 0.2% of the global burden of disease. Iron deficiency also affects about two billion people. Recent estimates find that iron deficiency anemia is responsible for one fifth of early neonatal mortality and one tenth of maternal mortality. Iron deficiency also reduces cognitive development and work performance.



Iron deficiency is the cause of about 800,000 deaths and 2.4% of the global burden of disease. Childhood and maternal mortality. Globally, 21% of children have VAD and suffer increased rates of death from diarrhea, measles, and malaria. The importance of zinc deficiency is being increasingly recognized. Trials have shown that zinc supplementation results in improved growth in children, lower rates of diarrhea, malaria, and pneumonia, and reduced child mortality. In total about 800,000 child deaths per year are attributable to zinc deficiency. Zinc deficiency is the cause of 1.9% of global burden of disease. According to WHO, 19% of the 10.8 million child deaths globally a year are attributable to iodine, iron, vitamin A, and zinc deficiencies. Recent estimates indicate that fortification or supplementation with iron, vitamin A, and zinc are among the most cost-effective interventions available, even in areas that are poor or have high HIV infection rates.

The advantages of using Moringa in malnutrition prevention programs

It is a drought-resistant and fast growing tree which is present in nearly all tropical and sub-tropical countries. Its edible leaves are already an occasional food source in West Africa regions and appear at the end of the dry season: a time when other greens are in short supply. As a source of good nutrition, its leaves are considered the best of tropical legumes with its high quantities of vitamin A and significant quantities of vitamin C, calcium, iron, protein, potassium, magnesium, selenium, zinc and a good balance of all the essential amino acids. Also, the leaves can be easily dried into powder form for use as a nutritional supplement for sauces or as an addition to infant weaning foods. Moringa leaves can be produced intensively in a family-size small garden. The seeds can be spaced as closely as 10 cm apart. When the plants reach a height of a meter, they can be cut down to a height of 30 cm. The leaves can be stripped from the stems and used to prepared sauces or dried for long-term storage as a nutritious food additive, and the stems fed to livestock. The stumps survive the harvest and will re-sprout, allowing another harvest in as little as 50 days. Using this technique, a Moringa garden can continually produce green matter for several years with very little labor required.

Conclusion

The Moringa Oleifera plant is the most inexpensive and credible alternative to providing good nutrition. Moringa oleifera is the most nutrient-rich plant yet discovered. Not only is the Moringa oleifera tree extraordinary in that all parts of the tree are edible, but the most amazing aspect of the tree is its exceptionally high nutritional value. Moringa provides a rich and rare combination of nutrients, amino acids, antioxidants, anti-aging and -inflammatory properties used for nutrition and healing. The leaves of the Moringa tree are an excellent source of vitamin A (four times the amount in carrots), the raw leaves are rich in vitamin C (seven times the amount in oranges), and they are also a good source of vitamin B and other minerals. The leaves are also an outstanding source of calcium (four times the amount in milk), protein (twice the amount in milk), and potassium (three time the amount in bananas). The content of iron is very good as well and the leaves have purportedly been used for treating anemia in the Philippines. The content of amino acids such as methionine and cystine is also high. Carbohydrates, fats and phosphorous content are low making this one of the finest plant foods to be found.

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10. AGRICULTURE

Sensors in Agriculture

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Rapid growth in society, weather change, decreased rainfall, and demand for excess food to sustain billions of people globally are placing a lot of influence on farming. That provides negative impacts on traditional farming practices. We are here with smart sensors in agriculture. The current situation wants farming to become more "smart" by using modern and intelligent technologies. To find the solutions for the best utilization of resources, meeting the global population's ever-increasing consumption needs. Smart sensors in agriculture provide data that helps farmers monitor and optimize their crops and keep updated with changing environmental and ecosystem factors. A smart agriculture sensors helps the animal Identification, heat detection, and health monitoring, And helps to separate and treat sick cows while locating and tracking their herd. Smart sensors in agriculture, farmers can understand their crops and their productivity, sustain resources, and can prevent or control the crops from environmental impact or disaster.

Sensors used in agriculture for smart farming are known agriculture sensors. They provide data that helps farmers to monitor and optimize crops with environmental conditions and challenges. These sensors in agriculture installed and fixed in weather stations, drones, and robots used in the agriculture industry. They can be controlled by mobile apps precisely, which develops for this purpose. These sensors are based on wireless connectivity; they can be controlled directly using wifi or through cellular towers with the help of mobile phone applications.

Types of Sensors used in Agriculture

There are many types of sensors are used in agriculture. They are,

Location Sensors

Location-based sensors help farmers get greater insights on the cultivable land by increasing angles of examination of specific sections of the plot and unlock greater value. GPS based sensors, GIS-based sensors, and manned and unmanned aerial devices like drones and satellite imagery help get a 3-dimensional analysis of the land and the composition of soil in the cultivated region.

