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1. GENETICS AND PLANT BREEDING

   Transposable Elements Based Markers

   Asha, I.S

   1Ph.D scholar, Department of Genetics and Plant Breeding, UAS, GKV, Bengaluru

Transposable elements (TEs) are mobile DNA sequences. Transposable elements were first discovered by Barbara McClintock in maize (McClintock, 1950). TEs are ubiquitous components and repetitive sequences can change their location within a genome. They constitute >50% of nuclear DNA and generates genetic diversity through insertion into functional genes, excision from various genomic sites and generation of small structural rearrangements. Two basic classes of TEs based on the presence and absence of RNA intermediate are retrotransposons- (class I) which move using a copy-and-paste mechanism to amplify intermediate RNA and DNA transposons (class II)- which move within the genome by excising from their original location to a new region using a cut-and-paste mechanism (Feschotte et al., 2002). Retrotransposons transpose via an RNA intermediate transcribed from the original copy in the genome and can be classified into five orders: long terminal repeats (LTR) retrotransposons, Dictyostelium intermediate
repeat sequence (DIRS)-like elements, Penelope-like elements (PLEs), long interspersed nuclear elements (LINEs), and short interspersed nuclear elements (SINEs). LTR retrotransposons are further classified into five superfamilies: Copia, Gypsy, Bel-Pao, Retrovirus, and endogenous retrovirus (ERV). Other unclassified transposons are MITEs (Mature Inverted repeat transposable elements), which are small, not exceeding several hundred base pairs. Several marker systems are based on these retrotransposons but now it considered to be a derivative of class-II transposons. Most prevalent retrotransposons are dispersed throughout the genome. Their abundance, general dispersion, polymorphism and activity make them ideal sources for the development of molecular markers.

Retrotransposon-based molecular marker methods

**Sequence Specific Amplification Polymorphism (S-SAP method)**

S-SAP first used to investigate location of BARE-1 retrotransposons in Barley genome. It is a simple modification of the AFLP protocol, amplification is performed with retrotransposon specific and MseI-adopter specific primers to generate largest number of highly polymorphic markers that displays as bands the region between concerned retrotransposon insertion sites and the selected restriction site.

**Inter Retrotransposon Amplified Polymorphism (IRAP)**

The IRAP method detects retrotransposon insertion polymorphisms by amplifying the portion of DNA between two retroelements. It uses one or two primers pointing outwards from an LTR, and therefore amplifies the abstract of DNA between two nearby retrotransposons. IRAP can be carried out with a single primer matching either the 5’ or 3’ end of the LTR but oriented away from the LTR itself, or with two primers. The two primers may be from the same retrotransposon element family or may be from different families. The PCR products, and therefore the fingerprint patterns, result from amplification of hundreds to thousands of target sites in the genome.

**Retrotransposon microsatellite amplification polymorphisms (REMAP)**

It uses one primer based on LTR of a transposon and a second primer representing microsatellite sequence that may be anchored. REMAP marker detects polymorphism in the genomic fragment flanked by the insertion site of a retrotransposon on one side and SSR site on the other side.

The REMAP and IRAP methods were first described by Kalender et al (1999) and require comparatively little sequence information before implementing them in a new plant species. The primary requirement is the sequence of an LTR end, harvested either from a database or produced by cloning and sequencing the genomic DNA that flanks conserved segments of retrotransposons. Both markers are highly polymorphic, and upto 30 bands per individual may be obtained.

**Retrotransposons-based insertion polymorphism (RBIP)/ Tagged Microarray Marker (TAM)**

It uses one primer derived from the concerned retrotransposons and a pair of primers derived from the sequences flanking this retrotransposons at given insertion site. When the primer pair derived from the flanking sequences is used for amplification, a product would be obtained whenever there is no retrotransposon insertion in the region flanked...
by the primers. But when the primer based on retrotransposon is used with a primer specific to one of the flanking regions, a PCR product would be generated only when the concerned region contains the retrotransposon. Polymorphism can be readily detected by electrophoresis using an agarose gel or by hybridization with reference PCR fragment. It generates a co-dominant marker.

RBIP requires knowledge of unique sequences flanking a retrotransposon insertion so that a particular locus can be scored. Hence, development of a set of RBIP markers requires either extensive sequencing of insertion flanks or a fairly large genomic database for primer design.

d) RBIP, The alternative reaction between the primers for the left and right flanks is inhibited in the full site by the length of the retrotransposon.

Inter-MITE amplification (IMP)
The IMP technique is identical to IRAP, except for those primers based on MITE like transposable elements in the place of those derived from retrotransposon.

A major disadvantage of all retrotransposon based molecular markers techniques is the need for sequence information to design element-specific primers.

The number of whole plant genomes that are being sequenced is increasing exponentially and Transposable element based markers are potential evolutionary marker technique can be applied in more plant species.

References


2. BIOENERGY

Algae as a Rich Source of Biologically Active Ingredients for the Formulation of Functional Foods and Nutraceuticals

**Viral P. Joshi**

*Ph.D. Scholar, Department of Renewable Energy Engineering, CAET, JAU, Junagad*

**Abstract**
Algae or algae products are very rich and varied source of pharmacologically active natural products and nutraceuticals. The bioactive ingredients of algae have revealed numerous health-promoting effects, including anti-oxidative, anti-inflammatory, antimicrobial, and anti-cancer effects because algae is rich in dietary fiber, minerals, lipids, proteins, omega-3 fatty acids, essential amino acids, polysaccharides, vitamins A, B, C, E and carotenoids, phycobilins, sterols, and biologically active molecules for use in human and animal health. The antioxidative effects and bioactivities of several different crude extracts of algae have been evaluated both in vitro and in vivo. Natural products derived from algae protect cells by modulating the effects of oxidative stress. Because oxidative stress plays important roles in inflammatory reactions and in carcinogenesis, algal natural products have potential for use in anti-cancer and anti-inflammatory drugs. Use of algae, for antibiotics and pharmacologically active compounds has received ever increasing interest.

