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<th>VOLUME NO: 15</th>
<th>ISSUE NO: 11</th>
<th>September, 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Pages in this issue</td>
<td>68 pages</td>
<td></td>
</tr>
<tr>
<td>DATE OF POSTING</td>
<td>10-11 at RMS, Jodhpur</td>
<td></td>
</tr>
</tbody>
</table>

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**Editorial Office**

J. V. Publishing House  
15, Gajendra Nagar, Near Old FCI Godown  
Shobhawaton Ki Dhani, Pal Road, Jodhpur-342005

**Website:** [www.readersshelf.com](http://www.readersshelf.com)  
**Email:** info@readersshelf.com, jvph@rediffmail.com, readersshelf@gmail.com  
Typesetting: Ankita Arpita, Jodhpur

**Printed by:** Manish Kumar, Manak Offset, Jodhpur

**Published by:**  
Smt. Neeta Vyas  
For J.V. Publishing House, Jodhpur  
RNI No.: RAJENG/04/14700  
ISSN No.: 2321-7405

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Readers Shelf is posted through ordinary post and so our responsibility ceases once the magazine is handed over to the post office at Jodhpur.

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<table>
<thead>
<tr>
<th>Single Copy</th>
<th>Rs. 50.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Subscription: Individual</td>
<td>Rs. 500.00</td>
</tr>
<tr>
<td>Annual subscription: Institution</td>
<td>Rs. 900.00</td>
</tr>
</tbody>
</table>

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1. **AGRICULTURE MICROBIOLOGY**

**Importance of Microbial Biofertilizers to Maintain Soil Fertility and Enhance Crop Production**

Dhanni Devi

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**Introduction**

A bio-fertilizer is simply a substance which contains living microorganisms which when applied to the soil, a seed or plant surface colonizes the rhizosphere and promotes growth by increasing the supply or availability of nutrients to the host plant. A bio-fertilizer is a modernized form of organic fertilizer into which beneficial microorganisms have been incorporated. According to Hari and Perumal (2010) bio-fertilizer is most commonly referred to as selected strains of beneficial soil microorganisms cultured in the laboratory and packed in suitable carriers.

**Mechanism of actions of bio-fertilizers**

Among the PGPRs species, Azospirillum was suggested to secrete gibberellins, etlylene and auxins. Some plant associated bacteria can also induce phytohormone synthesis, for example, lodge pole pine when inoculated with Paenibacillus polymyxa had elevated levels of...
IAA in the roots. Rhizobium and Bacillus were found to synthesize IAA at different cultural pH, temperature and in the presence of agro-waste as carrier material. Unlike other phytohormones, ethylene is responsible for inhibition of growth of dicot plants.

**Types of Bio-Fertilizers and How they Work**

Bio-fertilizers are classified into different types depending on the type or group of microorganisms they contain. Table 1 shows the classification of bio-fertilizers on the bases of the different types of microorganisms used. The different types of bio-fertilizers include:

<table>
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<tr>
<th>Groups</th>
<th>Examples</th>
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<tr>
<td>Nitrogen fixing bio-fertilizers</td>
<td></td>
</tr>
<tr>
<td>Free-living</td>
<td>Azotobacter, Bejerinkia, Clostridium, Klebsiella, Anabaena, Nostoc</td>
</tr>
<tr>
<td>Symbiotic</td>
<td>Rhizobium, Frankia, Anabaena, Azollae</td>
</tr>
<tr>
<td>Phosphate solubilizing bio-fertilizers</td>
<td></td>
</tr>
<tr>
<td>Bacteria</td>
<td>Bacillus megaterium var, Phosphaticum, Bacillus subtilis,</td>
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<tr>
<td>Fungi</td>
<td>Penicillum Spp. Aspergillus awamori</td>
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<tr>
<td>Phosphate mobilizing bio-fertilizers</td>
<td></td>
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<tr>
<td>Ericoid Mycorrhiza</td>
<td>Pezizella ericae</td>
</tr>
<tr>
<td>Orchid Mycorrhiza</td>
<td>Rhizoctonia solani</td>
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<td>Bio-fertilizers for micronutrients</td>
<td></td>
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<tr>
<td>Bacillus Spp</td>
<td>Silicate and zinc solubilizers</td>
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<tr>
<td>Plant growth promoting Rhizobacteria</td>
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</tbody>
</table>

- **Nitrogen fixing bio-fertilizers (NFB):** Examples include Rhizobium Spp., Azosphirillum Spp. and blue-green algae; these work by fixing atmospheric nitrogen and converting them to organic (plant usable) forms in the soil and root nodules of legumes, thereby making them available to plants. Nitrogen fixing bio-fertilizers are crop specific bio-fertilizers.

- **Phosphate solubilizing bio-fertilizer (PSB):** Examples include Bacillus Spp., Pseudomoona Spp. and Aspergillus Spp. These work by solubilizing the insoluble forms of phosphate in the soil, so that plants can use them. Phosphorus in the soil occurs mostly as insoluble phosphate which cannot be absorbed by plants. However, several soil bacteria and fungi possess the ability to convert these insoluble phosphates to their soluble forms. These organisms accomplish this by secreting organic acids which lower the pH of the soil and cause the dissolution of bound forms of phosphate making them available to plants.

- **Phosphate mobilizing bio-fertilizers (PMB):** Examples are Mycorrhiza. They work by scavenging phosphates from soil layers and mobilizing the insoluble phosphorus in the soil to which they are applied. Chang and Yang (2009) stated that phosphorus solubilizing biofertilizer (PSB) sometimes act as phosphate mobilizers. Phosphate mobilizing bio-fertilizers are broad spectrum bio-fertilizers.

- **Plant growth promoting bio-fertilizer (PGPB):** Examples of plant growth rhizobacteria are Pseudomonas Spp. etc: these work by producing hormones and anti-metabolites which promotes root growth, decomposition of organic matter which help in mineralization of the soil thereby increasing availability of nutrients and improving crop yield. PGPB are crop specific bio-fertilizers.

- **Potassium solubilizing bio-fertilizer (KSB):** Examples include Bacillus Spp. and Aspergillus niger. Potassium in the soil occurs mostly as silicate minerals which are inaccessible to plants. These minerals are
made available only when they are slowly weathered or solubilized. Potassium solubilizing microorganisms solubilize silicates by producing organic acids which cause the decomposition of silicates and helps in the removal of metal ions thereby making them available to plants. Potassium solubilizing bio-fertilizers are broad spectrum bio-fertilizers.

- **Potassium mobilizing bio-fertilizer (KMB):** Example of potassium mobilizing bio-fertilizer is Bacillus Spp. These work by mobilizing the inaccessible forms of potassium (silicates) in the soil. Some phosphate solubilizing bio-fertilizers such as Bacillus Spp. and Aspergillus Spp. has been found to mobilize potassium and also solubilize phosphorus.

- **Sulfur oxidizing bio-fertilizer (SOB):** Example of sulfur oxidizing microorganism is Thiobacillus Spp. These work by oxidizing sulfur to sulfates which are usable by plants.

**Microorganisms used in Bio-Fertilizer**

Organisms that are commonly used as bio-fertilizers components include nitrogen fixers (N – fixers), potassium solubilizers (K – solubilizer) phosphorus solubilizer (P – solubilizer), phosphorus mobilizers (P – mobilizers), used solely or in combination with of fungi. Most of the bacteria used in bio-fertilizers have close relationship with plant roots. Rhizobacterium has symbiotic interaction with legume roots, and Rhizobacteria inhabit root surfaces or rhizosphere soil. The phospho-microorganisms mainly bacteria and fungi make insoluble phosphorus available to the plants. Several soil bacteria and few species of fungi possess the ability to covert insoluble phosphate in soil into soluble forms by secreting organic acids. While Rhizobium, blue-green algae, and Azolla are crop specific, bio-inoculants such as Azotobacter, Azospirillum, phosphorus solubilizing bacteria (PSB), and Vesicular Arbuscular Mycorrhiza (VAM) could be regarded as broad spectrum bio-fertilizers.

**Conclusion**

Our dependence on chemical fertilizers and pesticides has encouraged the thriving of industries that are producing life-threatening chemicals which are not only hazardous for human consumption but can also disturb the ecological balance. In fact, attention is now shifting from consuming food grown with chemical fertilizers to food grown with organic fertilizers because of the harmful effects that these foods have in the body when consumed.

**References**


2. **HORTICULTURE**

**Horse Gram Yellow Mosaic Virus – A Threat to Legume Production in Peninsular India**

Arindam Das, Sourav Mahapatra and Koushik Saha

Division of Vegetable Crops, ICAR-Indian Institute of Horticultural Research

Horsegram yellow mosaic virus is a major constraint for cultivation of legume crops in peninsular India. It was first observed in southern districts of Karnataka. The viral disease is caused by the genus Begomovirus, belonging to family Geminiviridae. Disease causes symptoms like yellowish discoloration upon the leaves that leads to irregular, small, greenish-yellow mosaic symptoms. Severe infection leads to stunted growth of the plant and reduction in the leaf size. The virus could infect pole bean, french bean, ring bean, lima bean and soybean with 90, 70, 60, 50 and 40 per cent infection, respectively in addition to horse gram. The virus failed to infect other legume plants viz., green gram, black gram, cowpea, pigeon pea, yard long bean, field bean,
moth bean, rice bean and cluster bean indicating that these plant species are not the hosts of HgYMV. This disease, transmitted by whitefly *Bemisia tabaci* (Gennadius), was prevalent in most parts of South India (Muniyappa and Reddy, 1976). Virus transmission percentage increased with increase in the number of adult whiteflies. Nymphs were less efficient than adults. The disease incidence ranged from 50 to 100 per cent in both summer and early rainy season crops causing substantial loss in legume grain yield. The increasing spread of the Horsegram yellow mosaic disease due to increase in *Bemisia tabaci* population resulted in almost complete loss of the crop during summer. Depending upon the time of infection, plants either produced fewer flowers and pods or none at all. Protecting the crop from the vagaries of this disease is a major challenge for farmers as well as researcher. Control of this disease through pesticide application is not a feasible method. Only alternate to overcome this devastating disease is development of resistant varieties against YMV.

**Disease management**

1. **Cultural method:**
   - Keep the field and its surroundings free from weeds and collateral hosts to check whitefly population.
   - Rouging out of infected plants form the vicinity of healthy plant as soon as they appear.
   - Border cropping with two rows of maize or jowar all around the bean plot can reduce the HGYMV incidence by delaying 10 to 15 days in the initial incidence and continuous insecticide application on border crop can be practised to keep the main crop healthy and contamination free.

2. **Physical method:**
   The most practising method in farmers field to keep the plant healthy and disease free is physical method. This method has become the norm of farming in now a days.
   - Silver colour plastic mulch can used as whitefly repellent in order to reduce HGYMV incidence.
   - Whitefly population can be monitored by the use of yellow sticky traps (3-4/ acre).

3. **Biological method:**
   Biocontrol agents like Whitefly Pathogens (*Verticillisum lecanii*, *Paecilomyces fumosoroseus* and *Aschersonia aleyrodis*), Whitefly Predators (*Delphastus pusillu*, *Macrolophus caliginosus* and *Chrysoperla spp*) and Whitefly Parasitoids (*Encarsia Formosa* and *Eretmocerus eremicus*) can effectively use in controlling whitefly. Although this method is quite good for protected conditions, they are not generally recommended for open field.

4. **Chemical method:**
   - Foliar spray of botanicals like Neem Seed Karnel Extract (NSKE) @ 5% or other materials like fish oil along with resin soap @ 1.4-1.5 Kg per hectare can be used to manage whitefly, especially in organic crops.
   - Borah (1995) reported that foliar application of cypermethrin (0.01%, 0.015%), deltamethrin (0.0028%, 0.0042%) and dimethoate (0.03%, 0.04%) were effective in reducing whitefly population.
   - Chemical method should not be the primary strategy of any disease management programme. Among the chemicals botanical group must be given priority in their use instead of extremely toxic one. A combination of above mentioned strategy is highly recommended for the farmers to support the sustainable and evergreen agriculture.

**References**


Introduction
Most traits in cultivated and natural populations are “Quantitatively Inherited” and have a complex genetic basis. The identification of quantitative trait loci (QTLs) represents a first step towards dissecting the molecular basis of such complex traits. A major advantage for researchers in plant and animal genetics lies in the ability to create an “Experimental populations”. Such populations allow: i) Well-characterization of founder genomes in controlled pedigrees and ii) Facilitate the investigation of genome itself as well as its relationship with traits and environment. However, each of these populations captures only a small snapshot of the factors affecting the trait due to the narrow genetic base i.e. It only possible to detect those genomic regions which differ between the two founders, and all alleles occur with high frequency in the population.

MAGIC Population
The weaknesses of existing designs have led to a new type of complex experimental design called as Multi-parent Advanced Generation Inter-Crosses (MAGIC) which is an inter-mate between the multiple inbred founders for several generations prior to creating inbred lines, resulting in a diverse population whose genomes are fine-scale mosaics of contributions from all founders. The term was coined by Mackay and Powel (2008). Similar to biparental populations, in MAGIC alleles occur at relatively high frequencies due to the limited number of founders, but the population encapsulates much higher diversity in polymorphisms.

Development of MAGIC Population
For MAGIC populations this is of particular importance given the complexity of the design, the time investment required for development, and the number of factors which eventually impact the power, diversity, and resolution of the progeny. The stages involve in the development of MAGIC population are as follow-

Founder selection
Prior to initiating population development, founder lines must be chosen (Fig.1). This may be based on genetic and/or phenotypic diversity, either in a constrained set of material (e.g., elite cultivars, geographical adaptation) or material of more diverse origins (worldwide germplasm collections, distant relatives).

Mixing
In the first stage of population development, multiple parents are inter-crossed to form a broad genetic base (Fig. 1). F1 so produce called as heterogeneous stock (HS). In this stage, the inbred founders are paired off and inter-mated in a prescribed order for each line, known as a funnel.

Advanced inter-crossing
In the second stage (Fig.1), the mixed lines from different funnels are randomly and sequentially inter-crossed as in the advanced inter-cross (AIC). The main goal of this inter-crossing is to increase the number of recombination’s in the population. At least six cycles of inter-crossing were required for large improvements in QTL mapping power.

Inbreeding
In the third stage, the individuals resulting from the advanced inter-crossing stage are progressed to create homozygous individuals (Fig.1). RILs in plants can be created via single seed descent or doubled haploid production.

Applications
Linkage map construction
The large number of polymorphic markers across all founders and accumulation of recombination events through many generations of the MAGIC pedigree can be used to achieve dense and high-resolution mapping of the genome.
Haplotype mosaic reconstruction
Combining knowledge of the pedigree structure with the observed data allows to probabilistically reconstruct the haplotype mosaics which represent the mixing of the founder genomes to produce inbred lines. Once a high-density map or reference sequence has been established, it serves as a foundation for investigation of genome structure relevant both within the MAGIC population and to the species in general. In MAGIC populations, these serve as surrogates for the underlying (unobserved) alleles inherited from each founder.

QTL mapping
The development of methods to utilize the additional information available in MAGIC population is essential to maximize the usefulness to identify the QTL resources. Methods can differ in a number of ways. Inputs may be marker scores or founder probabilities; search strategies may involve a genome scan or modelling of QTL while simultaneously accounting for all other markers genotyped. Statistical approaches can be frequentist or Bayesian, differ in type of model and the number of stages used (1-stage vs. 2-stage), and in how the QTL effects are modelled (fixed vs. random).

Advantages of the MAGIC Population
- MAGIC gives maximum number of informative crossovers among different mapping populations resulting greater number of recombination and genotypic diversity
- More targeted traits from each of the parents are analyzed at a time
- A MAGIC population also make possible to assess epistatic as well as G×E interactions to understand complex traits- yield, quality, abiotic stress tolerance etc
- MAGIC populations may be used directly as source materials for the extraction and development of breeding lines and varieties
- Development of variety with several agronomically beneficial traits which can adopt to several diverse regions of the world and suitable for diverse climatic conditions

Limitations
- Extensive use of the multiple crosses may be restricted by technical limitations
- Large no of population size is required for recovering recombinants with all desirable traits thus more time is required to establish population of desirable level
- They are likely to show extensive segregation for developmental traits, like maturity and plant height which may influence the overall performance for complex traits like yield

References
4. HORTICULTURE

Nano Technological Approaches to Enhance Shelf Life Improvement of Flower Crops

Mangaiyarkarasi. R1 and Arunkumar. P2

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2Assistant Professor, Agricultural Meteorology, RVS Padmavathy College of Horticulture, Dindigul

Introduction

Nanotechnology is the design, characterization, production and application of structures, devices, and systems by controlling the shape and size at the nanometer scale. A nanometer (nm) is one billionth of a meter. A nanometer equivalent to $1 \times 10^{-5}$ m and structures with 1 to 100 nanometer dimension named nanoparticles. The first reference to nanotechnology was made by Richard Feynman in his famous 1959 talk entitled “There is plenty of room at the bottom” in which Feynman suggested a means to develop the ability to manipulate atoms and molecules directly, by developing a set of one-tenth scale machine tools analogous to those found in any machine shop.

Nano in horticulture post harvest

- Controlling Growth and Development of Micro Organisms
- Introducing a New Generation of Packaging Coverage’s (Films) and the Polishes Ability to Control Influence of Gases and Harmful Rays
- Improving Strength, Quality and Packaging Beauty
- Using the Multiple Chips (Nanobiosensors) for Labeling Products

Nano in seed

Carbon nanotube is used for improving the germination of tomato seeds through better permeation of moisture. Their data show that carbon nanotubes (CNTs) serve as new pores for water permeation by penetration of seed coat and act as a passage to channelize the water from the substrate into the seeds.

Nano silver

- Nanosilver - antimicrobial compound which is applied as pulse treatment in preservative solution for cut flowers (Liu et al., 2009; Solgi et al., 2009; Abdel Kader, 2012, Jowkar and Hassanzadeh, 2013).
- It strongly inhibits microorganisms activities because its surface to volume ratio is high (Jiang et al., 2004)
- It releases silver ions which interact with nucleic acid (lose of DNA replication) and cytoplasm components and prevents respiratory enzymes, dissipates the proton motive force and also decreases membrane permeability and finally cell death (Feng et al., 2000)
- Addition of Silver nitrate (10 to 50 ppm) is used in many cut flower preservative solutions to effectively reduce the number of bacteria in the vase water and extend flower longevity.
- Silver nitrate - easily photo-oxidized and reacts with chlorine in the tap water to form silver chloride which precipitates and induce blackening of the solution and the flower stems (Halevy and Mayak, 1981).
- Silver nanoparticles (NPs) are clusters of silver atoms 1 to 100 nm in diameter and is the most commonly used nano formulation as an antimicrobial agent (Chaloupka et al., 2010; Morones et al., 2005).

Nano silver in vase of flowers

Devecchi et al., 2009 studied vase life of Carnation (Dianthus caryophyllus 'Idra di Muraglia') and Ranunculus (Ranunculus asiaticus 'Elegance'). In carnation, treatments with anti-ethylene compounds (synthesized 1-MCP, 1-methylocyclopentene, 2, 5-NBD, and AgNO3) included in nanospomes. In Ranunculus, the same treatments except for treatment 4 and 7 were applied. Nanospomes
could increase the bio-availability and the action of preservative molecules. β-CD could form a stable inclusion complex with 1-MCP, the thermal stability of which was greatly improved after complexation (He and Sun, 2006). Carnation cut flowers, 1-MCP-nanosponge complex (500 mg/L) added to tap water outperformed with high vase life of 23 days. On the contrary, no effects were observed in Ranunculus.

Vinodh et al., 2013 conducted experiment in Asiatic lilyum vase life with Nano Silver (NS) 25, 50, 75 ppm and addition of sucrose 2%. Holding of lilyum spikes with Sucrose 2%+ NS 50 ppm resulted in greater water uptake (16.97 g/stem) and flower size (17.82 cm) with maximum vase life of (17.8 days) as compared with (8.3 days) in control.

Hashemabadi et al., 2003 in rose studied vase life with Boric acid (0, 100, 200, 300 mg l−1) and Silver nano particles (0, 5, 10, 20 mg l−1). The lowest number of bacteria in the end of stem was highest concentrations of boracic acid (300 mg l−1) and nano silver (20 mg l−1).

Lü et al., 2010 in cut rose cv. Movie Star flowers treated with Nano Silver. Stems were kept for 24 h in 10 mg L−1 of Nano Silver with and without sucrose 5%. Combined application of Nano Silver with sucrose improved vase life, which was longer. This effect is probably attributed to supply of energy source by sucrose and regulation of water relations by Nano Silver.

Nemati et al., 2013 in Lilium orientalis ‘Bouquet’ by trimming lowermost leaves from all stems to 35 cm reated with Silver-nano particles (5, 15, 25 and 30 ppm ). The concentration of 30 ppm of silver-nano showed the highest vase solution uptake, initial fresh weight and lowest bacteria colony during the first 2 days of vase life.