Optical Sensors

Optical sensors are used in agriculture to understand the properties of the soil and crop by the analysis of the amount of reflected light on the growing parts of the crop in real-time. Optical sensors tell the analysis tools to increase the dosage of nitrogen for weaker and unhealthy plants and regulate the dosage of nitrogen for the healthy ones. Optical sensors are also used to study the crop vigour by including the biomass of the soil and Nitrogen to other gases ratio in the soil as variables. This helps farmers regulate the moisture levels in the air and soil and prevent damp conditions. (Damp conditions accelerate the rate of growth for bacteria and moss).

Electro-Chemical Sensors

Monitoring the pH level of the soil is essential for sustainable and eco-friendly farming while maximizing revenue. Electrochemical sensors are used to monitor and analyse the soil quality and take measures to alter the pH level or continue practices to maintain the current level for the next phases in the lifecycle of a crop. Electrochemical sensors are used in both outdoor farms and greenhouse-based farming establishments. Electrochemical sensors are mainly used to monitor the levels of Phosphorous, potassium, Calcium, Sodium, Nitrogen, Copper, and Iron.

Mechanical Sensors

Mechanical sensors are used to measure the resistance offered by the soil by applying resistive forces. This is mainly carried out with load cells or strain gauges. Mechanical sensors are used to determine the amount of force that roots are exerting to absorb water and this data is used to optimize the tilling methodologies and

optimizing the inflow of water. This data is also used in the early stages of the life cycle of the crop to determine the right amount of pressure that is exerted by the tractor to offer maximum yield on a long duration.

Dielectric Soil Moisture Sensors

Dielectric soil moisture sensors are used to monitor the moisture levels of the soil to help optimize methods of irrigation management. This helps the farmer better understand the nature of the soil, its capacity to hold moisture, understand the median and mean of the evaporation rate and also get a detailed insight on the root zone of the crop. Water potential sensors and tensiometer sensors are the two prominently used di-electric soil moisture sensors used in precision farming.

Air Flow Sensors

Airflow sensors are used to record the number of gaseous substances present in the soil at a particular landscape after irrigation or to get an overview of the land that is to be cultivated before the seeding process. It determines the optimum pressure required to pump air to aerate the soil and make it more fertile. It is also used to determine the properties of the soil, its compaction, moisture-holding capacity, and more.

Advantages of Sensors in Agriculture

There are many advantages of Agriculture Sensors,

- They are easy to operate and use and easy to maintain.
- Sensors are cheaper in price and best in quality.
- They can used for measuring pollution and global warming.
- These sensors equipped with wireless chips so that they can be controlled remotely.

Labour shortages and the need for food to feed an increasing global population, agricultural robots and technologies now commonly used by farmers. The vision and mission of machine education now allow robots and sensors to see and train surroundings, and of the cheaper costs of smart sensors, they used for more than a year. New innovative sensing technology allows farmers to monitor their fields' pest groups remotely and take immediate action to protect their crops, using online cloud services and a dashboard.

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11. AGRICULTURAL ECONOMICS

Geographical Indication Tags: Embedding Traditional Brands in Global Space

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Introduction

The protection of Geographical Indications (GIs) has, over the years, emerged as one of the most contentious intellectual property right (IPR) issues in the realm of the World Trade Organisation (WTO). Notably, the Agreement on Trade Related Aspects of Intellectual Property Rights

(TRIPS)- an integral part of the WTO Agreement, which was concluded among 117 countries of the world in April 1994, at Marrakesh-specifies norms and standards for the protection of GIs, along with six other categories of IPRs. Geographical Indications (GIs) generally refer to any indication that identifies a good as originating from a particular place, where a given quality, reputation or other characteristics of the good are essentially attributable to its geographical origin. Names such as 'Champagne', 'Sheffield', 'Havana', 'Darjeeling', 'Basmati' etc. are examples of some such well known GIs that are associated throughout the world with products of a certain nature and quality. GIs need not always be geographical names to designate the origin of the goods to which they are associated, but may consist of symbols as well, if such symbols are capable of indicating the origin of the goods concerned without literally naming the place of their origins. One such indication is 'Basmati' for particular varieties of fragrant rice produced in India and Pakistan. The term 'Basmati' does not refer to a geographical location. However, if the public perceives it as a sign of rice from India and Pakistan, and if that rice draws its quality, reputation, or other attributes from that geographical region, 'Basmati' could very well qualify as a GI. While GIs may be associated with manufactured or industrial products, the vast majority are agricultural products, mostly food and beverages. Those non-agricultural products, which enjoy GI protection typically, include handicrafts, jewellery and textiles (Kasturi, 2009).

Definition of GI Tag:

The TRIPS Agreement, Article 22, Identifies GIs as: "Geographical Indication are, for the purposes of this agreement, indications which identify good as originating in the territory of a Member, or a region or a locality in that territory, where a given quality, reputation or other characteristic of the good is essentially attributable to the geographic origin"

Objective: GI tag ensures that none other than those registered as authorized users (or at least those residing inside the geographic territory) are allowed to use the popular product name.