**Introduction**
Algae can be divided broadly into macro- algae
(macroscopic algae) and microalgae (microscopic algae). Algae are one of the primary producers it is the divisions of lower plants that contains chlorophyll in plant cells. The wide diversity in the biochemical composition of algae provides an excellent choice to explore a variety of biologically active components in their bodily composition with a broad range of physiological and biochemical characteristics, many of which are rare or absent in other taxonomic groups. Compared to the terrestrial plants and animal-based foods, algae is rich in some health-promoting molecules and materials such as, dietary fiber, ω-3 fatty acids, essential amino acids, and vitamins A, B, C, and E. The majority of the investigations on the metabolites derived from algae species have revealed their potential antioxidant, ant-inflammatory, antidiabetic, antitumor, antihypertensive, and anti-allergic properties, as well as their role in hyaluronidase enzyme inhibition, neuroprotection, bone-related diseases and in matrix metalloproteinase (MMPs) inhibition activity (Fig: 1). Bioactive substances derived from algae have diverse functional roles as a secondary metabolite, and these properties can be applied to the development of pharmaceutically important products. Well-documented bioactive metabolites of algae include brominated phenols, brominated oxygen heterocyclics, nitrogen heterocyclics, kainic acids, guanidine derivatives, phenazine derivatives, amino acids and amines, sterols, sulfated polysaccharides, prostaglandins and many more. However, not all species of algae have health-promoting properties, as some are known to produce toxic metabolites that cause neurodegenerative disorders.

Algae- Antioxidant Property
Antioxidants play prominent role in the later stages of cancer development. The most powerful water soluble antioxidants found in algae are polyphenols, phycobiliproteins and vitamins. Oxidative processes promote carcinogenesis. The antioxidants may be able to cause the regression of premalignant lesions and inhibit their development into cancer. It is found that, several algal species have prevented oxidative damage by scavenging free radicals and active oxygen and hence able to prevent the occurrence of cancer cell formation, these Antioxidants are considered key compounds to fight against various diseases (e.g. cancer, chronic inflammation, atherosclerosis and cardiovascular disorder) and ageing processes. For example, ethanol extracts of C. japonica suppressed H₂O₂-induced cellular apoptosis and activated cellular antioxidant enzymes. Free-radical-scavenging assays using green algae revealed antioxidant properties for the sesquiterpenoids from Ulva fasciata Delile.

Algae- Antimicrobial Property
Algae exhibit antimicrobial activity which finds use in various pharmaceutical industries. Ochromonas sp., Prymnesiumand a number of blue green algae produce toxins that may have potential pharmaceutical applications. Various strains of cyanobacteria are known to produce intracellular and extracellular metabolites with diverse biological activities such as antibacterial, antifungal and antiviral activity. The biological activities of the algae may be attributed to the presence of volatile compounds, some phenols, free fatty acids and their oxidized derivatives.

Algae- Anticancer Activity
Algae produce variety of chemically active metabolites in their surroundings as a weapon to protect themselves against other settling organisms. The extensive biological activities mentioned for algae include the transcendent anticancer and antitumor effect of secondary metabolites isolated from various species of algae. Activation of the intrinsic and extrinsic pathway of apoptosis, increase in the immune response, suppression of angiogenesis, and reduction in the adhesion of tumor cells to human platelets are suggested as mechanisms responsible for significant antitumor activity of

![FIG. 1.: Health benefits of algae.](image-url)
metabolites (Table-1). The superiority of antitumor strength shown by oversulfated fucoidan found in brown algae. Carotenoid and to more extent its metabolite, fucoxanthinol, demonstrated noteworthy antitumor activity associated with the free radical scavenging potential, induction of apoptosis, and the antiangiogenic effect.

Conclusion

Algae are combination of significant sources of natural bioactive substances and there has now emerged a new proclivity towards isolating and identifying such compounds and constituents from algae. Observing various studies on algae bioactivity scientist concluded that microalgae is probable to develop antimicrobial, antioxidant and anticancer drug as it is a product of nature. However, further studies need to be performed to fully exploit its anticancer properties such as determination of the nature of cell death caused by the extract or visual detection and confirmation of apoptosis. From this review we conclude that marine algae are known to produce a wide variety of bioactive secondary metabolites and several compounds have been derived from them for prospective development of novel drugs by the pharmaceutical industries.

References


3. HORTICULTURE

Cis-genesis in Breeding of Fruit Crops

Panchaal Bhattacharjee¹ and Utpal Das²

¹Department of Fruit science, KRCCH, Arambhavi, UHS, Bagalkot, ²Ph.D Scholar, Department of Horticulture, UAS, Raichur

Introduction

Cisgenesis- A cisgenic plant is a crop plant that has been genetically modified with one or more genes isolated from an inter-fertile donor plant. A cisgene contains its native introns and flanking regions such as native promoter and terminator region in a sense orientation. We distinguish cisgenic plants from transgenic plants. Transgenic plants contain genes from non-inter-fertile organisms, synthetic genes or sequences, or artificial combinations of a coding gene with regulatory sequences, such as a promoter, from another gene.

Cisgenic plants can, in principle, also be obtained by means of classical breeding, as far as the phenotype is concerned. This indicates clearly its limits regarding breeding possibilities, but also its limits regarding possible bio-safety risks. Cisgenic plants are as safe as conventionally bred plants or safer (Jacobsen and Schouten, 2007; Schouten et al., 2006).

The treasure of isolated alleles is being filled at an increasing rate

A prerequisite of cisgenesis is the availability of isolated functional alleles. Currently, the amount of DNA sequence information is
increasing exponentially. Large EST-databases are available to everybody. In addition, whole plant genomes have been sequenced. After the whole genome sequencing of Arabidopsis thaliana and rice, many other crops will follow. For example, apple is being sequenced (genome size-742.3mb), and other fruit crops too. This provides unprecedented opportunities for identification of genes. In addition, numerous loci have been mapped genetically in diverse germplasms, including fruit crops (Kole, 2006).

The information on genetic positions on the linkage groups, together with the whole genome sequences, and knowledge of genes from model plant species, offer us great opportunities to isolate alleles for desired traits at an increasing efficiency. We expect that, in the coming ten years, a vast number of major alleles for desired traits will be isolated in many crops, including fruit. So, the treasure chest of isolated alleles for quality cultivars, presumably leading to red-fleshed apples. It will be investigated whether these apples will preserve their good taste.

Cisgenesis can be applied to all kinds of crops. It is particularly attractive to crops that are cross fertilizers, and are propagated vegetatively, such as banana, grape, strawberry, and apple.

Roles of the different approaches

In our view, conventional breeding remains of crucial importance. It provides us high quality cultivars with many genes working together in a concerted action, in ways that mankind may understand poorly. History has proven that, even if there is a poor understanding of the underlying genetic network, breeders are still able to develop superior cultivars, just on the basis of phenotyping with experienced eyes, noses, and mouths. This empirical way of improving cultivars will remain important, because of the complexity of the functioning of living plants. Conventionally bred plants can be improved further with isolated major genes from wild germplasm, such as resistance genes.

During the development of cisgenic plants, the empirical knowledge of conventional breeders remains of crucial importance for selection of cisgenic plants without unwanted side effects that may have been caused by the transformation or regeneration process.