Meysm Alimoradi et al., 2013 in Alstroemeria flowers with Nano silver (15, 20 and 25 ppm) and Sucrose at 4% was added. The best treatment to enhance postharvest factors of Alstroemeria, was the exact 15 ppm Silver Nano particles. Nano silver treatment is able to increase vase life of cut alstroemeria flowers by regulating the plant water and increasing total chlorophyll content.

Conclusion:
Nano Silver alone not involved in increasing vase life of cut flowers but when combined with sucrose useful in improving vase life of flowers, as a potential postharvest technology for cut flowers.

References

5. HORTICULTURE

Heavy Metal Stress in Flower and Ornamental Crops

Arunkumar. P1 and Mangaiyarkarasi. R²

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2 PhD scholar, Department of Floriculture and Landscaping, TNAU, Coimbatore

Introduction
Heavy metals (HM) are a natural component of earth crust and environment. In industrial areas, they are a major pollutant of air, water, soil and food with low toxicity threshold and damages. Organic contaminants include different compounds such as petroleum hydrocarbons (e.g., benzopyrene), chlorinated solvents, linear halogenated hydrocarbons (e.g., trichloroethylene), volatile organic carbons, and explosives such as trinitrotoluene. Inorganic compounds include nitrates, phosphates, metals and metalloids, such as mercury (Hg), arsenic (As), lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), selenium (Se), silver (Ag), and zinc (Zn) and nonradioactive or radioactive nuclides. Despite requirements for pollution control measures, these wastes are
generally dumped on land or discharged into water bodies (rivers, canals, lakes, etc.) without adequate treatment, and thus they become a large source of environmental pollution and health hazards. It is, therefore, urgent to adequately remove these pollutants from contaminated sites.

Sources of contamination
There are different sources of heavy metals in the environment such as: natural, agricultural, industrial, domestic effluent, atmospheric sources and other sources. Activities such as mining and smelting operations and agriculture have contaminated extensive areas of world such as Japan, Indonesia and China mostly by heavy metals such as Cd, Cu and Zn (Herawati et al., 2000).

Effect on plants

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<th>Heavy Metal</th>
<th>Role in Plants</th>
<th>Toxicity in Plants</th>
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<tbody>
<tr>
<td>Cadmium</td>
<td>-</td>
<td>Reduction in photosynthesis, water uptake and nutrient uptake</td>
</tr>
<tr>
<td>Lead</td>
<td>-</td>
<td>Inhibits the activity of enzymes at cellular level</td>
</tr>
<tr>
<td>Copper</td>
<td>Intensifies colour, increases sugar content</td>
<td>Pale yellow to white chlorotic mottle on mature leaves, inhibits root growth</td>
</tr>
<tr>
<td>Chromium</td>
<td>-</td>
<td>Inhibits cell division, reduces the dry matter production</td>
</tr>
<tr>
<td>Iron</td>
<td>Oxygen carrier</td>
<td>Bronzing of leaves</td>
</tr>
<tr>
<td>Zinc</td>
<td>Inhibit synthesis of tryptophane, Production of growth hormones like IAA</td>
<td>Yellowing and wilting 200-450 mg kg⁻¹ is toxic</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Drought resistant</td>
<td>Inhibition of ethylene synthesis</td>
</tr>
</tbody>
</table>

Techniques of phytoremediation

1. **Phytoremediation:** The use of plants that absorb pollutants and accumulate them in organs removed from fields, together with crops, in order to purify soil from heavy metal and organic substance contamination.

2. **Phytostabilization:** Plant-mediated immobilization or binding of contaminants into the soil matrix, thereby reducing their bioavailability.

3. **Phytovolatilization:** Contaminant uptake by plants and volatilization into the atmosphere.

4. **Phytodegradation:** The use of plants and associated microorganisms to degrade organic pollutants.

5. **Phytovolatilization:** Contaminant uptake by plants and volatilization into the atmosphere.

6. **Phytodegradation:** The use of plants and associated microorganisms to degrade organic pollutants in the plant root zone by microorganisms.

Heavy metals in ornamentals
Ramana et al., 2012 evaluated three varieties of tuberose (Prajwal, Shringar and Mexican single) with Cd Cl₂ - 0, 25, 50, 75 and 100 mg/kg. Applied Cd did not produce any toxic symptoms in all the three varieties of tuberose. Marginal reduction in the photosynthesis rate and total dry weight beyond 50 mg Cd kg⁻¹ soil. It was concluded that tuberose may be an effective accumulator plant for phytoremediation of cadmium polluted soils.

Mani et al., 2015 studied heavy metal contamination in chrysanthemum indicum with treatment of lead nitrate (0, 10, 20 and 50 mg/kg), Nitrate only (6, 12, 30 mg/kg), Sulphur (0.8 g/kg), Vermicompost (6 g/kg). Lead concentration in the tissues followed the order as root<shoot<flower. The combinatorial treatment T16 (50 mg/kg Pb, 0.8 g/kg elemental sulphur and 6 g/kg vermicompost) caused maximum concentration of lead in root, shoot and flower up to the extent of 43.58, 22.45 and 9.62 mg/kg, respectively, leading to the maximum bioaccumulation factor (0.38).

Hazem A. Mansour et al., 2015 investigated in Tagetes erecta, the feasibility of using some chemical additive treatments(such as nickel, EDTA+Fe and salicylic acid). Cadmium acetate (0, 2.5, 7.5, 12.5 mg/pot), Nickel sulphate (3 and
6 mg/pot), Salicylic acid (50 and 100 ppm), EDTA (15 and 30 ppm). Salicylic acid can be applied at 100 ppm in the nursery or the production field to increase yield of Tagetes erecta (Marigold) under cadmium stress.

Ramana et al., 2014 evaluated Euphorbia milli tolerance of chromium stress with treatment of Potassium dichromate (0, 25, 50, 75 mg/kg of soil). Cr was highly toxic to plants beyond 75 mg Cr/kg soil and grew well up to 50 mg Cr/kg soil.

Shivhare and Sharma, 2012 evaluated effect of heavy metal toxicity in Dahlia treated with Nickel (0.5 mg, 1.0 mg, 1.5 mg, 2.0 mg) and Lead (5 mg, 10 mg, 15 mg, 20 mg). The toxic concentration of lead and nickel which affected the growth and accumulation of lead and nickel plant growing in contaminated soil. It was also observed that the shoots of the Dahlia are more tolerant than roots of dahlia plant and the biomass and seed germination also affected by the nickel and lead toxicity.

Conclusion
Ornamental plants have built-in enzymatic machineries capable of degrading complex structures into simple ones, so it is ecologically sound. This may helpful in bringing polluted sites into productive use.

References


6. SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Role of Nitrogen in Plant and Their Management in Soil

NISHANT SINGH

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Introduction
The earth’s atmosphere is made up of about 78% nitrogen, making it the largest pool of this gas. Nitrogen is essential for many biological processes. It is in all amino acids, proteins and nucleic acids. These compounds are needed to build tissues, transport substances around the body and control what happens in living organisms. In plants, much of the nitrogen is used in chlorophyll molecules which are needed for photosynthesis and growth. The problem with nitrogen is that it is an ‘inert’ gas, which means that it is unavailable to living organisms in its gaseous form. This is because of the strong triple bond between its atoms that make it difficult to break. Something needs to happen to the nitrogen gas to change it into a form that it can be used. And at some later stage, these new compounds must be converted back into nitrogen gas so that the amount of nitrogen in the atmosphere stays the same. This process of changing nitrogen into different forms is called the nitrogen cycle.

Very broadly, the nitrogen cycle is made up of the following processes:

- Nitrogen fixation - The process of converting inert nitrogen gas into more useable nitrogen compounds such as ammonia.
- Nitrification - The conversion of ammonia into nitrites and then into nitrates, which can be absorbed and used by plants.
- Denitrification - The conversion of nitrates back into nitrogen gas in the atmosphere.
Plant uptake of soil nitrogen

Plants require more nitrogen (N) than any other nutrient but only a small portion of the nitrogen in soil is available to plants; 98% of the nitrogen in soil is in organic forms. Most forms of organic nitrogen cannot be taken up by plants, with the exception of some small organic molecules.

In contrast, plants can readily take up mineral forms of nitrogen, including nitrate and ammonia. Mineral nitrogen in soil accounts for only 2% of the nitrogen in soil. Soil microorganisms convert organic forms of nitrogen to mineral forms when they decompose organic matter and fresh plant residues. This process is called mineralisation.

Role of nitrogen in plant in field condition

Healthy plants often contain 3 to 4 percent nitrogen in their above-ground tissues. This is a much higher concentration compared to other nutrients. Nitrogen is so vital because it is a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e., photosynthesis). It is also a major component of amino acids, the building blocks of proteins. Without proteins, plants wither and die. Some proteins act as structural units in plant cells while others act as enzymes, making possible many of the biochemical reactions on which life is based. Nitrogen is a component of energy-transfer compounds, such as ATP (adenosine triphosphate).

Natural Sources of Soil Nitrogen

The nitrogen in soil that might eventually be used by plants has two sources: nitrogen-containing minerals and the vast storehouse of nitrogen in the atmosphere. The nitrogen in soil minerals is released as the mineral decomposes. This process is generally quite slow, and contributes only slightly to nitrogen nutrition on most soils. On soils containing large quantities of NH₄⁺-rich clays.

Bacteria such as Rhizobia that infect (nodulate) the roots of, and receive much food energy from, legume plants can fix much more nitrogen per year (some well over 100 lb nitrogen/acre). When the quantity of nitrogen fixed by Rhizobia exceeds that needed by the microbes, they are already receiving enough from the bacteria.

Symptoms of nitrogen deficiency in plant

- The chlorophyll content of the plant leaves is reduced which results in pale yellow color. Older leaves turn completely yellow.
- Flowering, fruiting, protein and starch contents are reduced. Reduction in protein results in stunted growth and dormant lateral buds.

Management of nitrogen in soil

- Never exceed nitrogen-based manure rates. The rate may not exceed the amount of nitrogen necessary to achieve realistic expected crop yields or the amount of nitrogen the crop will utilize for an individual crop year.
- Time manure and fertilizer applications as close to crop uptake as practical. Nutrients shall be applied to fields during times and conditions that will hold the nutrients in place for crop growth, and protect surface water and groundwater using best management practices.
- For fall-and winter-applied manures, cover crops are encouraged to be planted. For fall applications, manure should only be applied if a cover crop will be planted and grow enough for nutrient uptake. For winter applications, fields must have at least 25 percent cover by crop residue or an established cover crop.
- Setbacks and buffers. Manure may not be applied within 100 feet of a stream or intermittent stream bed unless a 35-foot permanent vegetative buffer is established.
- Use the PSNT or chlorophyll meter to determine supplemental nitrogen needs. Recommendations based on these tests may be used in place of supplemental N needs in a nutrient management plan.
Nutrition at various life stages has been associated with the risk of chronic diseases later in life. Therefore it is important for healthy food habit to be established in childhood since these are likely to track through adolescence into adulthood. Involving children in gardening is one type of intervention that has the potential to increase fruits and vegetable intake. Gardening can increase children’s exposure to fruits and vegetables and to positive modeling of peers and adults. Repeated exposure to Fruits and vegetables can build a positive habit of liking and intake. Researchers reported that children who spend less time outside have decreased physical activity. Thus, it is crucial to creating opportunities for children to experience the natural environment, thereby inducing interest and motivation in spending time outdoors. A school garden program is an educational tool to teach students about agriculture, nutrition, and health, and to equip them with the critical and holistic thinking to face challenges as environments change. Agricultural and environmental education positively increases students’ knowledge, understanding, and appreciation of the environment and food production system. It provides them with the ability to grow their own food for nutrition and equips them for a possible career in agriculture. The school garden movement originated in Europe and arrived in the United States in the 1890s (Swank et al., 2013).

The 3 ‘R’ s of School Gardening

Apart from different benefits as a teaching tool, there are 3 core areas of school gardening in which children’s lives are radically improved. They become Ready to learn, Resilient and Responsible.

School gardens come in all shapes and sizes, with a common focus on growing plants. A school garden may be as small as a few pots of herbs growing on a windowsill or as large as a half-acre plot of vegetables in a schoolyard. Gardening programs are flexible enough to fit the needs and resources of every school. School gardens with nutrition education implemented and rigorously tested in many schools in the US and Europe significantly improved students’ 1) Fruit and vegetable knowledge and awareness 2) Attitudes, preferences, and willingness to eat diverse foods 3) Fruit and vegetable intake 4) Healthy dietary habits 5) Physical activity levels 6) Academic performance 7) Appreciation and care for the environment 8) Sense of responsibility, confidence, enhanced communication and well-being, 9) Social/Emotional Learning and Life Skill Development. 10) The idea of gardening and planning.

Fun and Easy Vegetables to Plant in Your School Garden

Sugar snap peas, lettuce, spinach, leafy greens, radishes, carrots, potatoes, green beans, cherry tomatoes, tomatillos, pumpkins, broccoli, sunflowers, pakchoi, and kale.

To successfully achieve food and nutrition goals, a multi-intervention school garden program must contain the following elements: • A curriculum integrating agriculture, nutrition and WASH concepts and practices • A school garden for hands-on learning • Involvement of parents and the wider community for support and promotion. Vegetables Go to School (VGtS) is a multidisciplinary school garden project by WVC (World Vegetable Centre, Taiwan) piloting the use of multi-intervention school garden programs in Bhutan, Burkina Faso, Indonesia and Nepal to improve food security and nutrition. For lower-income areas where food security is the main concern, school garden programs must link to home gardening in the community to increase the local availability of...
healthy food. The major constraints perceived by students in school garden projects are high input cost, lack of students participation, lack of teachers involvement, non-availability of implements, high labour cost, poor storage facilities and lack of knowledge about gardening. But it can be minimized through collaboration between the ministries of agriculture, education, and health to a school garden program. Integration of a school garden program in a national curriculum ensures sustainability of its activity.

References

### 8. HORTICULTURE

#### Different Tea Varieties in India

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**Different Tea Varieties in India:**

**1) Darjeeling Tea**

Darjeeling has been growing the Chinese variety of the tea plant since 1841. But unlike other regions that grow this variety, the environment of Darjeeling has a unique and magical effect on the tea bush. Part of this magic can be explained by science, and part of it remains an endearing mystery. Darjeeling tea is sold at very high premiums in the international market due to its Muscatel flavour (or a musky spiciness). This flavour cannot be replicated in any other market because Darjeeling tea has a geographical indication (GI) status that is protected worldwide. The GI status has been provided to only 87 tea gardens in the region that produce around 10,000 tonnes of tea annually. Darjeeling tea can neither be grown nor manufactured anywhere else in the world. Just like champagne is native to the Champagne district of France, Darjeeling tea is indigenous to Darjeeling. Tea plantations in Darjeeling are situated at altitudes between 600 metres and 2,000 metres above sea level. The region gets adequate rainfall and the location of the plantations at these altitudes across steep slopes ensures excellent drainage. The soil, the intermittent clouds hovering above the mountains and the bright sunshine - all contribute to the magic of Darjeeling tea. Plucking Darjeeling tea leaves is a slow, exacting and time consuming process.

**2) Assam Tea**

The state of Assam (name derived from Asom, meaning one without equals), which includes the northern Brahmaputra valley, the middle Karbi and Cachar hills and the southern Barak valley, is home to the single largest contiguous tea growing region in the world. The region goes through extremely humid summers and heavy rainfall from March to September. Among its many reserved forests, Kaziranga is the most popular, being home to the Indian rhinoceros, also known as the ‘greater one-horned rhino’. Assam is also home to India’s largest tea research centre, which is located at Tocklai in Jorhat, and is managed by the Tea Research Association. Tea plantations in Assam grow the Camelia Sinensis var Assamica variety of the tea plant. Assam is the only region globally where tea is grown in plains, and also the only other region apart from Southern China, which grows its own native tea plant.

**3) Dooars and Terai Tea**

The first plantation in Terai was named Champta, and it was set up by James White in 1862. Subsequently, the Dooars region saw its first tea plantation in the form of Gazeldubi. In Dooars, the Assamese tea plant was found to be more suitable. Today, Dooars and Terai have a combined annual production of 226 million kg of tea, which accounts for around 25% of India’s total tea crop. The name Dooars is derived from doors, highlighting the region’s significance as a gateway to Northeast India and Bhutan.
elevation ranging from 90 m to 1,750 m, Dooars is a nature tourist’s paradise, with its rich tropical forests, streams meandering across tea gardens, low hills and undulating plains. The region receives an average rainfall of around 3500 mm and the monsoon season stays from the middle of May to the end of September. Tea from Dooars is described as clear, black, heavy with good volumetric count. The first flush has a fresh virgin flavour, good brightness and fragrance while the second flush is more brisk. This tea variety also plays a reducer role in very strong blends. Terai tea, on the other hand, is known for its spicy and slightly sweet taste.

4) Kangra Tea
The Kangra district in Himachal Pradesh was deemed as a potential tea growing region by Dr. Jameson in 1829, following a feasibility survey. He brought Chinese tea plants from Almora and Dehradun and had them planted at Kangra, Nagrota and Bhawarna. Kangra tea is now cultivated across an area of 2,063 hectares in Kangra and Mandi districts. The Kangra valley is located on the foothills of the snow-capped Dhauladhar mountains, at an altitude of around 1,500 m above sea level and an average rainfall of 230-250 cm. It has a temperature range between 13°C and 35°C for the cropping season from March to October and is also blessed with uniform rainfall. Due to the favourable natural climate that’s free of pests and insects, tea is grown organically in the Kangra valley. The Kangra region is famous for its range of green teas (Hyson, Young Hyson and coarse grades) and black teas (Pekoe, Pekoe Suchong, Coarse teas and Fannings) and are globally renowned for their exquisite flavour.

4) Nilgiri Tea
In 1823, John Sullivan, who was then the British Collector of Coimbatore, built his stone house in Ooty (Ootacamund). Subsequently, Europeans made a beeline for the Nilgiri Hills, or Blue Mountains, in their quest for a retreat to escape the summer heat. Initial experiments with tea cultivation commenced in the Ketti Valley in 1853, and commercial production was first undertaken in the Thiiashola and Dunsandle Estates in 1859. Over a century later, Glensmorgan emerged as the first estate in South India to produce green tea in 1909. Nilgiri tea is named after the Nilgiris, or Blue Mountains, where it is grown at elevations ranging from 1,000 metres to 2,500 metres. The mountains get their name from the saxe-blue kurinji flower, which blooms once every 12 years. The region receives an annual rainfall of 60 to 90 inches. The weather conditions provide Nilgiri teas with a characteristic briskness, exceptional fragrance and exquisite flavour. The liquor is golden yellow in colour, provides a creamy taste in the mouth and has notes of dusky flowers. Nilgiri tea has also been registered as a GI in India, and around 92 million kg of this tea are produced every year - around 10% of India’s total tea production.

5) Annamalais Tea
The Annamalais, a range of hills with altitudes from 900 to 1,600 metres between Kerala and Tamil Nadu, have around 12,000 hectares under tea cultivation. The mountain range is also home to the Tea Research Association, which is managed by UPASI. Until the late 19 century, this area was largely inundated with tropical forests. Two enterprising individuals - Carvesh Marsh and CRT Congreve - first visited the Annamalais in 1857 and attempted coffee cultivation at Paralai. Tea plantations started much later in 1908. The tea from Annamallais generates a brisk and bright golden saffron liquor in the cup. It has a strong flavour and a medium to high tone fragrance with biscuit to floral notes. Annamalais tea is regarded as the ideal refresher early in the morning. Wayanaad Tea: Tea from Wayanad is medium toned with a clean fragrance and produces an earthy reddish, full bodied liquor in the cup. The liquor is light on briskness and mild and mellow with biscuit notes.

6) Karnataka Tea
Karnataka is the coffee hub of India, but also produces around 5 million kg of tea every year. Tea plantations are mostly located around Chikmagalur, which is located in the Baba Budan Hills of the Sahyadris range. This area has a clean and healthy climate that's ideal for tea plantations. Teas from Karnataka produce a golden ochre liquor with a fair amount of briskness and body. They have a simple, balanced character and are medium toned. You can consume these teas many times a day.

7) Munnar Tea
Situated at a height of 6000 feet in Idukki district, the quiet, serene and beautiful hill
station of Munnar is viewed as a dream destination away from the hustle and bustle of city life. It has beautiful valleys, mountains, waterfalls, and forests and wildlife sanctuaries teeming with exotic species of flora and fauna. Tea was first grown in Munnar by AH Sharp in the 1880s. European company Finlay took over 33 tea estates in Munnar in 1895, and transferred management control to Kannan Devan Hills Produce Company in 1897. Tata Group and Finlay formed a joint venture in 1964, and tea plantations under the Tatas were transferred to a new company - Kannan Devan Hills Produce Co Pvt Ltd in 2005. This company now manages 16 estates over an area of around 8,600 hectares.

Tea from Munnar produces a golden yellow liquor with strong body, refreshing briskness and a hint of fruit. It has a clean, medium toned fragrance, which is described as being akin to that of sweet biscuit in a dip of malt.