Features of GI

- Collective community rights-protects groups of producers.
- Exclusive (no individual right).
- No right to assign- increases scope of protection.
- Right in perpetuity- remains with the community.
- Knowledge underlying GI remains in the public domain.
- Protects goods that are already famous- reputation must pre-exist.
- Functions like a trademark.

World Intellectual Property Organization (WIPO), one of the 16 specialized agencies of the United Nations created in 1967. Its function is to promote the protection of intellectual property throughout the world. GIs are closely related to trademark and both indicate product origin, and are regulated by TRIPS. The registration of geographical indication is valid for a period of 10 years and to be renewed after it.

Importance of GI

Geographical Indications, furthermore, may provide a strong rural advancement tool which has been perceived by the EU, as reflected in different policies and regulations. This rural development potential could require constitute exceptionally powerful basis for developing countries to grasp and support origin-labeled products within inside their domain. Protection of GI products supports to tolerate commercial events in rural regions. Generally GIs are traditional products, produced by rural communities.

Global Economic Value of GI

Estimated value for sales of GI products worldwide is more than US $ 50 billion. Italy alone has 430 GIs valuing 12 billion Euros and provide employment to about 3 lakh people. The GI registered products in EU on average command a premium of 2.2 times the price of non-GI products such as wines have highest premium at 2.7 times while cheese have premium of 1.6 times. Darjeeling Tea Association says that, the tea from Darjeeling

hills three times the price of Assam and Ceylon Tea. Export value of commodities with GI tag from France was 19 billion Euros, it is close to 10 percent of national food markets' total value (Naresh, 2016).

Global competitiveness is a key determinant for trade and economic prosperity of a country in the era of World Trade Organization (WTO). Consumers in today's market are increasingly becoming finicky about the quality and authenticity of the products that they are buying. Thus, branding is not just the necessity but has become compulsion.

The area, production and average yield of Darjeeling tea increased over the years (1994-2008). Darjeeling tea was first to receive GI in 2004. After this recognition, auction price depicted the continuously increasing trends where all other tea varieties showed mixed trends (Tarit, 2010).

Kasturi (2009) in the study, "A case analysis of the Indian handloom sector" reported that, 77.73 percent of manufacturers owned less than 5 looms (small manufacturers). The fabric got GI in 2004-05. After GI recognition the average growth rates of sales turnover, productivity and employment increased considerably over consecutive years. There was increase in product diversification along with increase in average prices of the products. The monthly income of the weavers has continuously and considerably started increasing over the years.

"Patenting Basmati in the US is like snatching away our history and culture." India won the tussle against US. Lahore based Basmati Growers Association (BGA) had moved IPAB challenging the APEDA application seeking GI tag for basmati rice. IPAB rejected the arguments saying BGA had "miserably failed" to comply with the rules. So the registry rejected the opposition as `abandoned' on December 31, 2013 (TIMES OF INDIA, 2013). Pashmina is a textile which became popular in the West in the late 1990s. It is very soft and warm, and used primarily in scarves and shawls. Again India gained its upper hand in getting GI against Pakistan.

Conclusion

No two coordinates on the earth have same geography. The geography is the factor that has designed our tradition and culture over the years. It not only influence the way of living but, it is also the reason for the occupation we are following. Geographical Indication certifies the good in terms of locality of its origin. When there is an authenticity, consumers are attracted and ready to pay the desired standard amount. In the era of TRIPS branding, recognition is prevailing character of marketing. Therefore, GI tag is holding the lamp to the roads for traditional brands to embed in the global space. GI is fulfilling the vacuum of legal protection to the local culture; this is tremendously increasing the standards of living in rural population with increase in employment opportunity. Thus, when tradition becomes profession, economic development becomes ritual if helping hand is led by providing proper legislation.

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12. AGRICULTURE

Prospects and Potential of Artificial Intelligence in Agriculture

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Abstract

Agriculture involves a wide range of activities, including soil preparation, sowing, irrigation, fertilization, weeding, insect and pest control, harvesting, and storage. Farmers in India face a number of obstacles, including extreme weather, inadequate nutrition, insufficient irrigation infrastructure, and faulty production and protection decisions. An important aspect of the successful implementation and decision-making in this case is artificial intelligence. An artificial intelligence system can think, perceive, learn, make decisions, and solve problems.

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Keywords: Agriculture, Artificial intelligence

Introduction

The principles of artificial intelligence are based on the concept that a computer can easily emulate human intellect and carry out tasks ranging from simple to complex. Artificial intelligence is being used to boost productivity and efficiency in several agricultural sectors. A number of industries are overcoming traditional barriers with the help of artificial intelligence (AI). By enhancing farming efficiency and lowering negative environmental impacts, artificial intelligence is supporting farmers in agriculture. Agriculture has welcomed artificial intelligence in an effort to improve its overall performance. The way food is produced is changing as a result of artificial intelligence. AI (artificial intelligence) can easily manage any undesired natural phenomenon by incorporating it into agricultural assistance.