Genetic mapping of traits in segregating populations and pedigrees will be of increasing importance. It allows marker assisted breeding, but also it will be critical in searching and isolation of desired alleles for important traits in the breeder’s germplasm. These alleles can be used for marker assisted breeding, but also for cisgenesis. Efficient and fast technologies for high throughput functional analysis of many alleles will be increasingly important.

Different technologies of genetic modification have been developed to introduce genes without leaving selection genes behind, such as genes for resistance to antibiotics or herbicides (Schaart et al., 2004). A remaining challenge is directed insertion of the cisin the host genome, e.g., by means of homologous recombination and zinc finger nucleases, for a directed genome surgery (Kumar et al., 2006), without insertion of foreign helper genes. All these approaches will help in developing cultivars that can be grown in an ecologically sound way, and to the benefit of consumers and society.

Reference

4. AGRICULTURAL ENTOMOLOGY

Insect Biotype: Causes and Management

Shweta Patel\(^1\) and Sunil Kumar Yadav\(^2\)

\(^1\)Ph. D. Scholar, Department of Entomology, College of Agriculture, GBPUAT, Pantnagar (Uttarakhand), \(^2\)Ph. D. Scholar, Division of Entomology, ICAR-IARI, New Delhi

The continuous growing of insect resistant variety may lead to certain physiological and behavioral changes in insect pest. So that they are capable of feeding and developing on resistant varieties. The term biotype is generally used to describe a population of insects capable of damaging and surviving on plants previously known to be resistant to other populations of the same species. Insect biotype studies genotypic interaction between resistance in plant and virulence gene in insect. The challenge for the host-plant resistance strategy is the constant development of new biotypes that can overcome the resistance of deployed genes. Biotypes are morphologically similar with normal insect types but they are physiologically differing from them.

The existence of biotype was discovered by painter in 1930 on Hessian fly, *Mayetiola destructor* on resistance varieties of winter wheat and referred them as biological strains. Sometime, the biotype is considered synonymous with clone. The development of insect biotype has posed a serious threat to the success of plant resistance for the management of insect pests. Biotypes are known to be occurs in 36 crop pest species belonging to 17 arthropod families in six orders. Aphids constitute about 50% of the spp. with known biotype. Ten of 18 are aphid species in which parthenogenic reproduction contribute greatly successfully development of biotype.

Causes of insect biotype

1. Biotypes are known to develop on varieties where antibiosis (biochemical defense) is the major component of resistance and rarely develop on varieties where antixenosis or tolerance is mechanism of resistance.
2. The continuous growing of insect-resistant varieties may lead to development of biotype.
3. Biotypes of the insects are evolving as a result of selection pressure exerted by large scale growing of resistant cultivars.

Prevention of insect biotype development

1. Systemic surveillance programme should be designed for monitoring the insect biotype development.
2. Adaptation of integrated pest management techniques likes inters- cropping mixed cropping.
3. Reduction of the alate phase will slow down the development of the insect towards a resistance breaking biotype.
4. Use of insect growth regulator:
   - Example-Buprofezin inhibits acetylcholinesterase activity in B-biotype *Bemisia tabaci*
5. Use good non-chemical controls: Remove older leaves, keep areas free from weeds, segregate infested from non-infested plants, discard heavily infested material.
   - E.g. Q biotype of white fly, insecticides for rotation include Azatin, insecticidal soap, horticultural oil, botanigard etc.
6. No single control treatment can be used on a long-term basis against this pest. Example: There have also been good results with applications of Orthene followed several days later by a pyrethroid. Give good result to control Q and B biotype of white fly.
7. Maintenance of Refugia: Provide harborage for susceptible moth production to reduce the chance of resistant (R). To support a virulent individual to mate with virulent individuals in the insect population.

Conclusion

Insect biotypes are main limitations of host plant resistance. Insect biotypes are more prevalent in Homopteran insect (about 50% are aphids). There is greater chance to developed biotypes on varieties having more biochemical defense than the varieties offering physical defense. However they can be managed by
Radioisotopes are radioactive isotopes of an element, have the same number of protons in their atomic nuclei but differing numbers of neutrons. In other words, these are the versions of a chemical element that have unstable nuclei and emit radiation during their decay to a stable form. This process of shedding the excess radioactive energy is called radioactive decay. The radioactive decay process of each type of radioisotope is unique and is measured with a time period called a half-life. For example, naturally occurring uranium is uranium-238; but uranium-235, which has three less neutrons, is the less stable or more radioactive. Radioisotopes have important uses in medical diagnosis, treatment, industry and research.

**Applications of Radioisotopes in Biology**

They are mainly used for diagnostic or therapeutic purposes. They are also employed in tracing the flow of contaminants in biological systems and in determining metabolic processes in small animals.

**Table 1. List of radioisotopes and their uses**

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<tr>
<th>Radioisotope</th>
<th>Half-life</th>
<th>Use</th>
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<tr>
<td>Chromium-51</td>
<td>27.7 days</td>
<td>Used to label red blood cells and quantify gastro-intestinal protein loss</td>
</tr>
<tr>
<td>Iodine-131</td>
<td>8.02 days</td>
<td>Used in treatment of thyroid disorders like Grave's disease.</td>
</tr>
<tr>
<td>Iridium-192</td>
<td>73.83 days</td>
<td>Supplied in wire form for use as an internal radiotherapy source for certain cancers, including those of the head and breast.</td>
</tr>
<tr>
<td>Molybdenum-99</td>
<td>66 hours</td>
<td>Used as the 'parent' in a generator to produce technetium-99m, the most widely used radioisotope in nuclear medicine.</td>
</tr>
<tr>
<td>Phosphorus-11</td>
<td>14.28 years</td>
<td>Used in the treatment of excess</td>
</tr>
<tr>
<td>32</td>
<td>days</td>
<td>red blood cells.</td>
</tr>
<tr>
<td>Samarium-153</td>
<td>46.7 hours</td>
<td>Used to reduce the pain associated with bony metastases of primary tumours.</td>
</tr>
<tr>
<td>Technetium-99m</td>
<td>6.01 hours</td>
<td>Used to image the brain, thyroid, lungs, liver, spleen, kidney, gall bladder, skeleton, blood pool, bone marrow, heart blood pool, salivary and lacrimal glands, and to detect infection.</td>
</tr>
<tr>
<td>Yttrium-90</td>
<td>64 hours</td>
<td>Used for liver cancer therapy.</td>
</tr>
<tr>
<td>Copper-64</td>
<td>12.7 hours</td>
<td>Used to study genetic disease affecting copper metabolism; in Positron Emission Tomography; and also has potential therapeutic uses.</td>
</tr>
<tr>
<td>Gallium-67</td>
<td>78.25 hours</td>
<td>Used in imaging to detect tumours and infections.</td>
</tr>
<tr>
<td>Iodine-123</td>
<td>13.2 hours</td>
<td>Used in imaging to monitor thyroid function and detect adrenal dysfunction.</td>
</tr>
<tr>
<td>Thallium-201</td>
<td>72.9 hours</td>
<td>Used in imaging to detect the location of damaged heart muscle.</td>
</tr>
<tr>
<td>Carbon-11</td>
<td>20.3 minutes</td>
<td>These are used in Positron Emission Tomography to study brain physiology and pathology; for detecting the location of epileptic foci; and in dementia, and psychiatry and neuropharmacology studies. They are also used to detect heart problems and diagnose certain types of cancer.</td>
</tr>
<tr>
<td>Carbon-14</td>
<td>5 715 years</td>
<td>Testing the potentiality of harmful byproducts new drugs and age of organic material that is up to</td>
</tr>
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Radioisotopes and their Applications in Biology