8) Travancore Tea

Vast expanses of plantations of tea, coffee, coconut, rubber, pepper, cardamom, rubber and eucalyptus are visible in the periphery of a high altitude region near Travancore - consisting of Peermade (which lies 85 km east of Kottayam), Vagamon, Thekkady and Vandiperiyar. The Periyar river flows through this region and it was once the summer retreat of the Maharaja of Travancore. Coffee production was started by JD Monro in 1862, and tea production started two years later. After the dreaded leaf disease began to hit coffee plants in 1875, the focus shifted rapidly towards tea cultivation. By 1906, tea plantations covered 8,000 acres, while coffee farms were reduced to just around 500 acres. This tea has medium fragrance with reddish liquor and yellow tinge. It has a balanced body and briskness - ideal for the elevenses (the British urge for tea and a light snack at around 11 am) and also for evening time.

9. FORESTRY

Live Fence – A Sustainable Way to Protect Plantation

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Introduction

Live fencing is one form of agroforestry that can provide a range of products and services on farmlands. Although live fencing systems are traditional, the extent of the many potential benefits and the number of different farmer-developed systems are currently used. The primary purpose of live fences is to control the movement of animals and people, however, they have proven to be extremely diverse, low risk systems that provide farmers with numerous benefits. Besides their main function living fences can provide fuelwood, fodder and food, act as wind breaks or enrich the soil, depending on the species used.

Live Fence

A live fence is a practice where trees/shrubs are planted in a line at relatively close spacing as part of a barrier. The barrier may provide services and/or products for the benefit of the farmer. Living fences are an option that not only have potential to protect crops from roaming livestock, but can also contribute to household cash income, nutrition, and increase the aesthetic value of the farm. A Live Fence is a fence made of living trees and shrubs. Made from thorny or non-thorny plants, it can also be called a green fence, or hedge. There are many ways of using a barrier to prevent harmful pests from coming onto the land. Everyone knows that stone and mud, bricks, barbed wire, bamboo, or even cut branches can be used to make a fence. But the most productive form of barrier is the live fence, because as well as being a barrier, it can also produce many other benefits for the home.

Benefits of Live Fence

- Crops are protected against harmful pests.
- Provide shade and a windbreak for the compound.
- As well as protecting the land, various products such as fodder, firewood, medicines, timber, nectar, etc. can be taken
from the live fence.

- Beneficial animals such as predator insects can also find a place to live in the live fence.
- The live fence saves money.
- Help in soil conservation.
- It can prevent terraces from collapsing.
- It can be used where materials for fencing are not found, e.g. plentiful rocks, barbed wire, large branches or trees, etc.

So, as well as using the live fence for protection, it can also be used to increase farm production. If a fence has tree cotton in it, for example, this is even a cash crop. Citrus varieties such as orange, lime, lemon, etc. can make very good fences. They also produce valuable fruit, and are good for bees.

**Choice of Species For Living Fence**

Many types of plant can be grown in home-made nurseries and planted in the fence when they are large. Many species grow from burying branches in the soil like cuttings. The fence can also be planted with suitable seedlings collected from the forest. By collecting seed and cuttings from around the community and local forest, and making home nurseries, we can grow small, large, climbing vine, or any type of seedling. In the live fence it is good to have as many thorny plants as possible. Thorny plants are mainly useful around the boundary of the farm. The following plants are suitable for living fence

- Acacia tortilis,
- Agave sisalana,
- Albizia amara,
- Calliandra calothyrsus,
- Carissa edulis,
- Croton megalocarpus,
- Cupressus lusitanica,
- Casuarina spp.,
- Euphorbia tirucalli,
- Gliricidia sepium,
- Morus alba,
- Lantana camara,
- Pithecellobium dulce,
- Prosopis spp.,
- Protium cardatum,
- Ziziphus spp.

**Management**

After planting seed, seedlings or cuttings in the live fence, mulch thickly with straw, leaf litter, etc. This controls the weeds, and allows the plants to grow well. Weeds need removing, and the plants should be watered if possible. Replace any plants that die. Once the plants have grown, there is not much maintenance. Well planned harvesting of products from the fence is the only maintenance that is needed. Cutting or pruning branches will give yields of fodder, firewood, mulch material, etc. If there is too much shade, branches can be cut to let in more sun. There are other beneficial yields of mulch material, fodder, flowers, etc. This can also be called edge farming or companion planting.

**Services from Live Fences**

- **Multipurpose trees:** When incorporated into live fences can also provide fuelwood, nutrient-rich mulch, erosion control and land stabilization, as well as other products such as food and fencing materials and a source of high quality forage for ruminants.
- **Fodder and Fuelwood:** Leaves, branches and twigs pruned from live fences provide farmers with an on farm source of fodder and fuel wood. Pruning intervals of 2 to 3 months yield more leafy material than pruning intervals of 4 to 8 months which result in more woody material. This allows farmers to choose which product is of higher priority during different times of the year and adjust their management techniques accordingly.
- **Fruits, Flowers and Medicinal Products:** Farmers can also plant fruit trees to supplement their diet and provide the household with important micronutrients, often lacking in some diets. The fruit can also be sold in the market to contribute to household income. There are a number of tropical fruit trees that have been incorporated into live fencing systems within live fence hedgerows.
  - ex: guava, citrus, Inga dulci, Moringa oleifera, etc.

**References**

Sugarcane is one of the important commercial crops in the country, belongs to grass family (gramineae) and it constitutes about 70% of the world’s sugar. Sugarcane is grown in 5.06 million hectare area with average yield of 67.43 t ha\(^{-1}\) while the sugar recovery is around 10.2%. It is grown in tropical and sub tropical agro-climatic regions; Maharashtra, Karnataka, Gujarat and Tamil Nadu being the significant cane growing states in tropical region while Uttar Pradesh, Punjab, Haryana and Bihar are important in North India. However, the average cane yield and sugar recovery can be increased to 100 t ha\(^{-1}\) and 11.0% respectively, if new technologies developed and properly transferred to the farmers fields.

Major constraints in sugarcane production are:

- Incidence of insect pests and diseases
- Increase in input costs due to indiscriminate use of chemicals
- Excessive application of inorganic fertilizers resulting in deterioration of soil health

In order to increase sugarcane productivity in a sustainable way with sound ecological practices, Integrated Crop Management (ICM) practices are necessary for sustainable sugarcane production. ICM is a system of crop production which conserves and enhances natural resources while producing food on an economically viable and sustainable foundation. It combines the best of traditional methods with appropriate modern technology, balancing the economic production of crops with positive environmental management. Basic components of ICM are crop management, nutrient management, pest management and financial management. ICM is a ‘whole farm approach’ which is site specific and includes use of crop rotations, choice of seed varieties, minimum reliance on artificial inputs such as fertilizers, pesticides and fossil fuels, maintenance of the landscape and enhancement of wildlife habitats.

**Objectives of ICM**

- Reduction or replacement of external farm inputs viz. inorganic fertilizers, pesticides and fuel, by means of farm produced substitutes and better management of inputs.
- Partial substitution of inputs by the use of natural resources, the avoidance of waste and efficient management of external inputs.
- Reduced production cost and less environmental degradation.

**Components of ICM**

**Nutrient management**

Sugarcane being a long duration, exhaustive crop removes noticeably higher amount of plant nutrients from the soil. On an average, crop yielding 100 tonnes, removes 208, 53 and 280 kg ha\(^{-1}\) of N, P\(_2\)O\(_5\) and K\(_2\)O, respectively from the soil. Farmers usually apply inappropriate quantities of inorganic fertilizers resulting in adverse effects on soil physical, chemical and biological properties resulting in low yield of...
sugarcane. Combined use of organic, inorganic and biofertilizers is essential to maintain a good soil physical and chemical environment and maintaining productivity at higher levels with overall improvement in the quality. Research results showed that integrated application of pressmud at the rate of 4 t ha⁻¹ + Azotobacter at 5 kg ha⁻¹ along with fertilizer N ranging from 112 to 224 kg ha⁻¹ recorded significantly higher cane yield than the application of chemical fertilizer alone.

**Crop management**
As sugarcane is long duration crop by following better management practices viz. early planting date, early maturing varieties which can sustain water stress and resistant to smut and grassy shoot diseases, dry method of planting and two eye budded sets can be improve yield. Some of the crop management techniques are as follows:

- Use of cover crops/green manures to improve soil fertility and reduce erosion
- Minimum tillage results in low-cost maintenance of soil structure and fertility
- Crop rotations prevent the incidence of pests, diseases and reduce weed infestation

**Pest management**
Shoot borer, scale insects, mealy bugs, mites and white flies were important pests of sugarcane. Integrated pest management (IPM), mechanical weeding, use of pest and disease resistant cultivars and biological control will reduce the pest incidence. Some of the IPM strategies for major pests of sugarcane are as follows:

<table>
<thead>
<tr>
<th>Pest</th>
<th>IPM strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early shoot borer</td>
<td>Planting in deep trenches (40cm wide, 20cm deep)</td>
</tr>
<tr>
<td></td>
<td>Early planting coupled with closer irrigations in the formative phase of the crop</td>
</tr>
<tr>
<td></td>
<td>Use of cane trash @ 3t ha⁻¹ in between rows on the 3rd day after planting</td>
</tr>
<tr>
<td>Internodal borer</td>
<td>Removal of water shoots at the time of appearance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pest</th>
<th>IPM strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale insect</td>
<td>Dipping setts in 0.1% malathion or 0.05% dimethoate for 15 minutes before planting</td>
</tr>
<tr>
<td></td>
<td>Detrashing lower leaves followed by spraying with dimethoate @ 0.05%</td>
</tr>
<tr>
<td>Mealy bug</td>
<td>Before planting adhering leaf sheaths from the setts should be removed</td>
</tr>
<tr>
<td></td>
<td>Avoid over dosage of N, destroy alternate host plants (cynodon) near sugarcane fields</td>
</tr>
<tr>
<td>Mites</td>
<td>Removal of infected leaves and spraying with wettable sulphur @ 3g l⁻¹</td>
</tr>
<tr>
<td>Whitefly</td>
<td>Application of N fertilizers at recommended dose and adequate drainage will reduce the incidence</td>
</tr>
</tbody>
</table>

In practical terms, ICM means integrated use of compatible technologies that meet farmers' needs and enhance their productivity and income. Two options identified for ICM were core and location specific.

- Core options perform similarly in multiple locations viz. locally adapted variety, good quality seed, robust young seedlings, crop need-based nutrient application, and integrated pest management (IPM)
- Location-specific options can be practiced only in particular locations viz. plant spacing, intermittent irrigation and use of organic manures etc.

Promotion of low cost technologies viz. trash mulching, bio-pesticides, bio-fertilizers, paired row planting method, deep ploughing, use of micro irrigation systems, intercrops (such as onion, French bean, soybean, greengram), integrated nutrient management (organics+ inorganics+ bio- fertilizers) and integrated pest and disease management in an integrated manner can enhance the productivity of sugarcane.
Trichoderma is a very effective biological mean for plant disease management especially the soil born. It is a free-living fungus which is common in soil and root ecosystems. It is highly interactive in root, soil and foliar environments. It reduces growth, survival or infections caused by pathogens by different mechanisms like competition, antibiosis, mycoparasitism, hyphal interactions and enzyme secretion.

**Method of preparation of Fortified *Trichoderma viride* mixture:** Mix 1 kg of *Trichoderma* talc formulation in 90 kg of farmyard manure and 10 kg of Neem cake cover it for 7 days with gunny bags. Sprinkle the heap with water intermittently. Turn the mixture in every 3-4 days interval. After observing the white mycelium growth on the heap and then broadcast in the field.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Disease and Casual organism</th>
<th>Symptoms</th>
<th>Method of application of <em>Trichoderma viride</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid lime and Sweet orange</td>
<td>Dry root rot: <em>Fusarium solani</em></td>
<td>Affected trees blossom profusely bear a heavy crop of small-sized fruits. The disease is characterized by sudden loss of turgidity yellowing and withering of leaves.</td>
<td>Apply Fortified <em>Trichoderma viride</em> mixture 10 kg per affected tree. 5 kg per healthy tree once in a year.</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>Fusarium wilt</td>
<td>Affected plants show yellowing of leaves in some twigs or branches, followed by drooping and drying of leaves. The entire tree dies in few months or a year. When affected tree is cut open lengthwise or cross-section dark greyish-brown discolouration of wood is seen.</td>
<td>Apply Fortified <em>Trichoderma viride</em> mixture 10 kg per affected tree. 5 kg per healthy tree once in a year.</td>
</tr>
<tr>
<td>Banana</td>
<td>Panama Wilt: <em>Fusarium oxysporum f. sp cubense</em></td>
<td>Wilting and light yellow colouring of the lower leaves. Splitting of pseudo stem base is a characteristic symptom When a cross-section is cut, the discolouration appears in a circular pattern around the centre of the rhizome where the infection concentrates due to the arrangement of the vessels</td>
<td>Apply Fortified <em>Trichoderma viride</em> mixture in pits during planting.</td>
</tr>
<tr>
<td>Papaya</td>
<td>Stem rot / Foot rot: <em>Pythium aphanidermatum</em></td>
<td>Water soaked spot in the stem at the ground level which enlarge and griddle the stem. The diseased area turns brown or black and rot. Terminal leaves turn yellow drop off. The entire plant topples over and dies</td>
<td>Drenching with Mix 10g <em>Trichoderma viride</em> talc powder in 1 liter of water.</td>
</tr>
<tr>
<td>Coconut</td>
<td>i. Basal stem rot/ <em>Ganoderma</em> wilt: <em>Ganoderma lucidem</em> and <em>Ganoderma applanatum</em></td>
<td>Yellowing and drooping of the outer whorl of leaves. Exudation of reddish brown liquid through cracks at the base of the trunk and oozing spread upwards.</td>
<td>Talc formulation of <em>Trichoderma viride</em> (50 g) in combination with 5 kg neem cake/palm/year</td>
</tr>
<tr>
<td>Crop</td>
<td>Disease and Casual organism</td>
<td>Symptoms</td>
<td>Method of application of Trichoderma viride</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>Musk melon and Water melon</td>
<td>Fusarium wilt: Fusarium oxysporumf. sp</td>
<td>Fusarium wilt is wilting and chlorosis (yellowing) of older leaves. Stem cracks and brown streaks often appear near the crown of the plant and are associated with a red-brown exudate. Fusarium wilt also causes vascular browning that is visible in stem cross-sections.</td>
<td>Apply Fortified Trichoderma viride mixture in last ploughing.</td>
</tr>
<tr>
<td>Turmeric and Ginger</td>
<td>Soft rot or rhizome rot Pythium aphanidermatum/ P. vexans / P. myriotylum</td>
<td>Collar region of the affected pseudostem becomes water soaked and the rotting spreads to the rhizome resulting in soft rot. Foliar symptoms appear as light yellowing of the tips of lower leaves which gradually spreads to the leaf blades</td>
<td>Drenching with Mix 10g Trichoderma viride talc powder in 1 liter of water.</td>
</tr>
<tr>
<td>Chrysanthemum</td>
<td>Wilt: Fusarium oxysporumf.sp. chrysanthemi</td>
<td>Initial symptoms are in the form of yellowing and browning of leaves. Affected leaves die from the base of the plant upward. Infected plants are stunted and often fail to produce flower. Wilting may cause rotting of root or the base of the stem.</td>
<td>Drenching with Mix 10g Trichoderma viride powder in 1 liter of water.</td>
</tr>
<tr>
<td>Betel vine</td>
<td>Phytophthora foot rot, Sclerotial wilt or collar rot or Fusarial wilt: Phytophthora capsici</td>
<td>Leaf spots brown, circular, necrotic spots with distinct greyish brown zonations or dark brown necrotic spots without zonations. Leaves turn yellow and drop. Blackish brown discolouration of stem at ground level. Disintegration of roots</td>
<td>Application of Trichoderma viride @ 2.5kg/ha from Nov.</td>
</tr>
<tr>
<td>Seed treatment:</td>
<td>Tomato, Chilli, Brinjal, Cucurbits</td>
<td>Trichoderma viride talc formulation use for seed treatment 8 g per kg of seed.</td>
<td></td>
</tr>
</tbody>
</table>

### Table No 2 DO'S and DON'TS in usage of Trichoderma viride

<table>
<thead>
<tr>
<th>DO'S</th>
<th>DON'TS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortified Trichoderma viride mixture prepare under shade condition only</td>
<td>Don't use chemical fungicide after application of Trichoderma for 4-5 days.</td>
</tr>
<tr>
<td>Cannot mix with Chemicals.</td>
<td>Don't use Trichoderma in dry soil. Moisture is a essential factor for its growth and survivability.</td>
</tr>
<tr>
<td>Use Trichoderma viride talc powder within 6 months.</td>
<td>Don't put the treated seeds in direct sun rays.</td>
</tr>
<tr>
<td>Use only Gunny bags or Dry Grass or Coconut leaves on</td>
<td>Don't keep the treated FYM for longer duration.</td>
</tr>
</tbody>
</table>

### References:


Introduction
Grinding is an important unit operation and the most power consuming operation because only 1% of the energy imparted into the material is utilized loosening the bond between particles, whereas almost 99% of input energy is dissipated as heat leads in rising the temperature of the ground product (Das, 2005). In spice grinding temperature rises to the extent of 42–93°C (Singh and Goswami, 1999) and this causes the loss of volatile oil and flavouring constituents; for high oil bearing material, oil comes out from oil bearing material during grinding, which makes ground product gummy, sticky and results in choking of sieves through which the product passes (Singh and Goswami, 1999). Spice is converted to powder by the mechanical process of grinding which leads to increase the temperature as high as 43–95°C under ambient or normal conditions which leads to losses of essential oils and quality deterioration of the obtained powder. To overcome above problem, cryogenic grinding is a novel and innovative grinding technique which helps in retaining good colour, flavour, aroma and volatile oil of the product (Singh and Goswami, 2000).

Cryogenics
The terminology ‘cryogenics’ is related with a Dutch physicist, Kamerlingh Onnes, who wanted to produce a gas in his laboratory that could be refrigerated and become a low temperature boiling liquid. The word ‘cryogen’ was coined to describe a low temperature boiling liquid. It is defined as a branch of engineering specializing in technical operations at very low temperature, generally below −50°C to create such a low temperature, cryogenic liquids are used. Cryogen liquids are those which boil at cryogenic temperature at atmosphere pressure. Liquid forms of hydrogen, helium, nitrogen, oxygen, methane, carbon dioxide, etc. are common cryogens. Liquid nitrogen (LN2) and carbon dioxide (LCO2) in liquid or solid form are the two major cryogens used for food applications.

Spices like Pepper, cinnamon, chilli, ginger, cumin seed, nutmeg, clove etc., have a characteristic taste and aroma. These characteristic qualities are essential for them to have their value as ‘spice’. These qualities exist in them due to the presence of etheric oils within. The etheric oils have their boiling points ranging down to 50°C. During conventional grinding, due to the heat produced by friction, the temperature of ground spices shoots up to about 90°C, where by most of the etheric oils oil off resulting in inferior quality of the ground product. This inferior quality is evident by the reduced taste and aroma.

Problems with conventional grinding
- Loss of volatile oil
- Clogging and gumming of the mill
- Oxidation and related degradation

In order to obtain high quality ground spices products, a cryogenic grinding system was designed and developed to cool the spices before feeding to the grinder and also to maintain the cryogenic temperature in the grinding zone as shown fig 1. The main components of the cryogenic grinding system are (1) pre-cooling unit (cryogenic pre-cooler) and (2) grinding unit (commercially available grinder, a pin mill and a hammer mill).
The function of the cryogenic pre-cooler is to remove the heat from the material before it enters the grinder. The pre-cooling unit (a cooling device) consists of a screw conveyor assembly, an air compressor, liquid nitrogen (LN2) dewar, a power transmission arrangement and control panels. The cryogenic pre-cooler is made up of a screw conveyor enclosed in a properly insulated barrel and a system to introduce liquid nitrogen into the barrel, thereby providing refrigeration (liquid and cold gas) within the system. The particle temperature must be low enough to absorb the heat generated in the grinder and still fracture. Cryogenic pre-coolers, therefore, must have the ability to reduce the temperature of the seed below its brittle point as well as the freezing point of its oil, before it enters the grinder.

Working of cryogenic grinding system

The material is fed to the hopper through a specially designed stainless steel augur to the cryogenic screw. The liquid nitrogen is directly sprayed into the material. The liquid nitrogen absorbs heat from the material and become vaporized. The liquid nitrogen is added until the temperature of the material is reduced to the predetermined set point. Cryogen makes the spices brittle and solidifies the oils present in them. The grinding zone temperature will be below -73 °C. At this temperature spices crumble and permits finer grinding.