Application of AI in Agriculture

Use of unmanned aerial vehicle (UAV) to monitor agriculture data: A UAV is an autonomous vehicle that uses remote sensing to capture images and data about a specific location. Unmanned aerial vehicles (UAVs) are cost-effective when used in large-scale environmental projects. Farmers are increasingly using drone technology because it allows them to do things such as in-depth crop analysis, long-distance crop spraying, and highly-efficient crop analysis which ultimately leads to increased yields.

Monitoring of soil health and seed sowing: AI may be used to monitor soil health by scanning the soil for nutritional properties using sensors, cameras, and infrared rays. It also helps to figure out how specific seeds react to different soils, the influence of weather changes on the soil, and the probability of disease and insect spread.

Water and nutrient management: Using high-definition photographs from aerial equipment, real-time estimation may be done during the cultivation phase by creating a field map and pinpointing places where crops require water, fertiliser, or pesticides (drones or copters). This leads to optimum utilisation of resources.

Drones for spraying: One of the most critical uses of drones in agriculture is its flexibility to move around in swift motions and maneuver to the destined locations. This ability of drones helps spray fertilizers and insecticides

to nurture crops and provide them required nutrients.

Issues pest-related advisories: A computer-aided system can accurately diagnose diseases and prescribe treatment options. After that, the infected part can be clipped and transferred to distant labs for further investigation. Image processing may also be used to identify pests and diagnose nutritional deficiencies.

Precision farming: Precision farming is a method of farming that requires high level of accuracy and control. Some of the advanced technologies that enable precision farming include high precision positioning systems, geological mapping, remote sensing, integrated electronic communication, variable rate technology, optimum planting and harvesting time estimator, water resource management, plant and soil nutrient management, and pest and rodent attacks. It mainly works on the 4R's principle. It provides farm inputs at the appropriate time, in the appropriate location, the appropriate source, and in the appropriate quantity.

Determine harvesting stage: Images of different crops taken in a white/UV-free environment can be used to predict harvesting phases. Capturing light determines the ripening stage of the crop/fruits. Farmers can determine several levels of preparedness depending on the crop/fruit type.

Post- harvest monitoring of Agricultural Products: Storage, drying, and grading of harvested crops are also significant components of agriculture. The artificial intelligence idea can be used to monitor and manage the quality of agricultural goods.

Artificial intelligence technologies for accurate supply and demand data: Artificial intelligence has made great advances in agricultural demand and supply management. Its successful application in supply chain planning and optimization, including demand forecasting and logistics. It also assisting stakeholders in overcoming the problem of information asymmetry.

Greenhouse Automation: Plant development and ripening of products in a greenhouse are influenced by a variety of variables. Farmers are not able to analyse all of these variables. AI allows for the examination of all of these development elements and offers very accurate results after assessing the plant growth.

Driverless Tractors: Self-contained tractors that do all farm operations autonomously and perfectly. They're equipped with sensors that can monitor barriers and determine where agricultural inputs should be applied, among other things. Agriculture is already merging off the-shelf technologies like GPS systems, radars, and sensors to open up new farming opportunities.

Weather Forecasting: Meteorologists use a range of sensors, satellites, and computer models to forecast weather trends. Artificial intelligence (AI) approaches use reinforcement learning to analyse prior predictions and actual results. As a result, AI is effectively used to reduce the risk of crop losses and i**Ways to Improve Adoption of AI at Farmer Level**

1. Organizing educational events and demonstrations on artificial intelligence applications and their use in agriculture.
2. Capacity-building programmes for farmers that convey knowledge and skills to them.
3. AI-based communities must be established at the grassroots level in order for AI practises to be adopted and disseminated.
4. Identification of master trainees at the village level in order to increase the horizontal diffusion of AI technologies.
5. AI applications are taught to farmers, researchers, and extension personnel at SAUs, as well as officers from agriculture departments, on a regular basis.
6. After the adoption of AI technologies at the farmer level, a follow-up system should be implemented.
7. Updating the knowledge and skills of scientists, extension workers and farmers for using these platforms.
8. Subsidies in the procurement of AI technology should be made available to make them more affordable to farmers.
9. Network fluctuations and erratic power supplies should be minimized through the development of necessary infrastructure to better serve rural farmers in remote areas.
10. Creating agriculture and rural development policies based on artificial intelligence. At the

national, state, and local levels, money for AI research and development for the benefit of farmers should be allocated.