Sunil Kumar Yadav¹ and Shweta Patel²

¹Ph. D. Scholar, Division of Entomology, ICAR-IARI, New Delhi, ²Ph. D. Scholar, Department of Entomology, College of Agriculture, GBPUAT, Pantnagar (Uttarakhand)-263145
<table>
<thead>
<tr>
<th>Radioisotope</th>
<th>Half-life</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-60</td>
<td>5.27 years</td>
<td>Used in gamma radiography, gauging, commercial medical equipment sterilization, treatment of cancer, irradiation of food products</td>
</tr>
<tr>
<td>Caesium-137</td>
<td>30.07 years</td>
<td>Used in the treatment of cancerous tumors, measure the correct dosages of radioactive pharmaceuticals, maintain the right level for food, drugs packaging</td>
</tr>
<tr>
<td>Calcium-47</td>
<td>4.536 days</td>
<td>Used in studying the cellular functions of formation of bone in mammals</td>
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<table>
<thead>
<tr>
<th>Radioisotope</th>
<th>Half-life</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-57</td>
<td>271.74 days</td>
<td>diagnose pernicious anemia</td>
</tr>
<tr>
<td>Iodine-123</td>
<td>32.22 hours</td>
<td>Diagnosis of thyroid disorder and disorders of metabolism including functions of brain.</td>
</tr>
<tr>
<td>Xenon-133</td>
<td>5.243 days</td>
<td>Used in nuclear medicinal studies for lung ventilation and blood flow studies.</td>
</tr>
</tbody>
</table>

6. AGRICULTURAL ENTOMOLOGY

Insect: As a Vector of Plant Viruses

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Introduction

Insect have a wide face on the damage of the plant communities beside the damages of the plant insect has another face of transmission of the plant viruses. Most plant viruses depend in insect vectors for their survival, transmission and spread. Specific virus-insect vectors interactions have evolved, in a mutualistic symbiosis at the detriment of the plant. Insect vectors of plant viruses are found in 7 of the 32 orders of the class Insecta. They transmit plant viruses by four major transmission modes.

The principal families of insect vectors which cause the most damage to agricultural crops through the spread of plant virus are in the order Hemiptera, and include the aphids, leafhoppers, planthoppers and whiteflies.

The transmission can be:

Non-Persistent Transmission: The virus binds the stilet during feeding and is released when the insect secretes saliva on a new feeding place.

Semi-Persistent Transmission: The vector require a long time to acquire virus. The probability of transmission increases with feeding periods 12-24 hours. Once acquired, it retained for a longer period. Virus appears to accumulate in the anterior gut - possibly binding at specific protein site.

Circulative, non-propagative: The virus circulates up through the food canal and cross the midgut and hindgut reaching the haemocoeel. Then virus particles cross accessory salivary glands and return to the plant via the saliva canal.

Circulative, propagative: The virus circulates in the host as described above, but actually infects insect cells and replicates in the vector.

Aphids: Order: Hemiptera, Family: Aphididae

These are soft, delicate, pear-shaped, small insects. The characteristic features of an aphid are its pear-shaped, fairly long antennae, a pair of compound eyes, several jointed rostrum, two-segmented tarsi with paired claws, nine pairs of lateral spiracles and a pair of dorsi-lateral elongate siphunculi, sometimes known as cornicles, at the posterior end of the abdomen arising from the dorsal side of the fifth or sixth abdominal segment, that secrete a waxy fluid.

Viruses Transmitted by Aphids and their Transmission Characteristics
Whitefly : Order:Hemiptera, Family:Aleyrodidae
Whitefly has seven segmented antennae, two ocelli and pair of reniform compound eyes. Wings are equal consistency, opaque, whitish, clouded or mottled with spot or bands. Whiteflies are usually separated on the basis of characters of fourth instar larva or pupa.

Viruses Transmitted by Whitefly and their Transmission Characteristics

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Virus/Viroids</th>
<th>Vector</th>
<th>Mode of transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Curtovirus: Beet curly top virus</td>
<td>Circulifertenellus</td>
<td>Persistent</td>
</tr>
<tr>
<td>2</td>
<td>Filivirus: Sugarcane Fiji disease</td>
<td>Perkinsielasaccharicida</td>
<td>Persistent</td>
</tr>
<tr>
<td>3</td>
<td>Rice tungro virus</td>
<td>Nephotettixvirescens</td>
<td>Semi-persistent</td>
</tr>
<tr>
<td>4</td>
<td>Maize chlorotic dwarf virus</td>
<td>Graminellanigrifrons</td>
<td>Persistent</td>
</tr>
<tr>
<td>5</td>
<td>Sesame phyllody</td>
<td>OrosiusalbicinctusDist</td>
<td>Persistent</td>
</tr>
</tbody>
</table>

Beetles : Order:Coleoptera, Family: Chrysomelidae
Beetle are oval convex, brightly colored and 3.5-12mm long characterizing features of beetles is their forewing are called elytra. These are more or less hard. Beetles have biting type mouthparts.

Viruses Transmitted by beetles and their Transmission Characteristics

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Virus</th>
<th>Vector</th>
<th>Mode of transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bromovirus: Brommosaic virus</td>
<td>Ceratoma trifurcate</td>
<td>Semi-persistent</td>
</tr>
<tr>
<td>2</td>
<td>Comovirus: Cowpea mosaic virus</td>
<td>Oothecanmutabilis</td>
<td>Semi-persistent</td>
</tr>
<tr>
<td>3</td>
<td>Machlomovirus: Maize chlorotic mottle</td>
<td>Diabrotica Sp.</td>
<td>Semi-persistent</td>
</tr>
</tbody>
</table>
Thrips: Order: Thysanoptera, Family: Thripidae

Thrips are very small 1-2mm long, slender and difficult to recognize. A characteristics features of this insect is absence of the right mandible. The left mandible is elongated and pointed. The maxillary stylets are elongated. Thrips has a fringed wings are the typical morphological identification.