References


13. ENTOMOLOGY

Locust Attack in Rajasthan after 26 Years

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Locust is a short-horned grasshopper with migratory nature. It attacks on green vegetations and causes extensive damage due to its voracious feeding habit. There are 10 species of locusts among which four species, desert locust (*Schistocerca gregaria* F.), migratory locust (*Locusta migratoria* L.), Bombay locust (*Patanga succinct* L.) and tree locust (*Anacridium rubrispinum* B.B.) are found in India. The desert locust is the most common species in India which has also been reported in Rajasthan and Gujarat in the past. Life cycle has three stages viz., egg, hopper and adult. Wings are colourless exceeding the abdominal extremity. The colour may be green, brown, yellowish green or grey. Adult congregation forms swarm and nymphal congregation forms hopper band. A desert locust swarm can fly up to 150 km; an average small locust swarm can eat as much food in one day as about 10 elephants, 25 camels or 2500 people. It causes damage by devouring the leaves, flowers, fruits, a seeds, bark and growing points. The mature female drills hole at a depth of 8-10 cm in moist sandy soil, oviposit thrice at weekly interval about 1000 egg pods/sq m area. Adults fly in swarms at a speed of 12 to 16 kmph and migrate in millions from country to country or from place to place.
About 12 locust plagues were observed in India till 1962. Since then no locust plagues occurred. Similarly, 13 locust upsurges were recorded since 1964 till 1997. Small scale localized locust breeding have also been reported and controlled during the period 1998, 2002, 2005, 2007 and 2010. Since 2010 till now, situation remained calm and no large scale breeding and swarms have been reported.

The last major locust outbreak was reported in Rajasthan in 1993 when 172 swarm incursions were noted. After 26 years, locust attack was reported from Jaisalmer district in Rajasthan and likely to spread in Barmer, Phalodi, Bikaner and Suratgarh. Generally, locust attack is reported in June-July from summer to rainy season. But this time, it is reported somewhat early in May month. It has come from Pakistan side due to continuous breeding in coastal areas of Pakistan, especially in Balochistan.

Locust Control and Research (LC&R) is responsible for control of desert locust in India and works through Locust Warning Organization (LWO) which further is a part of Directorate of Plant Protection, Quarantine and Storage (DPPQS) working under Union Agriculture Ministry. LWO is responsible for monitoring and controlling the locust situation in desert area in Rajasthan and Gujarat and parts of Haryana and Punjab.

To combat the present swarm, LWO is gearing up to tackle locust attack by spraying insecticides (Malathion). The control activity has been carried out over 800 hectares. Other control measures may be done like ploughing, digging and harrowing of places where eggs are laid on a large scale. For mechanical control, collect hoppers with catching machine, kill them with flame-throwers and crush them with rollers. In case they are found in bushes, destroy them by burning.

References


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14. VEGETABLE SCIENCE

Health Promoting Phytochemicals in Vegetable Crops

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Introduction

Vegetables are storehouses of phytonutrients and also called protective food because of a rich source of moisture, vitamins, proteins, carbohydrates, amino acids, and minerals, etc. Consumption of vegetables is an important part of a healthy diet. Phytochemicals are a plant bioactive compound, phytonutrients, phytonutraceuticals are organic compounds derived from plants that have health protective effects (Singh and Rao, 2012). These compounds are not a nutrient because these are the essential dietary factors like Amino acids and fatty acids. The common constituents of vegetables are low in fat and like all plant products, contain no cholesterol. Most phytochemicals are found in relatively small quantities in vegetable crops. When consumed in sufficient quantities vegetables, phytochemicals contribute significantly towards protecting living cells against chronic diseases. How many phytochemicals are enough by eating a variety of
vegetables of all colors, you will get a good mix of vitamins, minerals, and phytochemicals in your diet. Vegetables have been shown to protect against specific types of cancer, for example, the crucifers (Brassicaceae) including Broccoli, Brussels sprouts, Kale and Cabbage have been shown to protect against lung and chemically induced cancers. The alliums (Liliaceae), including garlic, chive, and onion have been shown to protect against stomach cancer, the solanaceous vegetables including tomatoes and pepper have been shown to protect against esophageal, gastric, and prostate cancers.

Major Groups of Phytochemicals


**Polyphenols**

Polyphenols are abundant micronutrients in our diet and evidence for their role in the prevention of degenerative diseases such as cancer and cardiovascular diseases is emerging (Claudine et al., 2004). Polyphones are a diverse group of compounds (nearly 8000 structurally known polyphones) widely distributed in the plant kingdom. It constitutes the largest ubiquitous group of phytochemicals in vegetables. Polyphenols have been divided into ten different classes based on their basic chemical structure (Singh and Rao, 2012). Phenolics mostly flavonoids and terpenoids represented the most important classes of polyphenolics in vegetables.

**Organosulphur compounds**

- **Glucosinolates:** Glucosinolates are thioglucosides, which are widely distributed in plants, particularly among members of cruciferae upon hydrolysis by plant microbial thioglucosidase (myrosinase) isothiocyanate and nitriles are released. The isothiocyanate residues are known to possess goitrogenic properties which inhibits iodine uptake by thyroid glands. Glucosinolates, the metabolites have an antibiotic-like effect and help ward off bacterial, viral, and fungal infection in the intestines and other parts of the body. glucosinolate-containing foods offer benefits that may extend well into the prevention of serious illnesses including cancer. (Shereen Lehman, 2017)

- **Thiosulfates:** Thiosulfate is an oxyanion of sulfur compounds found in alliums including garlic, onions, leeks, chive and green onions. Consumption of alliums has been found to retard growth of several types of cancers. Several allyl sulfides have been found to inhibit human tumor growth including prostrate, colon, skin, breast, lung, lymphoma, erythroleukemia, and lymphocye tumors. The cancer prevention by organ sulfur compounds is due to their function as blocking agents.

**Vitamin C**

Vitamin C or ascorbic acid is an essential vitamin to humans and other mammals that lack the ability to synthesize this vitamin, as they are deficient in the enzyme L-gulonolactone oxidase, involved in the biosynthesis of Vitamin C via the glucuronic acid pathway. In mammalian cells, vitamin C serves as cofactor for reactions that require reduced iron and/or copper metallo-enzymes.

**Dietary fiber**

Fiber, or roughage, is a group of substances chemically similar to carbohydrates. It is only found in foods derived from plants, and never occurs in animal products. Fiber provides bulk in the diet, so foods rich in fiber satisfies hunger without contributing excessive calories. A diet high in fiber may help prevent colon cancer and other types of cancer. Most health agencies recommend that adults should consume 20-35 grams of fiber daily (Anderson JW, et al., 2009).

**Folats**

Reduce the risk of colon, rectal, pancreatic and breast cancer It helps to produce red blood cells as well as components of the nervous system, maintains normal brain function Child-bearing women are advised to take 0.4 mg/day, which reduce neuro tube defects.

**Major Phyto-nutrients in Vegetable crops**

1. Allium vegetables (garlic, onions, chives, leeks):- Allysulfides
3. Umbelliferous vegetables (carrots, celery,
parsley, parsnips):- Carotenoids, Phthalides, Polyacetylenes
4. Compositae plants (artichoke) Silymarin:- Beans Flavonoids (isoflavones)
5. Carrot, squash, broccoli, sweet potatoes, tomatoes, kale, collards, cantaloupe and pumpkin :- Vitamin A (retinol)
6. Capsicum, broccoli, green leafy vegetables, cabbage and tomato ;- Vitamin C (ascorbic acid)
7. Green leafy vegetables:– Vitamin E .

References

15. POMOLOGY
Electronic-Nose Applications for Fruit Ripening and Quality Grading
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1Ph.D. Scholar, Department of Fruit Crops, HC&RI, Coimbatore- 641 003 2Ph.D. Scholar, Department of Plant Pathology,3Ph.D. Scholar, Department of Entomology, Agricultural College and Research Institute, Madurai - 625 604.

Introduction
Fruit aroma is most valued characteristic determining the fruit quality. Fruits produce Volatile Organic Compounds (esters, terpenoids, lactones and derivatives of amino acids, fatty-acids and phenolic compounds viz., esters, terpenoids, lactones and derivatives of amino acids, fatty-acids and phenolic compounds. Electronic-noses are ideal digital, electronic device for identifying, characterizing and grading fruit aromas from different fruits and fruit varieties. This instrument are capable of rapidly and consistently evaluating complex volatile gaseous mixtures without having to identify all of the chemical constituents present in the bouquet of fruit aromas (Wilson, 2009).

History of electronic nose
In 1982, at the University of Manchester, Persaud and Dodd constructed the first electronic nose, which consisted of three metal oxide sensors and was capable of identifying 20 odorants. And in 1988, Julian Gardner conducted his research on inventing more electric noses. Finally, a new artificial nose was developed on 19th august 2008.

Principle of an e-nose
E-noses contain a sensor array that evaluates all of the chemical constituents present in an aroma mixture (as a whole sample) and coverts the electronic output signals (via a transducer) from all of the sensors in the array and collectively assembles them to form a distinct digital pattern, sometimes referred to as an Electronic Aroma Signature Pattern (EASP) that is highly unique and specific to the particular gas mixture being analyzed (Wilson, 2005).

Comparison of e-nose with biological nose

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>BIO- NOSE</th>
<th>E-NOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Uses the lungs to bring the odor to epithelium layer.</td>
<td>Employs a pump</td>
</tr>
<tr>
<td>2.</td>
<td>It has mucus membrane and hair to act as filter.</td>
<td>It has an inlet sampling system that provides filtration</td>
</tr>
<tr>
<td>3.</td>
<td>Olfactory epithelium - millions of sensing cells that interact with the odorous molecules</td>
<td>Variety of sensors that interact differently with the samples provided</td>
</tr>
<tr>
<td>4.</td>
<td>Convert the chemical responses to electronic nerve</td>
<td>Similarly, the chemical sensors in the e-nose react with the sample</td>
</tr>
</tbody>
</table>
Sl.No | BIO-NOSE | E-NOSE
---|---|---
| impulses whose unique patterns are propagated by neurons through a complex network before reaching the higher brain for interpretation | and produce electrical signals. A computer reads the unique pattern of signals, and interprets them with some form of intelligent pattern classification algorithm |

**Sensors**

Sensors involved in the device viz., Conductivity Sensors, Piezoelectric Sensors, Gas Sensors and Optical Sensors. They detect volatile properties of the environment and transform the response into an electric signal.

**Advantages**

- The human sniffer is costly as compared to e-nose
- Detection of hazardous gases by human is not possible
- E-nose has wide range of sensitivity
- Results obtained by e-nose are fast and more accurate
- Also detect substances which are not detected by our human nose

**Applications of electronic-nose devices for fruit aroma characterizations (Brezmes,2012)**

The instrument could discriminate between ripe and unripe fruits with an accuracy of 90.2%. It sorts the fruits into three ripeness categories (unripe, half-ripe and fully ripe) with an accuracy of 83% (Brezmes, 2012).

<table>
<thead>
<tr>
<th>Common Name</th>
<th>E-Nose Type</th>
<th>Discrimination Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana (Musa sp)</td>
<td>Prototype MOS</td>
<td>Ripening stage after harvest</td>
</tr>
<tr>
<td>Mango (Mangifera)</td>
<td>FOX 4000</td>
<td>Maturity stage at harvest, shelf life</td>
</tr>
</tbody>
</table>

**Common Name | E-Nose Type | Discrimination Type**
---|---|---
| Peach (Prunus persica) | PEN2 | Shelf life and cultivar effect |
| Pineapple (Ananas comosus) | PEN2 | Shelf life |
| Grape (Vitis vinifera) | Cyranose 320 | Maturity stage at harvest |

**Challenges involved**

- E-nose can only identify a standard set of odors which is stored in its database.
- Though it is effective but still it can’t mimic the complex human olfactory system exactly.
- Moreover, e-noses available in market are not economical.

**Conclusion**

E-nose instruments offer potential future developments and new aroma-based applications to improve the post harvest quality of the fruits include

- Detection of pesticide residues on harvested fruit surfaces to facilitate enforcement of human health regulations
- Post-harvest fruit disease detection and management
- Monitoring gases released from fruits in storage to control fruit ripening (maintain fruit shelf life) and fruit quality

**Reference**


16. Agricultural Microbiology

Microbial Polymers: Synthesis and Degradation with Significance in Agriculture

Krupali Ramanuj
Anand Agricultural University, Anand.

Introduction

The Plastic industry promised to be a boon to mankind, however its overuse over the years has adverse impact on the society. Human beings produce about 34 million tons of plastic waste per year, recycling a mere 7%. The remaining 93% ends up in landfills and oceans. Plastics that have been universally used in our daily lives are now causing serious environmental problems. Millions of tons of these non-degradable plastics accumulate in the environment per year. Incineration engenders toxic waste pollution, suitable landfills are limited and reutilizing techniques for waste are usually expensive and involve high-energy consumption. Adding to it, the petroleum resources are limited (Pathak et al., 2014). Bioplastics play an enormous role as a viable, biodegradable substitute. Many polymers that are claimed to be ‘biodegradable’ are in fact ‘bioerodable’, ‘hydro-biodegradable’ or ‘photobiodegradable’. These different polymers come under the broader category of ‘environmentally degradable polymers’. Polymers are classified based on sources: Natural, Semi-synthetic and Synthetic where in, Microbial polymers are natural without any adverse effect.

The term “Polymer” derives from the ancient Greek word Polus, meaning “many, much” and meros, meaning “parts” and refers o a molecule whose structure is composed of multiple repeating units. The term was coined in 1833 by Jons Jacob Berzelius. A polymer is a large molecule (macromolecules) composed of many repeated subunits, known as monomers. Monomers can be linked together in various ways to give linear, branched and cross linked polymers. The polymers are broadly classified on the basis of source of origin into following categories: Synthetic which are derived from petro-chemicals, semi-synthetic polymers where one part of the polymer is chemically synthesized whereas the other part is natural, and last they are natural polymers. Though synthetic polymers have various applications and are widely utilized they have some drawbacks as:

- Production dependent on nonrenewable / limited resources
- Extended period of decomposition
- Take up space in landfill
- Cause pollution in oceans
- Produce poisonous gases on combustion
- Complex nature and hence difficult to recycle
- Toxic

Synthesis of microbial polymers

Poly (R)-Hydroxyalkanoic acids (PHA): PHA are a group of storage compounds of carbon and energy that are accumulated during unbalanced growth by many bacteria, e.g. in the presence of an excess of a carbon source and if growth is limited by another nutrient (e.g., nitrogen). PHA is deposited intracellularly in the form of inclusion bodies and may account for up to 90% of the cellular dry weight. Poly(R)-3-hydroxybutyric acid (PHB) is the most abundant polyester in bacteria.

Poly Lactic acid (PLA): Lactic acid (2-hydroxypropionic acid), the single monomer of PLA, is produced via fermentation or chemical synthesis. Its stereoisomers, the L(+) and D(−) are produced by bacterial homo and hetero fermentation of carbohydrates. The homofermentative method is preferably used for industrial production using Lactobacillus delbrueckii, L. amylophilus, L. bulgaricus, and L. leichmanii, in a pH range of 5.4 to 6.4, a temperature range of 38 to 42 °C, and a low oxygen concentration.

Chitin and its derivatives (Chitosan): Chitin is the second most abundant natural biopolymer, a linear copolymer of N-acetylglucosamine and N-glucosamine with β-1,4 linkage. Chitin is usually found in the shells of crabs, shrimp, crawfish, and insects. Recent
advances in fermentation technology suggest that the cultivation of fungi can provide an alternative source of chitin. Chitin is processed to chitosan by partial alkaline N-deacetylation.

**Degradation**

Biodegradation takes place in two stages: the first stage is the depolymerization of the macromolecules into shorter chains. Extracellular enzymes (endo or exo-enzymes) and abiotic reactions are responsible for the polymer chain cleavage. The second step corresponds to the mineralization. Once sufficiently small sized oligomeric fragments are formed, they are transported into cells where they are bioassimilated by the microorganisms and then mineralized. Biodegradation takes place in aerobic and anaerobic conditions.

**Biopolymer Applications in agriculture**

- Use of biopolymer chitosan as biocontrol (anti-fungal and anti-nematode) agent
- For controlled release of agricultural chemicals (Herbicide and urea)
- In improving Soil fertilizer efficiency
- For increasing keeping quality/ shelf life of food.

**Conclusions**

- The fundamental idea of bio-derived plastics is to alter the very source of producing polymers i.e. the conventional petroleum sources replaced with a more abundant, accessible, renewable, economic and degradable source.
- Different polymers like PHA, PLA, Chitosan are produced and degraded by various microbes.
- Biopolymers are having various applications in Agriculture for controlled release of fertilizer and herbicides, also useful in biocontrol of pathogens and improved shelf life of food.

**Future thrusts**

Biopolymers are natural, bio-degradable and environmentally friendly. It covers approximately 5-10% of the current plastic market however has remarkable scope in agriculture development.

Cost effective methodologies to be developed for agro-waste utilization by various existing and unexplored microbes to convert them into valuable products needs intensive research.

Use of such bio-packaging will open up potential economic benefits to farmers and agricultural processors.

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**17. HORTICULTURE**

**Bio-Stimulants: An Emerging Organic Input in Vegetable Cultivation**

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**Introduction**

Bio-stimulants are biological or biologically derived products that enhance the plant metabolism to achieve optimum plant growth, health and productivity. These are the materials, other than normal inorganic fertilisers, that promote plant growth when applied in low quantities. These are mainly of plant or animal origin. Organic molecules like bio-stimulants are emerging as an essential growth input in sustainable vegetable production.

The main categories of biostimulants are:

- Seaweed extracts
- Humic acid and Fulvic acid
- Microbial inoculants
- Protein hydrolysates and Amino acids
- Chitosan and other biopolymers

**Seaweed Extracts**

Use of fresh seaweeds as source of organic matter and as fertilizer. It includes the polysaccharides laminarin, alginites and carrageenans and their
breakdown products. Seaweed extracts contribute to the plant growth promotion include micro- and macronutrients, sterols, N-containing compounds like betaines, and hormones. Generally seaweed extracts are obtained from most of the algal species belong to the phylum of brown algae – with *Ascophyllum*, *Fucus*, *Laminaria* as main genera etc. These formulations are available in both powder and liquid formulation and mode of application is foliar spray.

Application of seaweed extracts increases plant nutrient uptake capacity, shoot and root growth, plant metabolism and physiology, resistance to biotic and abiotic stress and act as source of hormone.

**Humic Acid and Fulvic Acid**

Humic acid and fulvic acid are combinely called as humic substances. Humic substances (HS) are natural constituents of the soil organic matter, resulting from the decomposition of plant, animal and microbial residues, but also from the metabolic activity of soil microbes using these substrates. HS are collections of heterogeneous compounds, originally categorized according to their molecular weights and solubility into humins, humic acids and fulvic acids. These are essential contributors to soil fertility, acting on physical, physico-chemical, chemical and biological properties of the soil. Humic acids have high-molecular-weight, soluble in basic media. Fulvic acid have low-molecular-weight soluble in both alkali and acid media.

Humic acid and fulvic acid influence plant growth, stimulate cell division and root growth, increases water and nutrient uptake capacity, stimulate production of plant enzyme and hormones and act as source of energy for beneficial soil micro organism.

**Microbial Inoculants**

These are typically classified as bio-control agents (also called bio-pesticides) or bio-fertilizers. More emphasis is given on bio-fertilizer. Bio-fertilizers are biological products containing living micro organisms that, when applied to seed, plant surfaces, or soil, promote growth by several mechanisms such as increasing the supply of nutrients, root biomass or root area, and increasing nutrient uptake capacity of the plant. Beneficial fungi include Mycorrhizal fungi (especially P, and micronutrients), *Trichoderma* spp., (biopesticide and biocontrol ), *Trichoderma* spp., Basidiomycota, with *Piriformospora indica* (colonize roots and transfer nutrients to their hosts). Beneficial bacteria include Plant growth-promoting rhizobacteria (PGPR), plant growth-promoting bacteria (PGPB) (bacteria *Agrobacterium*, *Azospirillum*, *Azotobacter*, *Bacillus*, *Pseudomonas*, *Rhizobium*).

Major benefits include nitrogen fixation, induction of resistance to soil and seed borne pathogen, production of hormones, tolerance to drought and salinity stress, etc.

**Protein Hydrolysates and Amino Acids**

Protein-based products can be divided into two major categories: protein hydrolysates, consisting of a mixture of peptides and amino acids of animal or plant origin and individual amino acids such as glutamate, glutamine, proline and glycine betaine. Protein hydrolysates are prepared by enzymatic, chemical or thermal hydrolysis of a variety of animal and plant residues, including animal epithelial or connective tissues. The major amino acids include alanine, arginine, glycine, proline, glutamate, glutamine, valine and leucine. Protein/peptide and free amino acid contents of the hydrolysates vary in the range of 1–85 % (w/w) and 2–18 % (w/w), respectively.

Protein hydrolysates and amino acid increases yield and nutrient uptake capacity, induce plant physiology and metabolism, stimulate plant defence mechanism to biotic and abiotic stress and decreases plant toxicity to heavy metals etc.

**Chitosan and Other Biopolymers**

Biopolymers Chitosan is a deacetylated form of the biopolymer chitin, produced naturally and industrially. Chitosan can be extracted from insects, yeast, mushroom, cell wall of fungi, and marine shellfish such as crab, lobster, cuttlefish, shrimp. Fungal chitosan gives medium-low molecular weight chitosans, whereas the molecular weight of chitosans obtained from crustacean sources is high. Chitosan with a medium-low molecular weight has biomedical application.