Conclusion

Using artificial intelligence in agriculture may be a useful and efficient way to maximize resources. Artificial intelligence can significantly reduce shortages of resources and labor. A number of agricultural applications have shown promise. With the help of artificial intelligence, farmers can make the best decisions possible. Artificial intelligence may lead to a technological revolution and a boom in agriculture, which will help feed the world's growing population.

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13. AGRICULTURE

Safe Use of Herbicides in Agriculture

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Weeds are one of the most important biotic stresses in agricultural production particularly in developing countries like India. Weeds cause greater crop yield losses compared to other pests like insects, pathogens, rodents and nematodes. Weeds compete with crop plants for sunlight, water, nutrients and land space. In addition, weeds harbour insects and pathogens which cause heavy damage to the crops. Yield losses due to uncontrolled weeds in crops vary from 25 to 90% and even 100% yield losses are inevitable.

Management of weeds in cropped ecosystems can be accomplished by cultural, manual, mechanical and biological as well as herbicides. Herbicidal weed management has many edging over other methods as it is timely and most efficient with low cost. However, the success of herbicide usage will depend on the safe use of herbicides for weed control particularly, in cropped fields.

1. ***Selection of Herbicide***:
   a. Selection of herbicide based on the recommendation made by the experts and based on the types of crop and cropping systems grown.
2. ***Purchase, storage and handling of herbicides***:
   a. Purchasing of herbicides
      i. Purchase herbicides only from registered herbicide dealers having valid Licenses.
      ii. Purchase only required quantity of herbicides for single application in a specified area.
      iii. Check the approved labels on the containers/packets of herbicides.
      iv. Check the Batch No., Registration Number, Date of Manufacture/ Expiry on the labels of herbicides in well packed in containers.
   b. ***During Storage***
      i. Store the herbicides away from house premises and keep the herbicide in original containers.
      ii. Herbicides must be stored separately and away from the reach of the children and live stocks.
      iii. Storage place should be well protected from direct sunlight and rain.
   c. Handling of herbicides
      i. Keep herbicides separate during transportation and bulk herbicides should be carried tactfully to the site of application
3. ***Preparing and spraying of herbicides***.

a. Preparation of spray solution
   i. Always use clean water and use protective clothings viz., hand gloves, face masks, cap, apron, full trouser, etc. to cover whole body.
   ii. Always protect your nose, eyes, ears, hands, etc. from spill of spray solution.
   iii. Read instructions on herbicide container label carefully before use.
   iv. Prepare the herbicide solution as per requirement.
   v. Granular herbicide should be used as such.
   vi. Avoid spilling of herbicide solutions while filling the spray tank.
   vii. Select right kind of spray equipments and right sized nozzles.
   viii. Use separate sprayer for herbicide application.
b. Application of spray solutions
   i. Care must be taken to apply only the recommended dose and dilution at appropriate stage and time of application.
   ii. Herbicides are to be applied with appropriate methods like using water as carrier, sand mix application, herbigation and swabbing etc.,
   iii. Spray of herbicide should be conducted on cool and calm day and on sunny day in general.
   iv. Use recommended sprayer for each spray.
   v. Spray operation should be conducted in the wind direction.
c. After spray operation
   i. After spray operation, sprayer and buckets should be washed with clean water using detergent/soap.
   ii. Avoid the entry of animals/workers in the field immediately after spray
   iii. Left over spray solutions disposed at safer place viz. barren isolated area.
   iv. Empty containers should be crushed with stone/stick and buried deep in soil away from water sources.
   v. Wash hands and face with clean water and soap before eating.
   vi. On observing poisoning symptoms give the first aid and show the patient to doctor. Also show the empty container to doctor.

4. ***Drifting of herbicides***
   a. Always follow application directions and adhere to warnings mentioned in each specific herbicide label.
   b. Avoid treating nearby crops or other plants that may be affected when wind speed average is more than 10 km/hr.
   c. Eliminate fine spray droplets (lesser than 100 microns size droplets) by selecting proper spraying equipment and with appropriate nozzles.
   d. Provide buffer zone or time of application so as to avoid the herbicide injuries on sensitive crops or plants grown in nearby fields.
   e. Select appropriate time of spraying herbicides, spray preferably during early morning or late in the evening or night hours when wind movement will be practically nil or slight and temperature will be coolest and relative humidity is lower.
   f. Use herbicide spray adjuvants, surfactants or other wetting agents to make sure that the herbicides should reach and get retained in the targeted plants namely weeds.