Mealybug: Order: Hemiptera, Family: Pseudococcidae

The bodies of these insects appear to be dusted by white powdery material. They are elongate oval shape with distinct segmentation. Antennae are present and legs are well developed. Mealy bug are not very efficient vector as they are not particularly mobile and rely on crawling to move from plant to plant.

Viruses Transmitted by Mealy bug and their Transmission Characteristics

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Virus</th>
<th>Vector</th>
<th>Mode of transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bandavirus: Commelina yellow mottle virus</td>
<td>Pseudococcus citri</td>
<td>Semi-persistent</td>
</tr>
<tr>
<td>2</td>
<td>Vitivirus: Grapevine virus A</td>
<td>Pseudococcus longispinus</td>
<td>Semi-persistent</td>
</tr>
<tr>
<td>3</td>
<td>Ampelovirus: Grapevine leafroll associated virus-3</td>
<td>Pseudococcus fructus, P. citri</td>
<td>Semi-persistent</td>
</tr>
</tbody>
</table>

7. PLANT PATHOLOGY

Mechanism of Fungicidal Resistance and Ways to Overcome the Fungicidal Resistance

Puja Pandey and Aravind T

Department of plant pathology, Anand Agricultural University, Anand, Gujarat - 388 110

Introduction:

Fungicidal Resistance: It refers to the heritable character of a fungus which renders it less susceptible to a fungicide. Fungicidal resistance became problematic with the introduction of the single-site mode of action fungicides. Since these fungicides target specific locations in genes or metabolic processes, single changes in fungal DNA sequences or structural changes of binding sites may cause these fungicides to lose their effectiveness. In the last decades, numerous cases of fungicide resistance have occurred world-wide, leading to losses of entire fungicide classes in several cases. For example, resistance of Venturia inequalis (causal agent of apple scab disease) against dodine was reported in the late 1960s. Similar reports on resistance of Pyrenophora avenae (leaf stripe disease of oats) against organomercurials, of Botrytis cinerea (grey mold of vegetables and fruits) against benzimidazoles, of Phytophthora infestans (Potato late blight) against phenylamides, etc were published in the following years.

Types of Fungicidal Resistance: Qualitative and quantitative resistance have been coined to differentiate mechanism of resistance.

1. Qualitative Resistance: Qualitative resistance is mutation based, which may be introduced by UV radiation and it is more important in case of wind borne non-pigmented spores such as conidia of powdery mildew fungi. If a gene encoding the target protein is mutated so that an amino acid required for binding of the fungicide is exchanged inhibition of fungicide no longer occur and fungicide
treatment fails even if applied in high amount. For example, resistance of *Phytophthora infestans* against phenylamides.

2. **Quantitative resistance**: This type of resistance is mediated by keeping the intracellular fungicide concentration low, which occurs due to synthesis of efflux transporter that secrete drug molecules to the extracellular space, modifications of plasma membranes causing reduced fungicides permeability or by synthesis of enzymes that degrade fungicide molecules or utilization of alternative metabolic pathways. Population will shift towards increased level of resistance because different mechanism conferring tolerance are active at different level.

**Mechanism of Fungicidal Resistance:**

1. Decreased permeability of pathogen cell membrane to the chemical.
2. Detoxification of the chemical through modification of its structure or through binding it to a cell constituent.
3. Decreased conversion to the real toxic compound in the target organism.
4. Decreased affinity at reaction site in the cell.
5. Bypassing a blocked reaction through shift in metabolism.
6. Compensation for the effect of inhibition by producing more of the inhibited products.

**Ways to overcome the fungicidal resistance**

1. **Do not use any one product or fungicides with similar mode of action exclusively**: It is important to rotate fungicides with different mode of action (MOA) in weekly or bi-weekly fungicide applications. Continually applying same fungicide or fungicides from a single fungicide class may increase selection pressure and decrease the time it takes for the resistant population to outnumber the sensitive population.

In this situation, tank-mixing or buying pre-mixed packages of fungicides with different MOA can be advantageous. For example, applying a fungicide that is potentially exhibiting resistance to the target pathogen along with a contact fungicide (multi-site MOA) or a fungicide with a separate MOA not thought to be resistant can help in managing resistance development.

2. **Need based application of fungicides**: The main factor that adjusts from season to season is environment. If environmental conditions were not conducive for disease to occur, the number of fungicide applications could be reduced; however, if conditions are similar to previous seasons when disease occurred, it would be better to manage the disease preventively with a fungicide rotation.

3. **Maintain recommended dose**: There is some debate on whether or not lower or split rates of fungicides can increase the frequency of resistant isolates. If the chemicals are applied below label rates, the fungicides may not manage the fungal population in the desired manner and increase the chance of resistance development due to continuous exposure to sub-lethal dose of the chemical.

4. **Avoid curative rates**: The fungicides capable of entering the plant are beneficial because of their effectiveness at low concentrations. For some pests, especially insects and nematodes, pesticides are not applied until a threshold is reached. Generally, curative rates of fungicides are higher, exposing resistant isolates to higher concentrations of the fungicide.

5. **Use integrated disease management strategy**: Integrated disease management refers to a harmonious integration of various disease management tools in order to keep the disease level below the threshold level. It involves the efficient and economical use of the cultural, mechanical, biological and the chemical management tactics to keep the disease to the minimum. It emphasize on using the fungicides and other pesticides as one of the components for disease management rather than relying fully on it. Thus it not only helps in reducing the use of the fungicides but also helps to enhance the efficiency of the applied fungicide.

**References**

isolates resistant to strobilurin-related QoI fungicides. Plant Dis. 87:1426-1432.

8. AGRICULTURE

National Agriculture Market (NAM) for Stakeholders: Need of the Hour

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Maharana Pratap University of Agriculture and Technology, Udaipur

INTRODUCTION: NAM is envisaged as a pan-India electronic trading portal which seeks to network the existing APMC and other market yards to create a unified national market for agricultural commodities. NAM is online platform with a physical market or mandi at the backend. It is not a parallel marketing structure but rather a device to create a national network of physical mandis which can be accessed online. It seeks to leverage the physical infrastructure of the mandis through an online trading portal, enabling buyers situated even outside the State to participate in trading at the local level.

The NAM Portal provides a single window service for all APMC related information and services. This includes commodity arrivals & prices, buy & sell trade offers, provision to respond to trade offers, among other services. While material flow (agriculture produce) continues to happen through mandis, an online market reduces transaction costs and information asymmetry.