Chitosan provide protection against fungal pathogen, induces stomatal closure and induce...
tolerance to abiotic stresses like drought, salinity etc.

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18. AGRICULTURE AND HORTICULTURE

Microgreens - A Specialty Crop for New Generation
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Microgreens have been defined as salad crop shoots harvested after cotyledon leaves have developed for consumption within 10 to 20 days of seedling emergence and they are developmentally classified between “sprouts” and “baby salads. A microgreen is a tiny vegetable green that is used both as a visual and flavor component or ingredient primarily in fine dining restaurants. It’s used to enhance the beauty, taste and freshness of their dishes with their delicate textures and distinctive flavors. Micro green are smaller than “baby greens,” and harvested later than “sprouts,” It can provide a variety of leaf flavors, such as sweet and spicy. They are also known for their various colors and textures. In markets they are now considered a specialty genre of greens that are good for garnishing salads, soups, plates, and sandwiches. Edible young greens and grains are produced from various kinds of vegetables, herbs or other plants. A microgreen has a single central stem which has been cut just above the soil line during harvesting. It has fully developed cotyledon leaves and usually has one pair of very small, partially developed true leaves. The average crop-time for most microgreens is 10–14 days from seeding to harvest.

Need for growing microgreens
- They’re highly profitable
- They grow quickly (7-21 days for most crops)
- Don’t need previous growing experience.

Comparison between microgreens and sprout

<table>
<thead>
<tr>
<th>Sprouts</th>
<th>Microgreens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprouts are the first stage of a plants development.</td>
<td>Microgreens are the second stage of a plants development.</td>
</tr>
<tr>
<td>Sprouts are grown hydroponically and without medium and are keep moist and at room temperature until they germinate.</td>
<td>Microgreens are grown in a medium.</td>
</tr>
<tr>
<td>The entire sprout is consumed, including the root.</td>
<td>They are harvested after they have established roots and opened their cotyledons. Only the stems and leaves are consumed; they are harvested above their roots.</td>
</tr>
</tbody>
</table>

Categories and commonly grown microgreens

Microgreens fall into four main categories.
- **Shoots and tendrils**: Pea, sunflower and corn shoots, are often used as garnishes although they all have their own mild and somewhat surprising flavor.
- **Spicy greens**: Arugula, radish, cress and mustards.
- **Micro herbs**: Those used not only as
garnishes, but also for their characteristic flavor such as parsley, fennel, edible chrysanthemums, cilantro, basil, French sorrel, mint, dill, chives and onion.

- **Tender greens**: Highly diverse in flavor, leaf size, shape and color, and include red cabbage, broccoli, spinach, beet (red), tatsoi, mizuna, amaranth, chard, kale, corn salad, endive, chicory, celery, carrot and lettuce.

**Production of microgreen**

1. **Crop selection**
   A large number of vegetable, herb, and agronomic crops and crop varieties can be used for microgreen production. Lettuces may be too delicate, and are often not considered good candidates for microgreens. Crop selection is often based on seedling color texture, flavor, and market demand. How quickly and easily the seed germinates should be another consideration for the producer. Growers may need to evaluate a number of crops before selecting the ones most suitable to their production system and market.

2. **Production site and planting**
   The delicate nature of microgreens requires that they be protected from rainfall and other environmental stresses; thus, they need to be grown in a greenhouse, high tunnel, shade structure, or indoors. These crops may be grown in conventional bench-top production or hydroponically. Plastic flats with drainage holes at the bottom are generally used for microgreen production. The trays are either lined with a sterile fiber like seeding mat or partially filled with a peat based soilless germinating media. Hydroponic producers may utilize aggregate culture with rock wool as the inert growing medium.

   Pesticide free seeds of the desired crop are broadcast densely over the media. Treated seeds may have elevated levels of chemical residue in the small seedlings and are discouraged. The optimum seed density is one that maximizes production space while avoiding stands so thick that stems become elongated and/or disease issues develop. Depending on the crop and production system, a light layer of growing media may be spread over the seeds. It is best to seed only one type or cultivar per flat; Irrigation with overhead mist or an ebb and flow bench system is common.

3. **Growing sites**
   - **Greenhouse**: They can be grown in heated or unheated greenhouse. Microgreens can tolerate some shade also, so the advantage is growing microgreens in vertical space in the greenhouse.
   - **Indoors**: Growing indoors requires more investment in appropriate infrastructure including racks, lighting and increase electric needs. Need more for sophisticated water management system.
   - **Shipping container**: Potential of being mobile, Low cost in terms of infrastructure.

4. **Growing Media**
   Production is split between
   - Conventional method and
   - Hydroponic method.

   **a. Conventional method**: It is typically grow in nursery flats or plug trays filled with peat-based soilless growing mix. Common brands of “Peat-Lite” mixes include Promix and Sunshine Mix. Organic growers use similar mixes, often amended with compost or vermicompost.

   **b. Hydroponic method** -Steps in growing microgreens seedlings:
   - Place the grow mat in the tray and saturate with pH balanced water (5.5-6.5)
   - Sprinkle the seeds evenly and rather thickly over the pad. Spray with the mister bottle, using clean water.
   - Cover the tray with lightproof cover so that the seeds are in darkness.
   - **Days 1-5**: Keep covered, but open in the morning and at night for a good misting (every 12 hours).
   - **Days 6-10**: Remove the covering, place fluorescent lighting over the tray. Water by pouring small amounts in the tray itself (no more misting).
   - **Day 10**: Harvest by cutting off the seedlings at the base of the stems.

5. **Nutrients and Irrigation**
   There is no “standard” nutrient in the microgreens. Irrigation systems vary from simple manual systems to an assortment of automated systems including nutrient injectors, irrigation booms, drip systems, nutrient film and flood and drain systems.
Nutrients used include:

- Water soluble chemical nutrients – these commonly are conventional greenhouse nutrients or complete commercial hydroponic solutions.
- Water soluble organic nutrients – common ones are derived from sea water and compost teas.
- Organic additives such as compost, vermicompost and mineral dusts.

6. Harvesting

Only the stems with leaves attached are harvested; roots are left behind. Plants grown in soilless media are cut by hand just above the soil line using scissors. An electric knife or trimmer can be used to harvest microgreens grown on seeding mats. Mats are held vertically while the crop is “shaved” from the mat into a clean container.

19. HORTICULTURE

Cultivation of Cluster Bean in Arid Region

Shashi

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It is summer annual with angular stem. The pods are small, double ridged on the dorsal side and borne in clusters. It is one of the hardiest vegetable crops. It is grown for its small, tender green, pods, which are used as vegetable. It is drought tolerant and is also grown in arid zones as a fodder crop.

Food Value:
Cluster bean is an important source of protein and minerals. Its seeds are used a chemotherapeutic agent against small pox and as laxative. Per 100g edible pods contain 81.0g moisture, 10.8g carbohydrates, 3.2g protein, 1.4g minerals, 0.4g fat, 2.3g fiber, 330 IU vitamin A and 49 mg vitamin C.

Uses:
Green pods of cluster bean are used as a vegetable and the dry seeds as a pulse. It is also used as green manure and fodder crops. Some of the varieties are suitable for the extraction of gum (20 per cent on dry weight basis), which is becoming an important commodity in international trade. The gum is a major component of adhesives including those widely used on postage stamps and to impart lusture to silk and other textiles, paper and cosmetic industries.

Improved Varieties:
- Pusa Sadabahar (IARI, New Delhi): It was developed by selection from the local material collected from Rajasthan. The plants have single stem and suitable for growing in both summer and rainy seasons. The pods are green, tender, fibreless and 12-13 cm long. First picking is possible 45 days after sowing in summer season and 55 days in rainy season.
- Pusa Mausami (IARI, New Delhi): The plant have branched stem and is suitable for sowing in rainy season. The pods are bright green, smooth and 10-13cm long. It is late maturing variety and first picking is possible 65-80 days after sowing depending upon the weather conditions and the region.
- Pusa Navbhahar (IARI, New Delhi): The variety is suitable for sowing in both summer and rainy seasons. The plants are single stemmed and about one metre tall. The pods are attractive green and 10-12cm long. First picking is possible 40 days after sowing.
- Sharad Bahar (NBPGR, New Delhi): The plants have branched stem and the variety is suitable for sowing in both summer and rainy seasons. The pods are attractive green, succulent and long.

Climate:
Cluster bean is a warm season, hardy and drought tolerant vegetable adapted to arid and semi-arid region of the world. The plant does not tolerant heavy rainfall during flowering and pod formation. Quality pods are produced when average temperature ranges between 23-33 C.
However, it can tolerate spells of temperature as high as 44°C that is prevalent during extreme hot weather conditions in arid zones of Rajasthan and western parts of Haryana and Punjab. It prefers long day conditions for growth and short day conditions for flower induction and pod development.

**Soil:**
Thought cluster bean can be grown in various soils but well drained sandy loam soil with pH 7.0-7.5 is best suited. It tolerant saline and moderately alkaline soils. In heavy soils, bacterial nodulation is inhibited.

**Manures and Fertilizers:**
To facilitate nodulation on roots, inoculate the seed with *Rhizobium japonicum* culture where the bean is being sown for the first time. Under irrigated conditions application of 10-20 tonnes of FYM along with 40 kg nitrogen and 60 kg phosphorus is applied the time of sowing and remaining nitrogen is applied 20 days after sowing. In heavy nitrogen doses were applied to the previous crop, application of nitrogen fertilizer can be avoided.

**Sowing time, seed rate and spacing:**
In north Indian plains, sowing is done in February-march for summer crop and in beginning of July for the rainy season crop. The crop is sown during December to January in south Indian plains.

20-25 kg seed is sufficient for planting one hectare. Spacing is maintained at 45-60 cm between rows and 15-20 cm between plants. Sowing is done at a depth of 3-5 cm.

**Irrigation:**
Cluster bean is a hardy crop and tolerates water stress. However, there should be sufficient moisture in the soil at the time of sowing to facilitate germination. Flowering and pod formation are the critical stages for irrigation application. Under limited water availability, 2-3 irrigations may be enough. Excessive irrigation leads to luxuriant vegetative growth resulting in poor pod setting and yield.

**Weed Control:**
Two weeding, one after 20 days and the second 40-55 days after sowing are adequate to check the weeds. For chemical weed control, apply Fluchloralin @ 2 litres per hectare or Alachlor @ 1.5 kg per hectare or Alachlor @ 1.5 kg per hectare before sowing and Nitrofen @ 3.0 kg per hectare or Pendimethaline 2.0 litre per hectare as pre-emergence application.

**Harvesting:**
The pods for vegetable purpose are harvested when they have developed size but before they become fibrous. First picking of green pods is possible 45 days after sowing in summer crop and after 55-60 days in rainy season crop.

**Yield:**
Depending upon the variety and agronomic condition, the pod yield in cluster bean varies from 30-40 quintals per hectare.

**Seed Production:**
Cluster bean is a self-pollinated crop and an isolation distance of 50 m between two varieties is sufficient to prevent physical mixtures. The agronomic practices for raising the seed crop are the same as for the pod crop. For seed purpose, the pods are allowed to ripen on plants before the seed is extracted manually or by using mechanical thresher. To maintain genetic purity of the variety, the crop is inspected at least twice, once at flower initiation and secondly at pod maturity. The average seed yield is 10 quintals per hectare.

**Diseases and their control:**

1. **Anthracnose** (*Colletotrichum lindemuthianum*): The disease is seed borne and is characterized by appearance of small, depressed, black spots on stem, petioles and leaves. In later stages, these spots enlarge and girdle the stem and pods causing defoliation. At times, the seeds do not develop. The infected tissues become soft and sunken. Subsequently, the stem breaks down and pods and seeds rot. **Control:** Use disease free seed, follow crop rotation and treat the seed with Captan or Thiram @ 2 g per kg seed. Spray the crop with Bavistin or Benlate @ 0.1% percent at 10 day intervals.

2. **Leaf blight** (*Alternaria cyamopsidis*): All above ground parts are attacked but characteristic symptoms develop on leaves.
as dark brown, round to irregular spots. In the early stages, spots are water soaked which later turn grey to dark-brown with concentric rings. In the advance stage, the spots enlarges in the and coalesce giving the leaves a blighted appearance and resulting in defoliation seeds in pods.

**Control:** Treat the seed with Agrosan GN or Captan @ 2g per kg of seed. Spray the crop with Indofil M-45 @ 0.2 percent or Difoliation @ 0.03 percent as the disease appear in the field.

3. **Bacterial blight (Xanthomonas axonopodis pv. Cyamopsidis):** The disease is seed and soil borne in nature. The blight appears as very small translucent, water- soaked lesions on leaves. Later, these lesions become jet – black in colour. They coalesce to form necrotic patches surrounded by yellow halo. Infection from leaves spreads to stem through petiole. Infected pods also show heavy spotting.

**Control:** Use disease free seed, grow resistant varieties and follow crop rotation. Hot water seed treatment at 56 C for ten minutes eradicates the seed born infection. Spray the crop with Streptocycline @ 100-500ppm to reduce the secondary spread.

4. **Powdery mildew (Leveillula taurica):** The disease first appears on leaves and later spreads on to stem and pods. The disease is characterized by the appearance of a grayish powdery growth on leaves and young pods followed by pre-mature drying and defoliation of leaves.

**Control:** Keeping the field free of weeds and removing alternate host from surrounding fields checks the disease considerably. Spray the crop with sulfox or other formulations of wettable powder @ 0.2 percent. If required, repeat the spray at 10 days intervals.

**Insect-pests and their control:**

1. **Aphid (Aphis craccivora):** These are small green to black tiny insects, which suck cell sap from tender plant parts such as leaves, flowers and young pods. It causes curling of leaves, reduces vigour, yield and quality.

**Control:** Remove and destroy the affected plant parts during early stages of infestation. Spray the crop with Rogor 30 EC (dimethoate) @ 0.03 -0.05 percent. Apply carbofuran granules (Furadan 3G) @ one kg a.i. per hectare at the time of sowing.

2. **Pod borer (Adisura atkinsoni, Exelastis atomosa):** The cater pillar first feeds on the pod surface and then bores into the pods and feeds on the grains thus rendering them unfit for consumption.

**Control:** Remove and destroy the infested plant parts as soon as the damage is noticed. Spray the crop with Thiodan 35 EC (endosulfan) @ 2ml or sevin 50WP (carbaryl) @ 2g per litre of water.

### References:
Dhaliwal M.S., Handbook of Vegetable crops.
http://vikaspedia.in/ agriculture/vegetable crops.

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## 20. AGRONOMY

**Vetiver - A Versatile Crop of the Millennium**

Kancheti Mrunalini and G Srinivasan

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Vetiver (VetiveriazizanioidesL.) is a tall (1-2m), fast growing, C₄ perennial grass belonging to the family Poaceae, is well known since ancient times for its essential oil contents and soil binding properties.

Vetiver was called a “living nail” (improve the shear strength of soil) or “living contour bank” due to its effectiveness in soil conservation, use in road sides and in proximity to water bodies. Traditionally, vetiver has been used for soil and water conservation in India for 200 years before the vetiver System has been popularized in recent years. Vetiver Grass Technology (VGT) was used as a biological soil and water conservation measure stabilization in steep slopes due to its faster root growth upto 3 m in just one year, wetland rehabilitation due to broad root system. The stiff stems slow the
movement of the silt-laden runoff, spreading it out, trapping sediment, and causing deposition of the silt behind the barrier. Slowing of the runoff allows more water to infiltrate into the soil. Water infiltration is also aided by the deep root system of the grass.

Vetiver as a potential biofuel source, in carbon sequestration (carbon sequestration by terrestrial ecosystems was the net removal of carbon dioxide (CO₂) from the atmosphere or the avoidance of emission of carbon dioxide into the atmosphere (CO₂) from terrestrial ecosystem).

It could tolerate extreme climatic variation such as prolonged drought, flood, submergence and extreme temperature from −14 to 55 °C, soil pH < 3.5 to >10.5 and annual rainfall ranging from < 300 mm to > 5,000 mm. It also withstand frost, fire, salt and other adverse abiotic stresses such as; soil acidity, salinity with high electrical conductivity up to 4.0, sodicity, magnesium and acid sulfate conditions. Vetiver is a partial hydrophyte and is powerful tool to remove nitrogen (10,000 kg N/ha/year) and phosphorus (1000 kg P/ha/year) from polluted water and therefore the plant can be used for phytoremediation.

Vetivergrass enhances the degradation of heavy metals such as aluminium, arsenic, cadmium, chromium, manganese, copper, lead and nickel and polycyclic aromatic hydrocarbons in the soil. It is used for wastewater treatment and rehabilitation of old mines.

Dead vetiver plants, including cut leaves, culms, roots, roots after essential oil extraction, etc. in the making roof thatch, for essential oil extraction, as a medium for mushroom growing, as raw material for handicraft making, as raw material for processing into industrial products (e.g. biodegradable nursery blocks or pots, construction materials, etc.).

Apart from the above uses, it can also be used as traditional medicine; an ingredient in curry; the roots are woven into various articles such as baskets and coarse mats and screens which are fragrant when wet; a biomass fuel for generating electricity; an ornamental and as a potential trap crop for the stem borer (Chilopartellus).

<table>
<thead>
<tr>
<th>Economic benefits</th>
<th>Environmental benefits</th>
<th>Social benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercropping vetiver for improve land use efficiency and economic net return.</td>
<td>Soil conservation, decontamination and enrichment.</td>
<td>Food and water security by using vetiver to decontaminate soils and underground water.</td>
</tr>
<tr>
<td>Pests control brings higher productivity and lower losses. Vetiver oil for perfumery, cosmetics and medicine and considered to be an remunerative crop.</td>
<td>Water conservation, lower need for irrigation and water saving.</td>
<td>Use in medicine applications and natural perfume improving the health and wellbeing of the communities.</td>
</tr>
<tr>
<td>House hold articles, herbal drink; mushroom cultivation will fetch additional income and increases the use of bio products.</td>
<td>Groundwater and wastewater treatment. Vetiver cultivation is an environmental tool for C sequestration, climate change and its mitigation.</td>
<td>Local development and higher agriculture stability due to the ability to grow crops more efficiently.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increasing the employment and economic status of rural population.</td>
</tr>
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<td></td>
<td></td>
<td>Energy supply to rural population – improving energy security.</td>
</tr>
</tbody>
</table>

The crop also was stated to have distinctive resistant to pests and diseases. It could tolerate intensive harvest, grazing or mowing and it did not spread as a weed. It is tolerant and also remove agrochemical residues in intensive cropping areas with hugenutrients/pesticides. Vetiver grass is an economic attractive solution for sustainable livelihood of the farmers.
Chia Seeds - Potential Health Benefits

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Introduction

Chia is a medicinal and dietary plant species used since ancient times by Mayan and Aztec. Chia is a relative of mint, chia’s botanical name is *Salvia hispanica* L.; it’s part of the family of *Lamiaceae*, superdivision of *Spermatophyta*, and kingdom of *Plantae*. A flowering annual plant, it produces small white or purple blossoms and can grow up to one meter in height. The common name “chia,” derived from a word meaning “oily,” was given by the Aztecs and inhabitants of pre-Columbian South and Central America. These populations used chia as a medicinal and staple food. Chia is primarily grown for its seeds, which are high in alpha linolenic acid (ALA) - an omega-3 fatty acid, fiber, protein, minerals, and antioxidants, and are gluten-free. The seeds are small (1 mm to 2 mm), oval-shaped, and may be black, grey, white, or grey or white spotted with black (Mohdet *et al*., 2012).

Since chia can grow in arid environments, it’s been traditionally cultivated and consumed in Central and South America. Today, Argentina, Bolivia, Ecuador, and Peru are the top chia producing countries. Within the past few years others have entered the fast-growing chia market, including Australia and, most recently, the United States.

Nutrition

Chia has a high nutritional potential due to the seed composition. The composition depends on genetic factors and on the effect of the ecosystems where the plants were grown. Chia seeds contain 16-26% of protein, 31-14% of fat, 37-45% of carbohydrates in total, 23-35% of total dietary fibre. Apart from that, they are a source of minerals (calcium, phosphorous, potassium and magnesium), vitamins (thiamine, riboflavin, niacin, folic acid, ascorbic acid and vitamin A) and antioxidant compounds (Marcinek and Krejpcio, 2017).

The lipid content in chia seeds varies from...
25% to 40%, with 60% of the total lipids made up of ALA (n-3) and 20% composed of linoleic acid (n-6). When the oil is extracted from the chia seed, what remains is a significant concentration of dietary fiber (33.9g/100g) and protein (17g/100g) (de Souza et al., 2015).

According to the United States Department of Agriculture (USDA) National Nutrient Database, a 28 gram, or one-ounce serving of chia seeds contains: 131 calories, 8.4 grams of fat, 13.07 grams of carbohydrate, 11.2 grams of fiber, 5.6 grams of protein and no sugar. Eating one ounce of chia seeds each day would provide 18 percent of daily calcium needs, 27 percent of phosphorous, 30 percent of manganese, and smaller amounts of potassium and copper. Chia seeds provide more omega-3s, calcium, phosphorous, and fiber than flaxseeds. Most people do not consume enough of these essential nutrients.