14. GENETICS AND PLANT BREEDING

Association Mapping in Crop Plants

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Introduction

Gene mapping is mainly done to exploit molecular markers that are intimately linked to the genes that control quantitative traits,

allowing for marker assisted selection. The two most often utilised approaches for dissecting complicated features are linkage analysis and Linkage disequilibrium based association mapping (AM). Due to the small number of recombination events that occur during the generation of mapping populations at the expense of propagating and evaluating a large number of lines, linkage analysis has poor marker resolution. Association mapping, also known as LD mapping (Linkage Disequilibrium), is a population-based study that uses linkage disequilibrium to find trait-marker connections (Flint-Garcia *et al.,* 2003). By utilising historical and evolutionary recombination events at the population level, association mapping has developed as a technique for resolving complex trait variation down to the sequence level (Zhu et al., 2008). Association mapping, as a new alternative to classic linkage analysis, has three benefits: I higher mapping resolution, (ii) reduced research time, and (iii) a larger number of alleles (Yu and Buckler, 2006).

Linkage Disequilibrium (D)

AM refers to the significant connection of a marker locus with a phenotype trait, whereas LD refers to the non-random relationship of two markers or two genes/QTLs (Quantitative Trait Loci). Significant LD can be formed by genetic processes other than linkage between alleles at distant locations or even on different chromosomes. Factors affecting LD are genetic diversity, mating design, population structure, kinship (genetic relatedness), admixture, genetic drift, selection, and recombination and mutation rate.

1. **Steps of Association Mapping**
   a. Collection of diverse genotypes
   b. Precise phenotyping over years/environments
   c. Marker based genotyping (GBS - Genotyping by Sequencing)
   d. The population structure and kinships must be determined to avoid false positives.
   e. Different statistics are used for quantification of LD.
   f. Marker trait association analysis
2. **Two approaches under AM**
   a. **Candidate-Gene Association Mapping:** Candidate genes are chosen based on prior knowledge of the trait of interest gleaned from mutational analysis, biochemical pathway analysis, or linkage studies. An independent collection of random markers has to be scored to infer genetic links. Despite the fact that it is a low-cost, hypothesis-driven, trait-specific technique, it will miss other undiscovered loci.
   b. **Genome-Wide Association Mapping (GWAM):** Without any prior knowledge of potential genes, a huge number of markers are evaluated for correlation with a variety of complicated phenotypes. It is now possible to find hundreds of genome-wide polymorphisms using NGS (Next Generation Sequencing) and GBS (Genotyping by Sequencing) technologies due to the availability of low-cost, high-throughput genotyping and sequencing technology.
3. **Power of Association Mapping and Statistical Approaches:** The level of LD in the genomic region, the type of gene action involved, the size and makeup of the population, the field design and data processing, and the structured association to avoid false positives all affect the power of association mapping. The programme STRUCTURE can estimate population structure (Q-matrix) and kinship coefficient (K-matrix). To block population structure (Q) and kinship information, a mixed linear model (MLM) can be used (K). The MLM (Q+K) model outperforms any other model that only uses the Q- or K-matrix.

Regarding salt tolerance, Saeed et al. (2014) used 250 SSR (Simple Sequence Repeats) markers to screen 109 cotton types for polymorphism. The polymorphism of 98 of these was discovered. Five sub-populations were discovered using STRUCTURE software. The salt treatment was linked to the markers BNL3103 (D6), NAU478 (D8), and BNL3140 (D9), which could be used for cotton molecular breeding for salinity resistance. Rugieri et al. (2014) analyses ninety-six genotype of the tomato using 7720 SNPs. Seven tout of ten

quality traits and metabolites were linked with 20 SNPs significantly studied by GWAS. Finally, favourable allelic combinations between connected loci were discovered, which may be pyramided to create new genotypes with higher quality.

4. **Advanced Approaches**

Multiparent Advanced Generation Intercross (MAGIC): Continuous mating mixed the genome of the founder to made a stable set of inbreds lines by using SSD method and results in a RIL population using many founder parents.

Nested Association Mapping (NAM): NAM is an integrated mapping method that combines the advantages of linkage and LD both to improve mapping resolution while avoiding the use of unduly dense marker maps. It captures genetic variation by creating a large number of related mapping progenies, preferably RILs from a variety of founder lines, with one line serving as the common parent. The RILs are mosaics of the founder nested between common parent specific markers. This technique, which makes use of high-throughput genotyping technologies, is effective in detecting many QTLs and resolving them down to individual genes.

Conclusion

Association mapping take onto consideration the historical recombination events available in diverse population increased the mapping resolution by down the variation to the sequence level and decrease the time of research and higher number of alleles

Statistical methods *viz.,* mixed model approach, structured association, principal component approach, genomic control and have been proposed to reduce false positives which arise due to population structure and kinship. GWAM utilizing high throughput genotyping by sequencing (GBS) approach is a rapid way for associating functional polymorphisms to complex traits variation. Combining linkage and association mapping utilizing NAM and MAGIC populations coupled with GBS is a powerful and cost-effective approach which combine the trait variation with molecular variation and takes the advantage of both linkage disequilibrium and linkage

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15. HORTICULTURE

Phytoplasma: A Severe Threat to Agriculture

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Introduction

Phytoplasmas were discovered in 1967. Phytoplasma are wall-less prokaryotes, free living or parasitic. Phytoplasma come under mollicutes. The impact of phytoplasma diseases on agriculture is impressive and, at the present day, no effective curative strategy has been developed. Phytoplasmas arepathogens of agriculturally important plants like sesamum, coconut, sugarcane etc. They cause a wide variety of symptoms like yellowing to death.