NAM addresses these challenges by creating a unified market through online trading platform, both, at State and National level and promotes uniformity, streamlining of procedures across the integrated markets, removes information asymmetry between buyers and sellers and promotes real time price discovery, based on actual demand and supply, promotes transparency in auction process, and access to a nationwide market for the farmer, with prices commensurate with quality of his produce and online payment and availability of better quality produce and at more reasonable prices to the consumer.

Objectives of NAM:

1. A national e-market platform for transparent sale transactions and price discovery initially in regulated markets. Willing States to accordingly enact suitable provisions in their APMC Act for promotion of e-trading by their State Agricultural Marketing Board/APMC.
2. Liberal licensing of traders / buyers and commission agents by State authorities without any pre-condition of physical presence or possession of shop /premises in the market yard.
3. One license for a trader valid across all markets in the state.
4. Harmonisation of quality standards of agricultural produce and provision for assaying (quality testing) infrastructure in every market to enable informed bidding by buyers.
5. Single point levy of market fees, i.e. on the first wholesale purchase from the farmer.
6. Provision of Soil Testing Laboratories in/ or near the selected mandi to facilitate visiting farmers to access this facility in the mandi itself.
Stakeholders:
1. Farmers: NAM promises more options for selling produce and making competitive returns.
2. Traders: NAM provides access to a larger national market for secondary trading.

Advantages of NAM:
1. NAM promises more options for sale at his nearest mandi for the farmers.
2. It offers the opportunity to access a larger national market for secondary trading for the local trader in the mandi/market.
3. Bulk buyers, processors, exporters etc. benefit from being able to participate directly in trading at the local mandi level through the NAM platform, thereby reducing their intermediation costs.

The gradual integration of all the major mandis in the States into NAM will ensure common procedures for issue of licenses, levy of fee and movement of produce. In the near future we can expect significant benefits through higher returns to farmers, lower transaction costs to buyers and stable prices and availability to consumers. The NAM will also facilitate the emergence of integrated value chains in major agricultural commodities across the country and help to promote scientific storage and movement of agri-commodities.

Current status:
Trading of 69 Commodities namely apple, arhar/tur (red gram), bajra, barley, castor seed, chana whole (bengal gram), cotton, cumin, groundnut, guar seed, jowar, mahua flower, maize, masoor (lentil) whole, moong whole (green gram), mustard seed, onion, paddy, potato, red chilli(dry), shellings peas, soybean, sunflower seed, tamarind (with seed), tomatoes, turmeric, urd whole (black gram), wheat, rajma, ragi, lobia, basmati rice, kusum seed, sesame seed, pear, mandarin, sapota, musk melon, table grapes, litchi, pomegranate, banana, plum, peach, mango, orange, custard apple, watermelon, lemon, bottle gourd, bitter gourd, cucumber, brinjal, cabbage, cauliflower, green chillies, carrots, sweet potato, spinach (palak saag), mustard leaf (sarso saag), coriander leaves, garlic, lady finger, ginger, beetroot, ribbed celery, ajwain, coriander whole and jaggery or gud has been started in 250 mandis across 10 States. To facilitate assaying of commodities for trading on NAM, common tradable parameters have been developed for all the 69 commodities. So far, Ministry of Agriculture, Cooperation & Farmers’ Welfare, GOI has accorded in principle approval to the proposals of 12 States /UTs for integration of 365 mandis with e-NAM namely Himachal Pradesh (19 mandis) Haryana (54 mandis), Chandigarh (1 mandi), Rajasthan (25 mandis), Gujarat (40 mandis), Maharashtra (30 mandis), Madhya Pradesh (50 mandis), Chhattisgarh (5 mandis), Andhra Pradesh (12 mandis), Telangana (44 mandis), Jharkhand (19 mandis), and Uttar Pradesh (66 mandis).

NAM seeks to address the following challenges:
1. Fragmentation of state into multiple markets areas.
2. Poor quality of infrastructure and low use of technology.
3. Lowering intermediation costs and wastage of commodities, and
4. Builds on the strength of the local mandi and allows it to offer its produce at the national level.
Hydrogels’ Role in Retention of Nutrients and Water in Soil

Mukesh Kumar
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Introduction
Water stress is the key constraint for crop growth in arid and semi-arid regions, as the precipitation is low and uncertain in these areas. Efficient utilization of soil and water resources necessitates the adaptation of the appropriate water management techniques. In order to maintain water in the soil for longer period after an irrigation event, some additional materials such as organic matter, soil conditioners are added into the soil. Soil conditioners both natural and synthetic; contribute significantly to provide a reservoir of soil water to plant on demand in the upper layers of the soil where the root systems normally develop.

In recent years, crosslinked polymers with hydrophilic nature, known as hydrogels, have attracted much interest in this area as they can improve water and fertilizer retention in soil and thus increase plant growth (Zhang et al., 2006). Hydrogels absorb and store water hundreds of times their own weight, 400–1500 g water per dry gram of hydrogel (Bowman and Evans, 1991), performance being determined by the chemistry and formation conditions of hydrogel and the chemical composition of the soil solution or irrigation water.

Types of Hydrogel
Generally the commonly used hydrogels can be classified in two classes as natural polymers and synthetic polymers.

1. Natural Organic Matter or Polymers: Natural materials that are available in large quantities or certain waste products from industrial or agricultural operations, may have potential as inexpensive sorbents, thus several product including carbonaceous materials, agricultural by-products have been widely used. These include peat, wood, pine bark, banana pith, rice bran, soybean and cottonseed hulls, etc. these materials used for preparation or extraction of natural polymers such as agar, starches, alginates, pectins, cellulose derivatives, etc. they are environment friendly, biodegradable and independent of soil resources.

2. Synthetic Polymers
   a) Water soluble Polymers: They were the first ones to be developed, primarily to aggregate and stabilise soils, combat erosion and improve percolation. Examples include both homopolymers and copolymers such as poly (ethylene glycol), poly (vinyl alcohol), polyacrylates, polyacrylamide, poly (vinyl acetate-alt-maleic anhydride).
   b) Water insoluble Polymers: It is usually consist of polyacrylamides (PAM) and polyvinylalcohols. Fully synthetic polymers are chemically cross-linked to prevent them from dissolving in solution. The non-cross-linked PAM form is effectively used for soil erosion control, sediment reduction in surface waters and earthen canal bed stabilization.