**Health benefits**

Chia, *Salvia hispanica* L., is a medicinal and dietary plant species used since ancient times by Mayan and Aztec. Its product is a dry indehiscent fruit which is commonly called seed. In recent times, there was an increasing attention and diffusion of the seeds of the plant for their health benefits and uses in cooking. In fact, seeds are a rich source of nutrients first of all the polyunsaturated omega-3 fatty acids that protect from inflammation, enhance cognitive performance and reduce the level of cholesterol. Seeds are also rich in polyphenols derived from caffeic acid that are antioxidant compounds protecting the body from free radicals, aging and cancer. In addition, carbohydrate-based fibers, present at high concentration levels, are associated with reducing inflammation, lowering cholesterol and regulating bowel function (de Falcoet al., 2017). Hypotensive, antineoplastic, laxative and analgesic properties are attributed to chia seeds. They are said to protect the cardiovascular system, exhibit anti-inflammatory properties, control lipid metabolism, have anti-oxidative properties and increase the performance of athletes.

Chia seeds contain nearly 5 grams of fiber per tablespoon, and their high levels of omega-3 fatty acids and alpha-linoleic acid may be useful for weight loss. Of total dietary fiber, the greatest fraction (53.45g/100g) comprises insoluble fiber, which plays a role in satiety and proper bowel function (Vazquez et al., 2008). Rich in magnesium and phenolic compounds (mainly quercetin and kaempferol), chia seed offers significant antioxidant capacity, while its calcium and potassium content suggests it may be helpful in controlling high blood pressure (HBP) (Vuksan et al., 2007).

Chia seeds contain 25 - 40% of fat, most of which is in the form of polyunsaturated fatty acids, such as ω-3alpha-linolenic acid and ω-6 alpha-linoleic acid. As a result of the processes of desaturation and elongation these acids are converted into long-chainpolyenoic acids, such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In chia seed oil the ratio between ω-6 and ω-3 acids is 0.32-0.35. The high content of ω-3 acids in chia seed oil enables reduction of the share of ω-6 acids in daily food rations. Apart from that, an adequate supply of unsaturated fatty acids reduces the risk of ischaemic heart disease and increases immunity of the organism (Ciftci et al., 2012; Marcinek and Krejpcio, 2017).

Research suggests that omega-3s can decrease the risk for thrombosis and arrhythmias, disorders that can lead to heart attack, stroke and sudden cardiac death. Omega-3s may also decrease LDL, total cholesterol and triglyceride levels, reduce atherosclerosis plaque, improve endothelial function, and slightly lower blood pressure. The richest sources of plant-based omega-3s are chia seeds, flaxseeds, flaxseed oil, hempseeds, hempseed oil and walnuts.

**Potential health risks of consuming chia seeds**

Chia seeds can absorb up to 27 times their weight in water. One man with a history of swallowing problems developed an esophageal obstruction after he ate a tablespoon of dry chia seeds and then tried to wash them down with a glass of water. The seeds formed a thick gel in his esophagus that he was unable to swallow without medical treatment. This was a rare case, but it highlights the importance of mixing chia seeds into another food or liquid before consuming, especially for people with a history of swallowing problems. Small children should not be given chia seeds.
22. GENETICS AND PLANT BREEDING

Cisgenesis: An Important Technique for Conventional Plant Breeding

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Introduction

Cisgenesis, sometimes also called intragenesis, is a product designation for a category of genetically engineered plants. Cisgenesis and transgenesis are two technically similar approaches to create genetic variability through gene-splicing technology. Cisgenic plants are defined as plants that have been genetically modified with one or more genes (including introns and flanking regions such as native promoter and terminator regions in a sense orientation) isolated from a crossable donor plant; that is, of the same or a closely related species or isolated from within the existing genome.

Brief Process of Cisgenesis

Cisgenesis is one term for organisms that have been engineered using a process in which genes are artificially transferred between organisms that could otherwise be conventionally bred. Unlike in transgenesis, genes are only transferred between closely related organisms. However, while future technologies may allow genomes to be directly edited within an individual organism, currently nucleic acid sequences must be isolated and introduced using the same technologies that are used to produce transgenic organisms. The term was first used in a PhD thesis by Jan Schaart of Wageningen University in 2004, discussing making strawberries less susceptible to Botrytis cinerea.

Role of Cisgenesis in Conventional Breeding

Indeed, cisgenesis has great potential to overcome a major bottleneck in traditional breeding. During introgression breeding, a wild plant with an interesting trait is crossed with a high-quality genotype, such as a cultivar. The wild plant, however, passes on not only its genes of interest to the progeny, but also other, sometimes deleterious, genes. This so-called linkage drag can slow down the breeding process tremendously, especially if the gene of interest is genetically tightly linked to one or more deleterious genes. To reduce linkage drag, plant breeders usually need successive generations of recurrent backcrossing with the cultivated plant and simultaneous selection for the trait to generate a genotype in which the gene of interest is no longer linked to any undesired genes. By contrast, cisgenesis isolates only the gene of interest.
interest from the donor plant, which is then inserted into the recipient in one step. As no other genes are transferred, this method avoids linkage drag. This can enhance the breeding speed, particularly if several genes from different relatives must be combined into an elite variety, for example to obtain durable multigenic resistance. This is the main advantage of cisgenesis compared with traditional introgression breeding. Cisgenesis is a particularly efficient method for cross-fertilizing heterozygous plants that propagate vegetatively, such as potato, apple and banana. It can directly improve an existing variety without disturbing the genetic make-up of the plant. Traditional introgression breeding of cross-fertilizing plants does not allow the introduction of genes from wild germplasm without mixing up the combination of alleles in the existing heterozygous elite recipient genotype.

Cisgenesis & Transgenesis
Although transgenesis and cisgenesis both use the same genetic modification techniques namely the introduction of one or more genes and their promoters into a plant, cisgenesis involves only genes from the plant itself or from a close relative, and these genes could also be transferred by traditional breeding techniques. If the current international GMO regulations, which are mainly based on the process of transferring transgenes, continue to fail to differentiate between cisgenic and transgenic plants, the use of cisgenesis could be seriously hindered. Only Canada now has a product-based rather than a process-based regulation system, and therefore has the legal possibility to control cisgenic plants less strictly than transgenic plants. Any restrictions on cisgenesis could block or delay further research on improving crop varieties, particularly as an increasing number of functional genes from crops and their crossable wild relatives are being isolated and are becoming amenable to cisgenesis. We argue that cisgenic plants are fundamentally different from transgenic plants, and should therefore be treated differently under GMO regulations.

Some people believe that cisgenesis should not face as much regulatory oversight as genetic modification created through transgenesis as it is possible, if not practical, to transfer alleles among closely related species even by traditional crossing. The primary biological advantage of cisgenesis is that it does not disrupt favorable heterozygous states, particularly in asexually propagated crops such as potato, which do not breed true to seed. One application of cisgenesis is to create blight resistant potato plants by transferring known resistance loci wild genotypes into modern, high yielding varieties.

Need for Cisgenesis
The prerequisite for cisgenesis is the isolation and characterization of genes of interest from crossable relatives. The rapidly increasing amount of DNA sequence information for individual genes, multigene families and whole plant genomes, combined with our increasing knowledge of gene functions, has enabled a directed search for beneficial alleles among cultivated plants and their wild relatives. In the past decade, a large number of natural genes from crops and their wild relatives have been isolated, many of which code for important traits such as disease resistance and quality. Many of these genes are now sufficiently characterized and are ready to be transferred into elite crops.

However, whether this technique will develop into a powerful new tool strongly depends on several factors: how cisgenic plants are treated by existing legal frameworks, consumer acceptance of such products; whether these plants and any products derived from them must be labelled as GM; and intellectual property rights on GM technologies and genes. Although intellectual property and consumer acceptance are largely beyond the control of lawmakers and regulators, it would be sensible to regulate cisgenic plants differently to transgenic plants. Self-evidently, cisgenic plants should still be tested to confirm that they contain only the intended modifications and no foreign genes, such as a backbone gene from a plasmid. If such a foreign gene is unintentionally introduced, the plant is, by definition, transgenic.
Introduction
The living soil is instrumental to key life support functions (LSF) that safeguard life on Earth. The soil microbiome has a main role as a driver of these LSF. Current global developments, like anthropogenic threats to soil (e.g., via intensive agriculture) and climate change, pose a burden on soil functioning. Therefore, it is important to dispose of robust indicators that report on the nature of deleterious changes and thus soil quality. The current rapid development of molecular (DNA-based) methods that facilitate deciphering microbiomes with respect to key functions will enable the development of improved criteria by which molecular information can be tuned to yield molecular markers of soil LSF. Microbial indicators should allow easy measurement and be accurate for the purpose they were developed for. In addition, it would be advantageous if costs were kept low.

'Soil health' is defined as a state of dynamic equilibrium between flora, fauna and their surrounding soil environment in which all the metabolic activities of the former proceed optimally without any hindrance, stress or impedance from the latter (Goswami and Ratan, 1992). ‘Soil quality’ is the capacity of a specific kind of soil to function within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality and sustain plant-animal and human health (Doran and Parkin, 1994). The term ‘soil quality’ and ‘soil health’ are often used interchangeably in scientific literature. Soil health is considered as the state of a soil at a particular time, equivalent to the dynamic soil properties that change in short term considering soil as an ecosystem; while soil quality may be considered as soil usefulness for a particular purpose over a long time scale considering soil as a component of larger ecosystem (Goswami, 2006)

Quantitative measure of soil health: It can be determined as per the following steps:

- Soil health indicators
- Minimum datasets
- Scoring curves
- Soil quality index computations

**Soil health indicators:** Soil quality can’t be measured directly, but must be inferred from measuring changes in its attributes or attributes of the ecosystem, referred to as indicators. These can be classified into 3 categories such as:

- **Soil physical indicators:** Bulk density, Aggregate stability, Effective depth of soil and rooting, Pore size distribution and continuity, Penetration resistance, Surface and sub-surface Hardpan, Depth to hardpan, Aeration and Soil temperature, Available water capacity, Water Holding Capacity, Infiltration rate etc.

- **Soil chemical indicators:** Soil reaction or pH, Electrical conductivity, Organic carbon, Total and plant available nutrients, Cation exchange capacity, Exchangeable Ca$^{2+}$, Mg$^{2+}$, Base saturation, Heavy metals, other plant toxins etc.

- **Soil biological indicators:** Microbial biomass (C and N), Organic matter content, Earthworm and Nematode populations, Mycorrhizal fungi, Soil Respiration, Soil enzymatic activities, Decomposition rate, Disease suppressive capacity etc.

**Organisms in soil:** Organisms in soil can be broadly classified into flora and fauna, which can be further classified into:

- **Micro fauna (<0.1 mm):** Nematodes, rotifers, Amoebae, Cillates and Flagellates etc.
- **Meso fauna (0.1-2 mm):** Mites, Collembola, Enchytraeid, Protura etc.
- **Macro fauna (>2mm):** Earthworms,
Mice, Moles, Ants, Bettles, Centipeds, Millipeds, Grubs, Maggots, Snails, Slugs, Termites etc.

- **Micro flora (<0.1mm):** Root hairs, Greens, Diatoms, Yeasts, Molds, Bacteria, Cyanobacteria, Algae, Fungi, Archaea etc.

- **Macro flora (>0.1mm):** Feeder roots, Macro algae and Mosses etc.

**Criteria for selection of bio-Indicators**

The bioindicators that report on key LSF in soil need to follow several criteria, i.e., (1) they should be as universal for the different soil microbiomes as possible, (2) they should represent the function addressed in a representative and accurate manner, and (3) they should adequately report on soil disturbances that may cause deterioration or harm. In a well-designed monitoring system that assesses soil quality, the suite of indicators selected on the basis of such criteria should be sufficient to allow pinpointing situations or conditions in the local microbiomes that are out of a pre-defined range that determines (acceptable) quality. Ideally, a suitable framework should include markers that report on the key LSF. These include, minimally, important processes for nutrient cycling (C, N, P, and S), important beneficial microbial groups and their traits (for example, mycorrhizae, plant beneficials, pathogens, and pollutant degraders) and markers for microbiomes.

**Determination of soil health/ quality**

A key aspect in the assessment of parameters that define the quality of soils is the integration of the appropriate variables into one framework or even a single unit, which, ideally, should be able to characterize the soil quality status. Parameters describing the soil microbiome, grouped into such a unit, should thus enable discerning “normal” (range) situations from stressed (out-of-normal-range) situations.

First, a selection of proxies for key functions needs to be made including the molecular ones, to establish a minimal data set. The indicators should each work well, reporting in a robust manner on soil (stress) status, and indicating the range of values that define acceptable quality, discerning it from unacceptable quality. Then, the indicators can be combined in order to establish a modeling approach (resulting in a normal operating range (NOR) for a particular soil type in a given region under a certain land use type). In this approach, the NOR of a soil is captured into a multidimensional model that may encompass a large number (n) of variables in n-dimensional space; the model needs border values that define the acceptable range of each parameter. In such a process, levels of acceptability/unacceptability need to be fed into the system and correlations to be drawn with the data inside the model (Schloter et al., 2018).

**Conclusion**

Soil microorganisms are vital indicators of soil health which affect other physical, chemical and biological indicators directly or indirectly. Balance among the three pillars of fertility i.e. physical, chemical and biological fertility is essential in establishing and maintaining the farmer’s factory (soil) and therefore future profitability. A continual program of testing therefore becomes the most important and effective way for growers to improve soil conditions and income potential. It is vitally important to add testing of soil microbial health on a regular basis, particularly because that health can change so quickly due to physical and chemical activities. In an optimized framework for soil quality assessments, both traditional (black-box) and novel (more process specific) indicators should be combined. The more traditional indicators have been based on assessments of “visible” soil attributes, as well as chemically/physically measurable ones. These should now be combined with advanced novel tools that come about from our progressively-increasing understanding of soil microbial processes, as supported by molecularly-based soil analyses, such as via metagenomics.

**References:**


Goswami, N.N. and Ratan, R.K. (1992) Soil health- key to sustained agricultural productivity,
Integrated Pest Management of Insect Pests under Protected Cultivation

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The protected cultivation technology provides favourable climatic conditions and reduces the stress levels for realizing the yield potential of crop plants. This technology has great potential in tropical islands where open cultivation of vegetables is restricted by heavy rains during rainy season. Intense heat and high incidence of UV rays in dry months reduce the quality of leafy vegetables in open which otherwise very good in protected structures. Further, in many of the tropical islands the land resources are very limited therefore; protected cultivation has great scope to achieve self-sufficiency in vegetable sector even with less area. In terms of area of fruit and vegetables crops under protected cultivation, china ranks first (27, 60,000 ha), while India stands at seventh (25, 000 ha) worldwide (Nair and Barche, 2014). The warm, humid conditions and abundant food under protected conditions provide an excellent, stable environment for pest development. Often, the natural enemies that keep pests under control outside are not present under protected environment. For these reasons, pest situations often develop in the indoor environment more rapidly and with greater severity than outdoors. Many greenhouses use Integrated Pest Management (IPM) strategies to manage their pest problems. IPM can be defined as a systematic approach to managing pests that focuses on long-term prevention or suppression with minimal impact on human health, the environment, and non-target organisms. An IPM Program consists of: Monitoring; Identification of Pest Problems; Control Methods- Biological Control, Chemical Control, Cultural Control/Sanitation, Mechanical Control and Evaluation.

1. Monitoring: It provides reliable information to guide the decision-making process in an IPM program. It provides the means of detecting problems early, allowing for more effective and (often) localized action. Good record-keeping is a key part of a monitoring program.

2. Cultural control: It includes a number of strategies that can be thought of as best management practices in the production of the crop.
   a) Sanitation: Good hygiene is the first step in any pest control program. If a source of infection or infestation persists due to poor sanitation, pest control programs will be expensive and frustrating. It is important to- Remove dead and dying leaves and flowers, Remove crop residues, Hang hoses up so that the nozzles are clear of the ground, Keep walks and the surfaces of beds clean. Clean benches between crops, For vegetable operations, wash and disinfect structure, irrigation lines, and all tools and equipment between crops, Maintaining warm temperatures in an empty greenhouse, completely devoid of vegetation and moisture for several days, can significantly reduce pest survival and carryover to the next crop, Check carefully for pest infestations when bringing new plant material into the greenhouse, Avoid overwintering garden or house plants in the greenhouse, otherwise pests will be maintained for an early invasion of the next crop, Remove all weeds from inside and immediately outside the greenhouse. They can provide a refuge for pests and act as a reservoir for diseases.
   b) Environment: Factors such as light,
temperature, humidity, water and nutrients affect not only the plant, but also the pests and diseases that afflict them. Humidity can play an important role in pest and disease development. 1. Humidity (greenhouse vegetable growers often work with a related but slightly different concept known as Vapour Pressure Deficit – VPD) can be affected by temperature, airflow, plant spacing, irrigation (timing and technique) and greenhouse structure. Management of humidity is important in the management of foliar diseases such as powdery mildew and Botrytis. Pests such as spider mites prefer hot, dry conditions and increasing humidity with overhead misting can help to retard the development of this pest.

i) During the winter months, insects are not particularly mobile. For example, if thrips are not flying because of environmental conditions, they will not be caught by yellow sticky cards, even if they are present and actively feeding in the crop.

ii) Maintain good drainage to eliminate puddles and wet surfaces, as these provide ideal breeding sites for fungus gnats and shoreflies, and are a possible source of infection.

iii) If the greenhouse is empty between crops, heat treatment can be an effective way to remove pest infestations. If temperatures are maintained at >40°C and humidity at <50% for 3–4 days, insect and mite pests will be effectively controlled.

c) Cultivar Resistance: Many plant species display varietal differences in their susceptibility to insect and disease attack. In the meantime, growers with pest problems can improve their pest management program by examining the varieties grown and how pests affect these varieties. Use susceptible varieties as indicators for pests and diseases (e.g. the colour of the flower might attract more thrips); consider whether it is possible to eliminate or reduce the amount of a susceptible variety and replace it with a more resistant one.

3. Biological control: Biocontrol is the use of living organisms such as insects, mites, nematodes, fungi and bacteria to control pests such as insects, mites and diseases. Biocontrol requires very different approaches for vegetables and ornamentals. While it has been widely used in greenhouse vegetable crops for many years, it is only since the late 1990’s that it has become more widely used in ornamentals. The development of resistance to pesticides is a primary reason for increasing use of biocontrol in ornamental crops.

4. Chemical control: Insecticides are the most powerful tools available for use in pest management. Insecticides are the only tool for pest management that is reliable for emergency action when insect pest populations approach or exceed the economic threshold. Some of the important insecticides used against protected crop insect pests are diafenthiuron, fenpyroximate and abamectin @ 0.5ml/l for mites (Shah and Shukla, 2014); imidacloprid @ 0.4g/l, acephate @ 1g/l or acetamiprid @ 0.2g/l, phosphomidan @ 0.2ml/l for thrips, whiteflies and aphids (Kaur and Singh, 2013 and Sabir et al. 2012); spinosad @ 0.3ml/l or abamectin @ 0.5ml/l for leaf miner and spinosad, chlorantraniliprole @ 0.3ml/l, fuberdiamide @ 0.1ml/l for caterpillars (Sabir et al. 2010).

References
Kaur S, Singh S. Efficacy of some insecticides and botanicals against sucking pests on capsicum

Table 1. Insect-pests Scenario under Protected Environment

<table>
<thead>
<tr>
<th>Group</th>
<th>Insect and mite pests</th>
<th>Host</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aphids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Aphis gossypii</em></td>
<td>Capsicum</td>
</tr>
<tr>
<td></td>
<td><em>Macrosiphoniellasanborni</em></td>
<td>Chrysanthemum</td>
</tr>
<tr>
<td></td>
<td><em>Macrosiphum luteum</em></td>
<td>Orchid</td>
</tr>
<tr>
<td></td>
<td><em>Myzus persicae</em></td>
<td>Capsicum, Gerbera</td>
</tr>
<tr>
<td></td>
<td><em>Toxopteraaurantii</em></td>
<td>Orchid</td>
</tr>
<tr>
<td><strong>Caterpillars</strong></td>
<td><em>Helicoverpa armigera</em></td>
<td>Capsicum, Tomato, Carnation</td>
</tr>
<tr>
<td></td>
<td><em>Spodoptera litura</em></td>
<td>Rose, Tomato, Capsicum, Cucumber</td>
</tr>
<tr>
<td><strong>Leaf-</strong></td>
<td><em>Liriomyzatrifolii</em></td>
<td>Tomato</td>
</tr>
<tr>
<td><strong>Mites</strong></td>
<td><em>Polyphagotarsonemus latus</em></td>
<td>Capsicum</td>
</tr>
<tr>
<td></td>
<td>(yellow mite)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Stenotarsonemusfragariae</em></td>
<td>Strawberry</td>
</tr>
<tr>
<td></td>
<td><em>Tetranychuscinnabarinus</em></td>
<td>Carnation</td>
</tr>
<tr>
<td></td>
<td><em>Tetranychusneocalidonicus</em></td>
<td>Cucumber</td>
</tr>
<tr>
<td></td>
<td><em>Tetranychusurticae</em></td>
<td>Tomato, Capsicum, Tomato, Carnation, Gerbera</td>
</tr>
<tr>
<td><strong>Thrips</strong></td>
<td><em>Scirtothrips dorsalis</em></td>
<td>Rose</td>
</tr>
<tr>
<td></td>
<td><em>Thripspalmi</em></td>
<td>Gerbera</td>
</tr>
<tr>
<td></td>
<td><em>Thrips tabaci</em></td>
<td>Gerbera</td>
</tr>
<tr>
<td><strong>Whiteflies</strong></td>
<td><em>Bemisia tabaci</em></td>
<td>Gerbera, Capsicum</td>
</tr>
</tbody>
</table>

25. **PLANT PHYSIOLOGY**

**Heat Shock Proteins (HSPs) and Thermotolerance in Plants**

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Heat shock proteins (HSPs) are ubiquitous proteins found in plant and animal cells. Ritossa, 1962 originally described HSPs in relation to heat shock, but now they are known to be induced by a variety of stresses, including exposure to cold, UV light etc (Vierling, 1991). The term “heat shock protein” is a misnomer as many stresses apart from heat induce expression of hsp genes.