Characters of Phytoplasma –

- Lack of cell wall.
- Colony appearance on agar medium.
- Pleomorphic.
- Filterability through 450 mm membrane.
- They are considered as saprophytic and parasitic or both.

- They are mostly found in phloem tissues of plants.
- Transmitted by vector like leaf hopper
- Cell of Phytoplasma are usually resistant to the antibiotics eg. Penicillin, cephaloridine, which act on cell wall, but sensitive to tetracyeline.

Systematic Position of Mycoplasma

Group	Prokaryotes
Class	Mollicutes
Order	Phytoplasmatales
Family	Phytoplasmataceae
Genera	Phytoplasma

Symptoms of Phytoplasma Disease in Plant

- Greening of petals and conversion of petals to leafy structure.
- Yellowing of leaves.
- Length of leaves area more as compare to width than a plant leaf.
- Proliteration of axillary buds resulting in mitches brown effect.

Important Diseases Caused by Phytoplasma

- Witches brown of Alfalfa, potato
- Sesamum phyllody
- Bunchy top of banana and papaya
- Potato and tomato purple to roll
- Pear and peach decline
- Rice and tomato yellow dwarf
- Citrus greening disease
- Yellow milt of sugar beet
- Little leaf of brinjal and legumes

Some major Plant Diseases Symptoms

- **Sesamum phyllody** - The most common symptoms are floral virescence, phyllody, and proliferation. Sometimes these symptoms are accompanied by yellowing, cracking of seed capsules and formation of dark exudates on the foliage.

- **Bunchy Top of Banana**- The most characteristic symptom are Narrow and short leaves and bleached (chlorotic) margins.

- **Citrus Greening Disease** - The most characteristic symptoms of citrus greening consist of smaller leaves, yellowing of the leaves of part or, usually, the entire canopy of the trees and also severe dieback of twigs.

- **Little Leaf of Brinjal** - The most characteristic symptoms of the disease include shortening of the petioles and production of leaves. Petioles are so short that leaves seem to be glued to the stem. They become soft and glabrous and somewhat yellow in colour.

- **Rice Yellow Dwarf** - The most characteristic symptoms are stunted and have yellowish green to whitish green leaves. Also reduced root growth significantly. Chlorosis occurs on the leaves occasionally even spreading to the leaf sheaths. Streaks may also form parallel to the leaf veins.

Management Practices for Control of Phytoplasma Caused Diseases

- Rouging of infected plants.
- Adjustment of date in sowing.
- Use of clean propagating materials.
- Rotation with non-host crops.
- Removal of weeds.
- Vector control are effective methods for the containment of phytoplasma-associated diseases. Spraying Monocrotophos, Cypermethrin, deltamethrin, malathion and demithoate will be effective for vector control.

16. PLANT PATHOLOGY

Biogas: A Novel Sustainable Approach

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Biogas is a term used to represent a mixture of different gases (varied composition) produced as a result of action of anaerobic microorganisms on domestic and agricultural wastes. Depending on where it is produced, biogas can also be called swamp, marsh, landfill or digester gas. It comprises of hydro-carbon which is combustible and can produce heat and energy when burnt. Bio-gas is produced through a bio-chemical process in which certain types of bacteria convert the biological wastes into useful bio-gas. Since the useful gas originates from biological process, it has been termed as bio-gas.

Composition:

The composition of biogas varies depending upon the origin of the anaerobic digestion process. Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55-75% CH_4. Methane gas is the main constituent of biogas.

Typical composition of biogas:	
Matter	%
Methane, CH_4	50-75
Carbon dioxide, CO_2	25-50
Nitrogen, N_2	0-10
Hydrogen, H_2	0-1
Hydrogen sulphide, H_2S	0-3
Oxygen, O_2	0-2

Substrates:

- The substrate usually employed for biogas generation is a waste product of industrial, agricultural, animal husbandry, or domestic and municipal origin.
- Therefore, the waste would contain a variable proportion of non-biodegradable matter in form of plastics, inorganic materials, lignin, etc. Lignin is virtually non-degradable under anaerobic conditions.

Factors Affecting Biogas Production:

Biogas yield is measured as m3 gas/kg volatile solids.

- Type of waste,
- Temperature during digester operation,
- The retention time (the period of time a given sample of waste/substrate stays in the digester/fermenter before it flows out) and
- The presence of inhibitors.