Properties of Hydrogel
Hydrogel is defined as a lightly crosslinked three-dimensional polymer network, usually composed of ionic monomers, whose property of interest is the capacity of swelling in the presence of aqueous or biological fluids (Ullah et al., 2015). Regarding its crosslinking structure, it forms covalent bonds between the polymer networks resulting in a permanent state or physical crosslink in which polymer networks are bonded through intermolecular forces, such as ionic interactions, hydrogen bonds, or Van-der-walls forces. The cross-links between chains prevent endless swelling and thus the polymer doesn’t dissolve in water. The greater the degree of cross-linking, the lower the
swelling capacity becomes and the greater is the mechanical strength of the polymer. When the superabsorbent polymers come in contact with water, there is hydration of \( \text{C} = \text{OO}^- \) and \( \text{Na}^+ \) ions and the formation of hydrogen bonds or absorb water due to the presence of hydrophilic groups such as -OH, -CONH, -CONH\(_2\), -COOH, and -SO\(_3\)H along the polymer chain.

They are prepared from materials such as gelatin, polysaccharides, cross-linked polyacrylamide polymers, polyelectrolyte complexes, and polymers or copolymers derived from methacrylate esters.

**How Hydrogel Work?**

The effect of ionic strength on the absorption capacity is also relevant. At low ionic strengths, the concentration of bund charges within the hydrogel network exceeds the concentration of salt in external solution, a large ion-swelling pressure causes the hydrogel to expand, thereby lowering the concentration of ions within the hydrogel. As the external salt concentration rises, the difference between the internal and external ion concentration decreases and the hydrogel deswells. The hydrogel continues to deswell with increasing external salt concentration until the mobile-ion concentrations inside and outside are approximately equal.

**Importance of Hydrogel**

Soil water affects plant growth directly because it influences aeration, temperature, nutrient transport, uptake and transformation. There are many advantages of controlled-release materials such as regular and continuous nutrient supply to plants, lower frequency of applications in soil, reduced nutrient loss due to leaching, volatilization and immobilization, mitigation of root damage by high concentration of salts, greater convenience over handling fertilizers, contribution to the reduction of environmental pollution by \( \text{NO}_3^- \), and improved ecological health to agricultural activity and reduction in production costs (Azeem *et al.*, 2014).

**How to Use?**

Hydrogel application rate depends on various factors like water absorbing capacity of absorbent, crop type, irrigation method, soil type, climatic conditions, etc. Generally hydrogels having 400 to 600 times water absorbing capacity and used as per desired quantity with mixing of fine sand in a ratio 1: 10 and incorporate in upper 8-10 cm soil depth or preferably to the root zone. It is found more effective when it applies below the seed or mix with seed then sowing.

**Effect on Water and Nutrient use Efficiency**

The water and nutrient holding capacity of sandy and permeable soils, in particular, are extremely limited. These soil types are characterized by excessive drainage of water and plant nutrients leaching below the root zone. This leads to inefficient water and fertilizer use by crops. These conditions are intensified in shallow rooted crops or when irrigation water or irrigation systems are missing.

Hydrogels widely proposed for water scarce areas mostly in light textured soils for enhancement of the water-holding capacity, nutrient retention and as slow release fertilizers. Superabsorbent addition in soil improved water retention capacity of soil and delays permanent wilting percentage under intense evaporation, thus significantly reduce irrigation requirement of many crops. A larger surface area of nutrients offers greater chance for the plant roots to encounter zinc fertilizer (Shaver and Westfall, 2008). Hence, there is much need to explore some specific and efficient crop nutrient-based hydrogels nanocomposites to not only enhance the soil water retention capacity and porosity, but also to simultaneously improve the crop yield and productivity.

The following aptness of hydrogels makes it for better use in Agriculture:

1. Maximum equilibrium swelling in saline condition and variable pH range as well as temperature fluctuation.
2. Desired rate of absorption depending on the application requirement.
3. The lowest soluble content and residual monomer.
4. The highest durability and stability in the swelling environment and during the storage.
5. The highest biodegradability without formation of toxicity.
6. As agricultural point of view it should have re-wetting capability, so that hydrogel has to be able to give back the imbibed solution.
or to maintain it.

7. The material should be available on lowest or reasonable price.

References


10. HORTICULTURE

Adaptive Features of Arid and Semi-arid Fruits under Drought Conditions

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Drought is a major limiting factor for growth and development in higher plants. Drought is a common occurrence in dry environments, many perennial plant species have developed mechanisms to cope with a restricted water supply. Plants can avoid drought stress by maximizing water uptake (e.g., tapping ground water by deep roots) or minimizing water loss (e.g., stomata closure, small leaves).

Arid zone is characterized by extremes of temperature, low and erratic rainfall, high wind velocity, high evapotraspirational losses of water and light sandy soil with very poor water holding capacity and fertility status. Looking into the very dismal future scenario of water in arid zone, growing of less water-requiring crops with high water use efficiency is necessary.

Drought-hardy crops especially perennial fruits with deep root system are capable of surviving in extreme temperatures and provide income security and nutritional security. Ber, pomegranate, custard apple, aonla, karonda, kair, khejri and date palm are the major fruit crops which are commercially grown in arid regions. The native plant species have adaptations that are capable of growing, reproducing and surviving in semi-arid, arid and even desert regions. Plants are adapted to aridity by several mechanisms that are as under.

Ber

It is a perennial hardy fruit tree which gives income from multiple products such as fruits, fodder and fuel wood even in severe drought conditions to the resource lacking farmers. It is the only fruit crop which can give good returns even under rainfed conditions. It is possible due to following mechanisms.

1. It has deep & extensive root system to draw ground water from the deeper soil profile.
2. Leaves are xerophytic in nature and the buds are scaly due to which it stands in extreme summer heat without damage.
3. Leaf shedding mechanism in adverse condition either in summer or winter to conserve moisture. In those areas where leaf shedding is not effective, plants are pruned in summer (April-May) depending upon situation to reduce the water requirement by removing leaves.
4. Flowering in ber starts with onset of monsoon & character of this dryland fruit is that it sheds its leaves completely and thus conserves moisture by evading transpiration.
5. It has also some adaptive mechanisms to
cope up with dryland conditions through
a) Reducing in the cell and stomata size
b) Increased vascular bundles
c) Compact mesophyll cell arrangement
d) Low osmotic/water potential & low desiccation rate etc.

Aonla
It is hardy, prolific bearer and highly remunerative even without much care and can be grown in variable agro-climatic and soil conditions. Aonla bears flowering during spring, after fruit setting, fruits enter into dormancy and resume growth after onset of monsoon. Owing to such character, plants do not require irrigation during summer. Thus, it is the most ideal rainfed fruit crop.