**Role of HSPs**

HSPs are essential components contributing to cellular homeostasis under optimal and detrimental growth conditions in both prokaryotic and eukaryotic cells (Wang et al., 2004). HSPs are responsible for protein folding, assembly, translocation, and degradation during normal cellular growth and development. HSPs also function in the stabilization of proteins and assist protein refolding under stress conditions (Huttner and Strasser, 2012). Most members HSPs family perform critically important chaperone functions such as three-dimensional folding of newly formed proteins and/or proteins damaged by stress within cells, for this reason many chaperones are considered as HSPs due to their nature to aggregate when denatured by heat stress.

**Types/Families of HSPs**

There are five major families of HSPs in plants and animals, conservatively recognized as molecular chaperones based on their
approximate molecular weights, such as HSP100, HSP90, HSP70, HSP60, and small HSP (sHSP) Gupta et al., 2010). Most of the HSPs are located in the cytoplasm and respond to both biotic and abiotic stresses. In addition to the cytosol, HSPs are located in other organelles such as endoplasmic reticulum, chloroplasts, mitochondria, and nucleus, indicating the different roles of HSPs in protein homeostasis.

### Table 1. Summary of HSPs in plant immunity

<table>
<thead>
<tr>
<th>Classes</th>
<th>Molecular size (kDa)</th>
<th>Location</th>
<th>Functions</th>
<th>Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSP100</td>
<td>100-105</td>
<td>Cytosol, mitochondria and chloroplast</td>
<td>Protein folding, disaggregation</td>
<td>HSP100, Clp</td>
</tr>
<tr>
<td>HSP90</td>
<td>82-90</td>
<td>Cytosol, ER, nucleus, mitochondria and chloroplast</td>
<td>Genetic buffering, regulation of receptors, protein translocation</td>
<td>HSP90, Grp94/gp96</td>
</tr>
<tr>
<td>HSP70</td>
<td>68-75</td>
<td>Cytosol, ER, nucleus, mitochondria and chloroplast</td>
<td>Assisting refolding, preventing aggregation</td>
<td>HSP70, BiP/Grp78</td>
</tr>
<tr>
<td>HSP60</td>
<td>35-54</td>
<td>Cytosol and ER</td>
<td>Co-chaperone</td>
<td>HSP40, ERdj</td>
</tr>
<tr>
<td>sHSP</td>
<td>15-30</td>
<td>Cytosol, ER, mitochondria and chloroplast</td>
<td>Preventing aggregation, Co-chaperone</td>
<td>HSP</td>
</tr>
</tbody>
</table>

**HSPs are molecular chaperones**

Heat-shock response at the molecular level is a transient reprogramming of cellular activities featured by synthesis of HSPs, concomitant with cessation of normal protein synthesis. HSPs accumulate in a dosage-dependent manner to amounts sufficient to protect cells and to provide a higher level of thermotolerance. HSPs are functionally linked to a large and diverse group of molecular chaperones that are defined by their capacity to recognize and to bind substrate proteins that are in an unstable, inactive state. All cellular proteins probably have to interact with molecular chaperones at least once in their lifetime, such as during synthesis, subcellular targeting, or degradation. Owing to heat denaturation, the fraction of potential targets for molecular chaperones increase manifold upon heat stress and the cellular chaperone pool will be replenished. Different HSPs have different functional properties but common to all of them is their capacity to interact with other proteins and to act as molecular chaperones (Schofflet et al., 1998).

**Role of HSPs in thermotolerance**

Many organisms including plants can survive otherwise lethal high-temperature treatments if they are first subjected to pretreatment at nonlethal high temperatures. This phenomenon is called acquired thermotolerance.

When plants face abrupt increase in temperature, the HSP gene transcripts accumulate within first five minutes of heat stress (Roberts and Key, 1990). HSP expression also occurs when plants experience a gradual increase in temperature. In field conditions multiple stresses occur at single time, heat and drought are mostly in combined form, during moisture stress plants exhibit elevated leaf temperatures and accumulated proteins with molecular weights similar to HSPs.

Production of HSPs may occur frequently in plant structures not effectively cooled by transpiration. Reproductive structures that have limited numbers of stomata or are too large for rapid heat exchange, will be at higher temperatures than surrounding leaves and they are at higher risk.

**HSPs expression during plant development**

Induction of HSPs synthesis in response to high-temperature stress occurs in most tissues that are transcriptionally active. The transcription of HSP gene and HSP synthesis have been shown to occur in all vegetative tissues, in mid-maturation seeds, in the aleurone of imbibed seeds, and in germinating embryos. The two developmental stages in which full activation of the heat shock response does not occur are very early embryo development (pre-torpedo stage) and pollen...
germination.

The half-life of HSPs was determined to be approximately 52 and 37 hr for the chloroplast and cytoplasmic HSP, respectively. The persistence of these HSPs suggests that their participation in recovery process could be as important as their possible role during the stress period itself.

References

Role of Insect Museums and Collections in Pest Management

Incomparable diversity of the insect species with more than a million and described species and more than half a billion preserved specimens, the insects has an upper hand than any other group of animal on earth. Shear biodiversity put them far beyond all the organisms combined. Taxonomists working in insect collection museums around the world are constantly collecting and curating and preserving the insect specimens and adding new species into the vast biodiversity of the insect every day. Most of the new estimates regarding the number of insect species indicate that globally there are approximately 1.5 million of beetles, 5.5 million insects, and 7 million terrestrial arthropods species. Which is much lesser than many other previous estimates, but even with this reduced extent with only about 1 million known species, more than 80 percent of the biodiversity of the insects is still out there in the wild that is waiting to be discovered (Stork, 2018).

Role of the insect collecting museums doesn’t end there, they are not merely the collection hub but they are the treasure-trove of knowledge for the insect systematists and pest management experts alike around the world. The natural history of the insects preserved in these museums experiencing a rapid transition in recent years than any other time in the past. It was once largely a domain of the taxonomists, systematists, and morphologists, these biological collections now emerging as the scientific stage for the variety of disciplines that relies upon the study of captured biodiversity in museums. These biological collections are now fundamentally important in many fields including documentation and descriptions of populations, species and tremendous biodiversity they possess, in improving the public health, in agricultural and forest pest management, in food security, for monitoring of environmental contaminations, studying the biological invasion and also the global climate change.
change. Recent transitions of the digitization of the museum specimens have opened major frontiers like the liberation of vast troves of specimen data that were previously available to the privilege once, who have been able to physically handled specimens to the people around the world and modernizations and scientific advances in the field of genomic sequencing and morphological imaging. Together they generate an unimaginable magnitude data of which seemed impossible without these developments in the past decade or so.

**Insect museums and major collections in India:**

National Pusa collection (NPC), Indian Agricultural Research Institute, New Delhi, Zoological Society of India, Kolkata, National Bureau of Agriculturally Important Insects (NBAIR), Bangalore, etc. houses the majority of the wealth of the scientific collection of insects in India. Recently India’s first museum dedicated to insect was opened by the Tamil Nadu Agricultural University (TNAU) in Coimbatore with more than 75,000 insect specimens up for the display followed by the NBAIR’s very own insect museum inaugurated in 2019. These collection helps in not only increase the knowledge about the natural history of the insects but also provide an important guide in agricultural and forest pest management to the common people as well as farmers. These type of museums can help in drawing the attention and developing the scientific curiosity among the common people as well as the future entomologists.

**Helping hand in pest management**

One of the major aspects that draw benefits from the museum specimens is insect pest management. The full proof pest management strategy requires the correct identification of the pests, and the insect museums can provide the helping hand by identification of the insects pest so that the pest management expert can have the first-hand information what they are dealing with in turn this information can be forwarded to the farmers for the necessary pest management actions to keep the pest under check. All the pest management strategies are planned to focus on the particular kinds of the pests where the identification of the pest is a must. Many a time a wrongful identification of the pest leads to the devastating consequences which can do more harm than good. For a long time, the museum specimens have been the go-to guide for the identification of the insect pests, mostly utilized by the taxonomists and persons involved in the pest management programs. Insect museum can serve the farmers too, who may find it informative and helpful. These type of state of the art museums which are dedicated to the insects are helpful for the farmers in distinguishing the one those are problematic to the farmers from those that provide some benefits to them. Some insects are harmful to crops, while others are natural enemies and are helpful in pest management, insect museums would also help farmers understand insects and their management. The initiative taken by the government of India in establishing India’s first museum dedicated to the insect is admirable and more such museums are required around the country to spread the knowledge and awareness among the farmers who are the main stakeholders in agriculture. The museum displays the insects in a thematic style along with facts giving more user-friendly educative experience. If the farmer can identify the pest problems by themselves it will not only reduce the time of action to be initiated but also drastically improve the decision-making ability of the farmers to initiate the timely pest management activities. It will reduce the farmer’s reliance on the SAUs as well as KVKs for identification of their crop pest, natural enemies and damage symptoms at the farm level which at times get delayed due to the non-availability of expert personal which seriously hampers the decision making by the farmers. Entomological museums whether physical or online can ensure availability information to the farmers, researchers as well as the extension workers. With present day scenario where digitization of the data it is easily accessible to the masses, and this data can serve as the identification tool for specialist as well as armatures alike. More the number of insect museum more will be the awareness among the farmers and governments should also concentrate their efforts not only opening such museums but also work towards drawing the attention of the farmers and common peoples.
Green manures, also referred to as fertility building crops, may broadly be defined as crops grown for the benefit of the soil. Leguminous plants will fix nitrogen from the air whilst non-legumes will conserve nitrogen by preventing nitrate leaching. Green manures add organic matter to the soil, improving its physical and biological properties and they can assist with pest, disease and weed management.

**Nitrogen fixation**

Green manures are often grown to add nitrogen to the soil. In organic systems this represents the main source of nitrogen, whilst for conventional growers; it can be a way of minimizing fertilizer inputs. Almost all legumes use Rhizobia bacteria to fix nitrogen from the atmosphere. Different bacterial species interact with different groups of legumes (clovers, lucerne and trefoils, lupins, beans etc.). Sometimes the nitrogen fixation still does not occur, even if the roots form symbiosis with the bacteria. Some strains will infect the plant but not be very effective. For effective fixation, a minimum soil temperature of about 7°C is needed and the plants need to have adequate nutrients available to them. Active nodules have a pinkish colour when broken open. The amount of nitrogen fixed varies between different species. If there are high levels of available nitrogen in the soil from fertilizers or as a result of the decomposition of crop residues plants will not fix much nitrogen.

**Nitrogen conservation**

Large quantities of nitrate can be lost from soil when it is left bare over winter. Unlike other nutrient ions, nitrate is not strongly attracted to soil particles, so any nitrogen that is in solution in the autumn will be washed away as water moves down through the soil with the onset of heavy winter rains. Winter green manures can be very effective crops for ‘mopping up’ excess nitrate in the soil in the autumn. Different species vary in their ability to reduce leaching.

**Available Nitrogen**

Large amounts of nitrogen are added to the soil by a successful green manure. Bacteria and fungi carry out a process called mineralization where complex molecules are converted to ammonium and nitrate ions. Mineralization proceeds fastest when the soil is warm and moist. The quantity of nitrogen released is also dependent on the total amount actually added to the soil and the chemical composition of the incorporated material. Non-legumes (e.g. mustard) can add as much total nitrogen to the soil as legumes. However, the nitrate availability is slower. This is because they have a lower percentage nitrogen content (1 to 2%) and thus a higher C:N ratio. Furthermore, the nitrogen concentration in many non-legumes usually decreases even further as the plants age and prepare to set seed so the date of incorporation is crucial.

**Effects on other soil nutrients**

The uptake of potassium, and to a lesser extent phosphorus, can be substantial over a period of 1 to 3 years. In grass clover leys, the grass component takes up more potassium than the clover; this is probably related to the more extensive rooting system of the grass. Some plants, particularly lupins and buckwheat, can increase phosphate mobility in the soil by the exudation of organic acids from the roots. Sulphur may be leached out of sandy soils and thus eventually becoming deficient in low input systems. Cruciferous crops such as winter rape or fodder radish can be particularly effective at preventing sulphur being leached into lower soil.
Other greenmanures (for example chicory, with its deep tap root) have been reported to accumulate large amounts of sulphur, boron, manganese, molybdenum and zinc. This ‘mining’ effect is particularly useful if the subsoil is rich in nutrient elements but the topsoil is relatively poor.

Effects on soil structure
Legumes usually decay rapidly and so have relatively little effect on long term soil organic matter. However, they do stimulate microbial activity in the first few months after incorporation. In contrast non-legumes generally break down relatively slowly with their residues providing a physical effect for some time.

- Extensive fine roots enmesh the soil, helping to stabilize aggregates and increase pore size.
- Some species (e.g. lucerne, chicory and red clover) produce deep tap roots which help break up compacted soil.
- Root exudates provide food for micro-organisms, which in turn produce polysaccharide gums, that ‘glue’ soil aggregates together.
- Green manures can maintain the population of soil mycorrhiza between cash crops; these fungi, as well as being important in phosphorus nutrition, help to maintain soil structure by enmeshing soil aggregates. Brassicas and lupins however are non-mycorrhizal.
- The root system has a binding effect on the soil, so water erosion is substantially reduced. A green manure increases surface roughness, lessening the wind speed close to the soil and helping to minimize wind erosion.
- Increased soil organic matter can help to improve water holding capacity.

Effects on weeds
One of the major benefits of green manures is their ability to suppress weeds. Growing a green manure adds diversity to the rotation and reduces the opportunities for weeds to become adapted to a particular cropping pattern. Management practices associated with growing a green manure (e.g. mowing and grazing) can also suppress weeds. The lack of soil disturbance during the long growing period of a ley can also reduce viable seed numbers. Green manures will compete with weeds for light, water and nutrients.

Effects on pests
Green manures can act as habitats for general predators. These can be especially important to provide cover over winter whilst summer flowering plants will encourage good populations of hoverflies, lacewings and parasitic wasps.

Effects on diseases
The glucosinolates in Brassica green manures have also been used in disease control (e.g. against Verticillium wilt of strawberries and Rhizoctonia of various vegetables). Many green manures will support microbial communities of non pathogenic bacteria and fungi which will antagonize pathogenic organisms. However, as with pest effects, there is the danger of maintaining a green bridge that increases some disease risks (e.g. clubroot).

28. HORTICULTURE

Celosia: an Emerging Cut Flower

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Celosia spp. belongs to the family Amaranthaceae and derived from Greek word ‘kelos’ (Burned). Its chromosome number is 2n = 2x = 36. Some of the species are Celosia argentea, Celosia cristata, Celosia nitida, Celosia palmeri, Celosia plumose, Celosia trigyna, Celosia virgata. Cultivated in sandy loam soil with pH 6.5 to 8.8. It is a Short-day plant which is well grown in tropical and sub tropical climate with optimum temperature is 20- 22°C. Best season
for growing celosia is July to November. Celosia is propagated through seeds with seed rate of 600g/ha. Planting of celosia seeds are sown in bed after 30 days transplanted to field, transplanted with spacing of 30x30 cm. It is highly cross pollinated crop. Celosia is tolerant to heat, cold, drought, salinity.

Celosia plumosa
- Fluffy, feathery heads & blooms in mid-spring to summer.
- Inflorescence pink to light violet & leaves are dark green than other cultivars.
- Have feathery plume like flower heads, 4-10 in (10.2-25.4 cm) tall, that look a little like tiny Christmas trees.
- Cultivars:
  - 'Apricot Brandy' is freely branched, to 20 in (50.8 cm) tall, with orange flower heads.
  - 'Forest Fire' has maroon leaves and bright scarlet flower heads.
  - 'New Look' has purplish leaves and crimson flower heads.
  - 'Kimono Series' cultivars are small, to 8 in (20.3 cm) tall, with flower heads in rose, pink, creamy white and red.

Celosia cristata
- Compact rounded, crested or fan-shaped flower heads with convoluted ridges.
- The flower heads are 3-12 in (7.6-30.5 cm) across and look a little like velvety brains, cauliflower heads or roosters' combs.
- 'Big Chief Mix' - tall to 3 ft – cauliflower shaped flower heads 15.2 cm (dia).
- 'Jewel Box Mix' - very small - with bronzy leaves and flower heads in hot, bright colors - the flower heads are fan-shaped, like a rooster's comb
- Toreador - 18-20 inch tall, Bright red comb, 12 inch across

C. spicata
- Cultivars with slender, cylindrical pink or rose flower heads which have a metallic sheen because the individual flowers are silvery-white at their bases.
- Flamingo Feather - 36-48 inch tall, White plume with pink top
- Flamingo Purple - 36-48 inch tall, Purple plume, Good colour retention when dried

Cultivation:
While transplanting celosia, Farm Yard Manure of 25-30 t / ha is given in field before planting and nutrient NPK with the ratio of 150:200:150 kg/ ha. Pinching is done at 10-15 days after transplanting.

Harvest and yield:
Central part of the inflorescence starts opening first but should harvest before starting colour fading of the peripheral region. The yield of celosia is 6.5 to 7.5 t/ha. The flower will be in same colour for 5 to 7 days. Pigment extracted from celosia flowers is Betalain. The pest attack by aphids, thrips, white fly which is reduced by spraying dimethoate 0. 2% and repeat this 2 weeks intervals. The disease attack is damping off (Rhizoctonia, Phythium, Phytophthora ), nematode (Meloidogyne spp.).

Review:
- Tanveer F Miano et al., 2017 conducted experiment on seeds of Cockscomb Amigo Red and Cockscomb Amigo Orange were sown at different dates (S1=5th March, S2=20th March and S3=4th April) with the interval of 15 days in the earthen pots. Seedlings at 2 to 4 leaf stage were transplanted in the separate earthen pots. The results showed that planting date 4th April with variety Amigo Orange proved better
- Yagi et al., 2014 studied the effect of nitrogen [25, 50 Kg N (as urea)] and Spacing (20, 30, 40 cm). The results showed that 40 cm spacing and 50 Kg N/fed given maximum flower yield.
- Yahya Awang et al., 2009 evaluated that media mixtures with cocopeat. The treatments are T1 - 100% cocopeat: T2 - 70% cocopeat :30% burnt rice hull; T3 - 70% cocopeat: 30% perlite: T4 - 70% cocopeat: 30% kenaf core fiber: T5 - 40% cocopeat: 60% kenaf core fiber. Result revealed that chemical and physical properties (increased bulk density, air-filled porosity, available water and wettability) of cocopeat can be
improved through incorporation of burnt rice hull and its positive effect was clearly reflected in the growth and development of *Celosia cristata*.

- Agbagwa et al., 2003 evaluated growth and development of *Celosia argentea* L. by Crude Extracts of *Senna alata*. Weighed 300g of the fresh leaves of *S. alata* and kept for homogenizing in 1 Litre of distilled water then green paste was filtered. Wine colour filtrated and stored in refrigerator at 4°C, 100 % crude extract, 75% C, 50% C, 40% C, 30% C, 25% C, 12% C, 10% C, and 5% C were prepared. Seeds sown in petridishes, 50 seeds were used for each concentration. Measurements were taken at intervals of 24 hours. The results showed that ability of *S. alata* to promote early flowering (16 - 18 days) of *C. argentea* is a significant observation. Earliness in flowering and overall increase in height was obtained from seedlings sprayed with 75% C and 100 % C crude water extracts.