Biogas production process:

The process of bio-gas production is anaerobic in nature and takes place in two stages. The two stages have been termed as acid formation stage and methane formation stage. In the acid formation stage, the bio-degradable complex organic compounds present in the waste materials are acted upon by a group of acid forming bacteria present in the dung. Since the organic acids are the main products in this stage, it is known as acid forming stage. In the second stage, groups of methanogenic bacteria act upon the organic acids to produce methane gas.

Components of biogas plants:

- **Mixing tank:** The feed material (dung) is collected in the mixing tank. Sufficient water is added and the material is thoroughly mixed till a homogeneous slurry is formed.
- **Inlet pipe:** The substrate is discharged into the digester through the inlet pipe/tank.
- **Digester:** The slurry is fermented inside the digester and biogas is produced through bacterial action.
- **Gas holder or gas storage dome**: The biogas gets collected in the gas holder, which holds the gas until the time of consumption.
- **Outlet pipe:** The digested slurry is discharged into the outlet tank either through the outlet pipe or the opening provided in the digester.
- **Gas pipeline:** The gas pipeline carries the gas to the point of utilization, such as a stove or lamp.

Four groups of bacteria are involved in Biogas Production:

Hydrolytic and Fermentative Bacteria-

- This group includes both obligate and facultative anaerobes, and may occur upto 10^8-10^9 cells/ml of sewage sludge digesters.
- They remove the small amounts of O_2 present and create anaerobic conditions.
- These bacteria hydrolyze and ferment the organic materials, e.g., cellulose, starch, proteins, sugars, lipids, etc., and produce organic acids, CO2 and H2.
- But usually only 50% of the polysaccharides present in the waste may be digested.

(2) Syntrophic H2 Producing Bacteria:

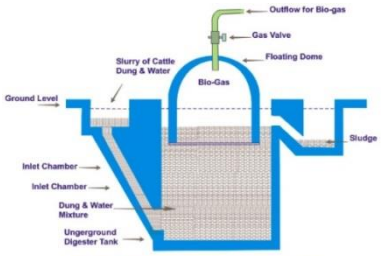
- This group is also called obligate H2 producing or obligate proton reducing bacteria since they oxidise NADH by reducing H+ to H2 and thereby produce hydrogen.
- These bacteria breakdown organic acids having greater than two carbon atoms in their chain to produce acetate, CO2 and H2.
- However, they are able to grow freely and produce H2 only under low H2 partial pressure, which is maintained by methanogens.
- Sewage sludge digesters have about 4 x 10^6 cells/ml of this group. Examples of these bacteria are *Syntrophomonas wolfei, and S. wolinii.*

(3) Methanogenic Bacteria:

- This group of bacteria converts acetate, and CO_2 + H_2 into methane.
- Thus methanogens remove the H_2 produced by obligate H_2 producing bacteria, thereby lowering the H_2 partial pressure and enabling the latter to continue producing H_2.
- Methanogenic bacteria are the strictest possible anaerobes known.
- They may occur up to 10^6-10^8 cell/ml of the slurry in digesters.
- These belong to the new kingdom called Archaebacteria and oxidise H_2 by reducing CO_2 to obtain energy.
- Examples of methanogenic bacteria are *Methanosarcina barkeri, Methanobacterium omelianskii, etc.*
- $4H_2 + CO_2$ $CH_4 + 2H_2O$ (ΔG^0 = -139 kJ/mol)

(4) Acetogenic Bacteria:

- These bacteria oxidise H_2 by reducing CO_2 to acetic acid, which is then used up by methanogens to generate methane, CO_2 and H_2.
- Thus acetogenic bacteria also remove H_2 and enable the obligate H_2 producing bacteria to continue their function.



Floating Dome type Bio-gas Plant

Advantages of Biogas:

1. The technology is cheaper and much simpler than those for other biofuels, and it is ideal for small scale application.
2. Recovery of the product (methane) is spontaneous as the gas automatically separates from the substrates.
3. Dilute waste materials (2-10% solids) can be used as substrate.
4. Organic pollutants are removed from the environment and used to generate useful biogas; this helps clean up the environment.
5. Aseptic conditions are not needed for operation.
6. Any biodegradable matter can be used as substrate.
7. Biogas is suitable for heating boilers, firing brick and cement kilns, and for running suitably modified internal combustion engines.
8. There is reduced risk of explosion as compared to pure methane.
9. Anaerobic digestion inactivates pathogens and parasites, and is quite effective in reducing
10. The incidence of water borne diseases.

Disadvantages of Biogas:

1. The product (biogas) value is rather low; this makes it an unattractive commercial activity.
2. The biogas yields are lower due to the dilute nature of substrates.
3. The process is not very attractive economically (as compared to other biofuels) on a large industrial scale.
4. Recombinant DNA technology and even strain improvement techniques cannot be used to enhance the efficiency of the process.
5. The only improvement in the process, can be brought about by optimizing the environmental conditions of the anaerobic digestion.
6. Biogas contains some gases as impurities, which are corrosive to the metal paris of internal combustion engines.

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