- Abhishek Mangrati, 2017 conducted experiment to standardize microwave oven drying technology for cockscomb. Fresh full bloom bright celosia flowers were collected from flower market. Flowers were subjected to 8 treatment combinations with sand and silica gel as embedding media and dried in Microwave at 720Hz. The results showed that maximum moisture loss (82.52%) occurred in embedding media silica gel (M2) which was differed significantly over other embedding media sand (M1) (73.65%). This might be due to the strong hygroscopic nature of the fine silica gel which led to rapid removal of moisture from the flowers. Drying of celosia flowers in microwave at 3.5minutes with embedding in silica gel can be commercially employed for drying.

References:


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### 29. HORTICULTURE

#### Nursery Techniques of Banana

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**Introduction**

In India, use of conventional suckers cannot be completely avoided because of some regional special varieties tissue culture technique is yet to be perfected. Further for resource poor small scale growers the cost of tissue culture plants stills a hurdle in adoption. There are three types of planting material used for propagation namely, Suckers, Peepers, Rhizome.

**The tissue culture banana process**

The tissue culture banana process entails 4 main stages;

- **Stage one:** Sourcing of starter material,
- **Stage two:** Multiplication of explants, **Stage three:** Rooting, **Stage four:** Hardening Nursery (Robinson and Galan 2009a).

**ESTABLISHING THE HARDENING NURSERY**

1. Where should a hardening nursery be located?
   a) A nursery should be located in a banana growing area
   b) The nursery should be accessible
   c) Water should be available near the site
   d) The nursery should be free from pests such as insects, fungi, nematodes, weevils
e) The nursery should be fenced to protect seedlings from both wild and domestic damage.

2. Soil mixtures: The soil should comprise of top soil/virgin soil + any of the following gravel, rice husks, sawdust, wood shavings, wood bark, or sand at a ratio of 6 parts to 1 part. Fertilizer application is not necessary at this stage.

3. Soil sterilization: It is important to sterilize soil to kill harmful organisms such as soil-borne fungal diseases, nematodes and weeds. This can be done through either steam sterilization, soil solarization or chemical sterilization (Robinson and Galan 2009b).
   a) **Steam sterilization:** Steam sterilization improves the soil physical structure, it is harmless to beneficial organisms in the soil, fast, easy, cheap, more effective than chemicals, and user friendly. The main disadvantage is the use of firewood which may be costly and environmentally unfriendly.
   b) **Soil Solarization:** This involves using solar energy to heat the soil. The soil is collected and spread in a shallow 'pit' then covered with a clear polythene sheet in an open area to allow sunlight to penetrate. It takes 30-60 days depending on the weather.
   c) **Chemical Sterilization:** This involves the use of chemicals. The commonly used chemicals are furadan (2kg per tonne of moist soil); mocap 10G (3kg per tonne) and Basamid (one tonne=2 pickup trucks =80 wheelbarrows).
      
      **Note:** Manure and compost should not be sterilized, but added after the soil has been treated.

4. Nursery media, fertiliser and bags: Various types of organic nursery media can be used including composted pine bark, coconut husk fibre, composted coffee husks, rice husks or milled maize cobs. Avoid media mixes containing more than 50% soil or river sand because these components can cause compaction, which increases the risk of waterlogging and root dieback following over-irrigation (such media have high water-holding capacity but low air-filled porosity).
Bag, medium, fertiliser and transport costs, and fewer plants fitting into the available nursery space.

5. Handling and transplanting weaned plants into bags
   a) **Step 1:** Fill the nursery bags to the brim with the premixed potting medium prior to arrival of the plants from the weaning house, in order to prevent unnecessary delay before planting.
   b) **Note:** there are three reasons for filling the bags full as recommended. Firstly, the bags and plants are better stabilised against each other on the base structure; secondly, this prevents the sides of the bags from collapsing inwards which would reduce water access into the bag; thirdly, rooting volume is maximised.
   c) **Step 2:** Count and closely inspect all plants on arrival at the nursery and immediately refer any queries or problems to the supplying laboratory. Label the box with cultivar name, size grade and destination nursery. These tender plants with open root plugs can survive in a healthy condition for 5–7 days in a cooled box, but the sooner they can be planted out after packing, the more successful the transplanting will be.
   d) **Step 3:** Water the medium in the bags well before planting out. This facilitates planting and ensures the young transplants do not dry out. Make a hole slightly larger and deeper than the plug size in the middle of the medium surface, using a conical or pyramid shaped tool depending on the plug shape. After inserting the plant, fill in the hole and compact it only lightly. Water the bags thoroughly again after transplanting.
   **Note:** deep planting encourages plant strength and stability, whereas shallow planting can cause plants to become unstable during later movement and transport.

References

30. AGRICULTURAL ENTOMOLOGY

Rodent pests and their management

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**Introduction**
Rats are the most notorious pests of different commodities in the fields as well as when these commodities are stored. A number of crops like vegetables, oilseeds, cereals etc., at early stage in field are eaten and contaminated by rats. They are also seen playing a vital role in transmission of public health diseases viz., plague, leptospirosis etc. to humans and other animals.

**Common traits of rodents**
- Nocturnal in habit
- Excellent swimmers
- Good climbers
- Good sense of smell and hearing
- Can gnaw through materials like lead, sheathing, aluminium, wood, wiring, etc
- Can enter through very small opening

**Common rat (Rattus rattus)**
- It is reddish or yellowish brown with a pure white belly.
- It lives in roofs of houses and underground burrows.
- It is destructive to tender coconuts.
- Its damage is great in ware houses and storage godowns.

**House mouse (Mus musculus)**
- Head + body length is 70–110mm, large ears
and relatively small eyes, they have characteristic musky odour that identifies their presence. A good climber.

**Indian mole rat (Bandicotabengalensis)**
- It is a dark grayish brown in colour with a grayish white belly and a bare tail, head and body 15 to 23 cm and tail 15 to 18 cm long. It feeds upon grass, grains and tubers and damage to rice crop is considerable in Tamil Nadu

**Indian gerbil rat (Teteraindica)**
- It is reddish grey in colour with white underside and equals the common house rat in size with about 18 cm long. Feeds on grain, grass, roots and fruits.

**Indian field mouse (Mus booduga)**
- It is brown in colour with a white belly. It burrows in field bunds causing extensive damage to bunds.

**Norway rat (Rattusnorvegicus)**
- Large size, brown in colour. The tail is shorter than body + head length. Ears are thick, opaque and short with fine hairs. They are excellent swimmers and grow rapidly in sewers and drainage systems, therefore also called as sewer rat.

**Large bandicoot (Bandicotaindica)**
- Large sized active burrower and is responsible for much structural damage to the storage buildings, ground, flooring and also spoils stored products. They are good swimmers and non-fussy eater. It is also serious a pest in poultry and agriculture.

**Management of rodents**
1. **Rat proofing:** Indoor stores can be made rat-proof by concrete flooring with iron meshes on the windows, over the ceilings, and by providing metal doors or metal bands at the bottom. In godowns, the entrance staircase must have an 18” long plank which has to be placed and removed whenever necessary.
2. **Trappings:** Caging / trapping of rats has been the most popular and common practice employed in place where rat infestation is low and poison baiting and fumigation are impracticable. Baits (roasted coconut, ground nut, etc.) are used to lure the rats into the traps. There are several types of traps: box-type, wonder trap (can trap more than one rat per trap at a time), pot trap, bow traps (Vallanad, Tanjore bamboo traps) and ‘break back’ trap.

3. **Habitat manipulation:** Availability of food, shelter and water are governing factors in rodent population in any habitat. Removal of any of these factors will affect adversely on the rodent population. These methods are easy, effective and require no extra expenditure and can be adopted by the removal of garbage, maintenance of good hygienic conditions and by following strict sanitary practices.

4. **Poisoning:** The most popular and effective method of controlling rats is the use of poison baits. The poison used in the baits are of two types:
   a) **Acute poisons:** which are used in a single dose, i.e., zinc phosphide. It is mixed with the bait at 1: 49 ratio. The bait can be any cereal, milled or broken. Acute poisons give better results if plain (unpoisoned) bait is laid from 4 - 8 days before being replaced with poisoned bait. This technique is known as pre-baiting.
   b) **Chronic poisons:** which act as blood anticoagulants and are used in multiple doses, i.e., hydroxyl coumarin (warfarin, fumarin, recumin). The other anticoagulants (bromadiolone) are lethal in a single dose but the rats die after several days of poisoning.

5. **Chemosterilants:** The chemical which makes the rat sterile is called as chemosterilant. Furadantine @ 0.02 g and colchicines @ 0.14 g are commonly used chemosterilants, which make the rat sterile. These are generally used as mixture of one tablet of furadantine and half tablet of colchicines in the water floor to make both sexes sterile.
6. **Fumigation:** Aluminium phosphide (Celphos), a fumigant available for restricted use in India, can be used inside the rat burrows. It is available as a 3 g tablet. Put it inside the burrow and close it. When it combines with atmospheric air, phosphine
gas is released, which is a nerve poison.

### 31. PLANT PATHOLOGY

**Management of Apple Scab Disease**

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**Introduction**

Apple scab is the most important disease of apple (*Malus × domestica*) throughout the temperate regions of the world. This disease results in 70% yield loss and even complete loss is also possible, if it is not managed in orchards properly. The infection begins in spring when ascospores are released and infect young emerging apple leaves. Conidia are then produced from these infections and continue the cycle of secondary infection in leaves and fruits. Different management strategies like cultural, biological, resistance, and chemical approach have been adopted for its control. In India, apple scab was first reported from Kashmir Valley on the native cultivar Ambri in 1935.

**Pathogen:** *Venturia inaequalis*

**Symptoms**

Symptoms which are visible and are severe occur on leaves as well as fruits. The early lesions of scab are defined with dark green velvety spots, seen on lower surfaces of leaves. Leaves and fruits are highly susceptible to apple scab when they are young and growing. Mature leaves and fruits gain resistance as they age. During the main growth period in early spring, there is more susceptible tissue available for infection and therefore, greater risk of disease than later in the season. Apple scab generally does not kill the trees but it can cause defoliation, which will weaken the tree and influence its survival during winter conditions. On leaves, young scab lesions are pale, irregular, and small. As they age, they become circular and olive-colored with a velvety texture. Lesions in a more advanced stage become black and slightly raised. Heavily scabbed leaves can desiccate, become deformed and fall.

- Early infections can lead to abnormal growth and fruit drop. The lesions on the fruits are similar to those on the leaves, but as they age, they will produce cracks.
- If the fruit is infected late in the summer or just before harvest, black, circular, very small (0.1 – 4 mm diameter) lesions called ‘pin-point scab’ will appear during storage.

**Disease cycle**

*Venturia inaequalis* overwinters mostly on dead leaves, in which small microscopic flask formed Black fruiting bodies, called pseudothecia, are developed. Ascospores start maturing in early spring and when temperature and moisture are suitable these spores are released forcibly in air. In the spring during the rainy season, fungal spores are released from the infected leaves that...
remain from the previous year and are carried by the wind to newly emerging leaves and fruits of healthy trees. Once primary infection occurs, secondary spores (conidia) are formed, allowing a tree to continually reinfect it or neighbouring trees as long as environmental conditions are favorable. The disease progresses rapidly and causes severe infections if plants remain continuously wet for at least a six-hour period with temperatures around 20 - 25°C.

**Management strategies**

**Cultural practices**

Through cultural practices, disease can be minimized, or even prevented, by good horticultural practices like selecting sites that provide more than six hours of sunlight per day, spacing trees adequately following proper pruning practices to open the tree canopy, sanitation in orchards to prevent pseudothecial formation in overwintering apple leaves, applications of 5 percent urea to autumn foliage to increase leaf decomposition, thereby reducing the amount of fungus that will survive the winter.

**Resistant cultivars**

The scab-resistant cultivars, including Freedom, Shireen, Firdous, Jona free, Liberty, Prima and Red free is essential if growers wish to produce organically grown fruit.

**Biological control**

Biological control is the method of controlling or suppressing of plant disease by using other microorganisms (Pal and Garden, 2006) several studies have identified different antagonistic agent to manage *Venturia inaequalis*. Such as, *Microsphaeropsis ochracea*, which occurs naturally on dead leaves and isolated, as a good antagonist of *Venturia inaequalis* when applied in August and September resulting in a 95 to 99% reduction in spring ascospore production as compared to untreated treatments (Carisse and Rolland, 2004).

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**Fig- Disease cycle of apple scab disease**

**Chemical control**

Spray schedule for management of Apple Scab disease
Different Stage of Apple Chemical spray

**Green Tip**  
Mancozeb 75 WP @3 gm/L of water or Captain 50WP @3 gm/L of water.

**Pink Bud**  
Dodine 65 WP @0.5 gm/L of water, Mancozeb 63% + Carbendazim 12% @2.5 gm/L of water.

**Petal Fall**  
Bitertanol 10EC @ 0.5 ml/L of water or Kresoxim methyl 44.3SC @0.4 ml/L of water or Difenconazole 25EC @0.3 ml/L of water.

**Pea Shaped fruit**  
Protectant fungicides like Hexaconazole5% + Captan70% @0.5gm/L of water.

**Walnut shaped fruit**  
Mancozeb 63% + Carbendazim 12% @2.5 gm/L of water or Myclobutanil10WP @0.5 gm/L of water.

References


### 32. PLANT PATHOLOGY

UG 99: A Super Race Causing Stem Rust in Wheat

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Wheat (*Triticum aestivum* L and *T. turgidum* var durum) are commonly growing cereal crop around the world including India. Many pathogen are infecting wheat. Among them stem/black rust of wheat caused by *Puccinia graminis* Pers f. sp. *triticci* cause severe lose in production of crop. This pathogen causes devastating epidemics occurred around the globe. In mid 20th century a series of epidemic of this pathogen is reported this lead to take up the diseases resistance breeding program for resistance gene. During that period, India having major proportion of stem rust reseentence gramlasms due to presence of Sr31 gene in them. Several other gene such as Sr24, Sr2, Sr26, Sr36 and Sr38 are gave sustainable protection. Consequently over a period of time stem rust of wheat did not appear as a threat for crop production. Leading to decline in diseases resistance research activity on this pathogen.

**UG99 emergence, threat it poses and research initiation taken to meet threat in India.**

During 1998, a new race has been reported in Uganda called as UG99. It called as TTKS now TTKSK according to naming system of North American Rust Worker. This race carries the broad virulence against of the rust resistance gene available in world including Sr31. So it called as 'Super race'. This race is moving from Uganda to Kenya and Ethiopia in 2005. Later, UG99 was established in Yemen in 2006, in Iran in 2007, in Tanzania and South Africa in 2009. This race has spreaded from Eastern Africa to Middle East and Asia, where is the major wheat production area are available. Although germplasm with resistance to this pathogen are available but genetic stock of this are not present in popular commercial varieties.

The popular varieties which are coverd million of ha area in india are proved to be susceptable to UG99 and along with that Indo Genetic plains of India having availability of favorable environment condition in the point of concern if UG99 dose spared unchecked. To
cheek this highly virulent race the global rust initiative (GRI) has been started in Nairobi in 2005. India is also on of the partner country to combat this problem.

India has initiated in Indian wheat program in collaboration with CIMMYT. To select, identify and to develop the resistance gene/cultivar. To combat the threat imposed by UG99 race in different wheat growing zone before it arrives. Up to now from rapid breeding taken up by resurchres from India developed many resistance and satisfactory resistance lines viz. HW1085, a var frm IARI regional station wellington, genetic stocks like FLW2, FLW6, FLW8 DWR regional station, Shimla and GW273, GW322, HD2781, HI1500, MP4010, H18498, MACS2846, HA4678 and cultivars UP2338 and HUW510.

\[\text{Fig. 1: Stem rust in wheat}\]

### 33. AGRICULTURAL ENTOMOLOGY

**Lightening in Fireflies**

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#### Introduction

Fireflies (Coleoptera: Lampyridae) are among the most charismatic of all insects with more than 2000 species in 100 genera. It makes bioluminescent signalling, which is used for species recognition and mate choice. Different firefly species and their developmental stages exhibit different signalling systems, which play important roles in sexual communication and defense.

#### Characteristics of firefly

**Male**

- Head is concealed by the semicircular pronotum
- Eyes are well developed and contiguous
- Forewings are soft and flexible. They do not fully cover the abdomen
- Photogenic organ is found in sixth and seventh abdominal segment.

**Female**

- Head is hidden by the pronotum
- Eyes are very much reduced
- Wings are absent and larviform
- Photogenic organ is present in seventh abdominal segment

#### Mechanisms of light Production

- Quiescent mode (above dotted line), oxygen delivered through lantern tracheae is consumed by respiration in photocyte mitochondria (green) clustered in the peripheral cytoplasm: little oxygen reaches peroxisomes that contain the light producing reactions of the luciferin-luciferase.
• In quiescent mode, ATP produced by oxidative phosphorylation promotes formation and accumulation of the activated luciferin-adenyl (luciferin*) by luciferase.

• In flash mode (below dotted line), nerve activity causes octopamine release that transiently activates lantern Nitric oxide synthase (NOS).

• Nitric oxide(NO) diffuses rapidly and inhibits oxygen use by photocyte mitochondria (red).

• Now oxygen delivered by the tracheal system diffuses through photocytes to the peroxisomes where it triggers the light-producing reaction.

Flash Signaling and Species Recognition

Fireflies male and female, find and recognize each other based on timing and pattern of flashes, the flashes are unique for each species.

Conclusion

• Fireflies ability to produce bioluminescent flashes is associated with several anatomical and physiological adaptations of the adult lantern and involves the signaling molecule nitric oxide.

• Based on the timing and pattern of flash they recognize each other.

References


https://www.nps.gov/grsm/learn/nature/firefly-flash-patterns.htm

### 34. AGRICULTURAL ENTOMOLOGY

#### INDUCED RESISTANCE AND BIOSYNTHESIS OF JASMONIC ACID

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**Plant resistance**

Resistance to pathogens and pests in a plant can be active and/or passive (Hammer Schmidt and Nicholson, 1999). Passive resistance depends on defenses that are constitutively expressed in the plant, while active resistance relies on defenses that are induced after infection or attack.

**Induced plant resistance**

Induced plant resistance is defined as the “quantitative or qualitative enhancement of a plant’s defense mechanism against pests in response to extrinsic physical or chemical stimuli” Kogan and Paxton (1983). Furthermore, Kloepper *et al.* (1992) defined the corollary for induced plant resistance to disease as “the process of active resistance dependent on the host plant’s physical or chemical barriers, activated by biotic or abiotic (inducing) agents.” Mechanical damages are also causes wound-induced responses in plants.

**Induced resistance- Three different time scales**

Baldwin (1989) proposed that plant induction be studied on three different time scales. Preformed induced responses occur immediately after damage and are restricted to damaged tissues. Rapidly induced responses occur within hours or days of plant injury and may be localized or systemic. Rapidly induced responses can occur in as little as 1 to 2 hrs and may remain in effect for a few days to several days. Delayed-induced responses occur in the following season’s foliage, and delayed-induced responses in some tree species may remain in effect for as long as 3 years.

**Early Events in the Plant-Insect Interaction**

(Mithofer and Boland, 2008)

Early events in plants after feeding by insect herbivores are immediate changes in the transmembrane potential ($V_m$) and are tightly followed by changes in the intracellular Ca$^{2+}$ concentration and generation of H$_2$O$_2$. Kinases and the phytohormone jasmonic acid (JA) are detectable within minutes. After roughly 1 h, gene activation followed by metabolic changes.

**Biosynthesis of jasmonic acid**

The primary event in the signalling pathway is proteolytic cleavage of a precursor polypeptide, prosystemin, to release the peptide hormone systemin. Systemine was the first plant peptide hormone with a characterized role in signal transduction in plants (Ryan, 2000). The prosystemin precursor is a polypeptide of 200 amino acid residues.

The signal transduction mediated by the systemin receptor results in activation of phospholipase via a MAP kinase, and thus leads to the release of linolenic acid from membrane lipids. Further effects such as calcium release from vacuoles, calmodulin synthesis, and the opening of ion channels in the plasma membrane...
JA-Ile, are found in both monocots and dicots. They are involved in several physiological activities, ranging from seed germination, over reproductive development, to senescence. Furthermore, the jasmonates play important roles as signaling molecules in plant defense, particularly against insect herbivores (Koo and Howe, 2009).

Advantages
Induced defenses are only invoked after tissue damage has occurred. This potentially provides defense at a lower energetic cost.

Limitation
It is not always easy to distinguish between constitutive and induced defense mechanisms since some defense related compounds are constitutively synthesized and stored, and also synthesized de novo as a response to herbivore damage (Ding et al. 2000; Gatehouse 2002).

References

Jasmonates
The jasmonate hormones, such as JA, MeJA and JA-Ile, are found in both monocots and dicots. They are involved in several physiological activities, ranging from seed germination, over reproductive development, to senescence. Furthermore, the jasmonates play important roles as signaling molecules in plant defense, particularly against insect herbivores (Koo and Howe, 2009).

Advantages
Induced defenses are only invoked after tissue damage has occurred. This potentially provides defense at a lower energetic cost.

Limitation
It is not always easy to distinguish between constitutive and induced defense mechanisms since some defense related compounds are constitutively synthesized and stored, and also synthesized de novo as a response to herbivore damage (Ding et al. 2000; Gatehouse 2002).

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