Pomegranate
Pomegranate is an economically important commercial fruit crop of arid and semi-arid regions. It has xerophytic characteristics and hardy nature makes it suitable crop for dry, rainfed, pasture and undulating land, where other fruit crops cannot grow successfully. Pomegranate crop synchronizes with its reproductive cycle with maximum moisture availability period. However, it bears fruits during **mrig bahar** coinciding with rainy season can be encouraged if few irrigations are available.

Custard apple
It is also hardy fruit crop and tolerates drought conditions. It can be grown on shallow soils. Its flowering habit and fruit development coincide with maximum moisture availability period i.e. flowering in June-July and harvesting in September-October. Custard apple also sheds its leaves in summer to escape moisture loss from plant tissue through transpiration. Custard apple also remains dormant for a short period during cold season. This is most ideal rainfed crop completing reproductive cycle during the period of moisture availability.

Tamarind
Tamarind is one of the most important rainfed fruit crops & has deep root system. It can tolerate scorchy wind. It bears flowers with onset of monsoon and its fruits are harvested during February. It is drought resistant and tolerates temperature up to 45°C. It can also be grown slight alkali and saline soils. Leaves are small which help in reducing transpiration & it sheds its leaves under certain conditions during summer.

Wood apple
It has tap root system and possesses great tolerance to drought and salinity. The reproductive phases of wood apple synchronise with high moisture availability. Reduction in number & size of leaves and dense attachment of aerial shoot are also adaptive mechanisms found in wood apple. Owing to such features, it is suitable crop for rainfed areas. It is also an excellent tree for waste lands.

Karonda
Karonda is an evergreen spiny shrub or a small tree up to 3 m height and suitable for arid tropics and sub-tropics. It grows successfully on marginal and wastelands. The plant is also useful for making attractive thorny dense hedge around any fruit orchard. Its main flowering season is March–April with fruits maturing during August–September which enables the plants to make best use of monsoon rain.

Bael
Bael is an indigenous hardy fruit crop and can be grown successfully in dry areas. It is well known for its nutritional and therapeutic properties. The marmelosin content of fruit is known as the panacea of the stomach ailments. Its flowering coincides with onset of monsoon and the fruits of bael mature before advancement of hot summer.

Fig
It can tolerate salinity and drought. Fruiting in fig synchronises with rainy season and the fruits are harvested in late winter. It has also some adaptive mechanisms to cope with dryland conditions through
1. Water binding mechanism
2. Shedding leaves during summer etc.

Date palm
Date palm can tolerate salinity and saline irrigation water to a great extent. For successful fruit maturation, nearly 3000° days heat unit are required. The heat units available in most of
the north-western districts of India, counted from the time of flowering, i.e. end February to July, indicate that these are suitable for date palm cultivation.

**Jamun**

Jamun is successfully grown under tropical and subtropical climate. It tolerates drought conditions due to having extensive root system. It requires dry weather at the time of flowering and fruiting. Flowering starts in spring season and fruits are available in June-July after onset of monsoon. For ripening of fruit and proper development of its size, color and taste, early rains are considered very beneficial.

In addition to these, there are many indigenous drought, hardy plants which have some adaptive mechanisms. Kair has scanty foliage and mucilaginous sap in plant bodies which holds water and does not loose in summer. As Indian cherry, locally known as lasoda is another important fruit plant suitable for arid and semi-arid regions of India. Its fruits and other parts have multiple uses in human health and nutrition. This plant also offers scope in using harvested rain water for fruit production since it requires irrigation only for 2–3 months period during summer season (April–June). Phalsa has ability to complete the life cycle during the period when there is no rainfall due to xerophytic characters like wax coating and closed stomata on leaves to reduce the loss of water through transpiration. It also bears flowering in month of January and fruiting in summer season.

**Conclusion**

The arid and semi-arid fruits are hardy in nature. They can grow well in dry areas and can tolerate drought conditions due to adaptive characters like deep & extensive root system, shedding of leaves during summer season. Mostly, these crops have reproductive phase synchronising with moisture availability during drought condition. These are source of the sustainability of small holdings of dry areas, also provide nutritional security and have high potentials to develop wastelands widely available in the region. Therefore, these may be ideal crops for drought condition of arid and semi-arid regions.

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**11. FOOD SCIENCE**

**Bioremediation**

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Bioremediation is defined as the process by which microorganisms are stimulated to rapidly degrade hazardous organic pollutants to environmentally safe levels below concentration limits established by regulatory authorities in soils, sediments, substances, materials and ground water. Bioremediation uses biological agents, mainly microorganisms i.e. yeast, fungi or bacteria to clean up contaminated soil and water. Bioremediation process involves biotransformation and biodegradation by transforming contaminants to non–hazardous or less hazardous chemicals. Biotransformation is any alteration of the molecule or structure of a compound by micro-organisms. Biodegradation is the breaking down of organic or bioaccumulation and biotransformation of inorganic compounds into environmental friendly compounds.

This technology relies on promoting the growth of specific microflora or microbial consortia that are indigenous to the contaminated sites that are able to perform desired activities (Agarwal, 1998). Establishment of such microbial consortia can be done in several ways e.g. by promoting growth through addition of nutrients, by adding terminal electron acceptor or by controlling moisture and temperature conditions (Agarwal, 1998). In bioremediation processes, microorganisms use the contaminants as nutrient or energy sources (Tang et al., 2007).

Recently, biological remediation process have also been devised to either precipitate...
effectively immobilize inorganic pollutants such as heavy metals. Stimulation of microorganisms is achieved by the addition of growth substances, nutrients, terminal electron acceptor/donors or some combination thereby resulting in an increase in organic pollutant degradation and bio-transformation. The energy and carbon are obtained through the metabolism of organic compounds by the microbes involved in bioremediation processes (Fulekar et al., 2009).

**Bioremediation Organisms**

Microorganisms that carry out biodegradation in many different environments are identified as active members of microbial consortiums. These microorganisms include: *Acinethobacter, Actinobacter, Acaligenes, Arthrobacter, Bacillus, Berijerinckia, Flavobacterium, Methylosinus, Mycobacterium, Mycococcus, Nitrosomonas, Nocardia, Penicillium, Phanerochaete, Pseudomonas, Rhizoctonia, Serratia, Trametes and Xanthofacter*.

Complete mineralization results in a sequential degradation by a consortium of microorganisms and involves synergism and cometabolism actions. Natural communities of microorganisms in various habitats have an amazing physiological versatility, they are able to metabolize and often mineralize an enormous number of organic molecules.

**Factors of Bioremediation**

The control and optimization of bioremediation processes is a complex system of many factors. These factors include:

1. The existence of a microbial population capable of degrading the pollutants
2. The availability of contaminants to the microbial population
3. The environment factors (Type of soil, Soil temperature and soil pH, the presence of oxygen or other electron acceptors and nutrients).

**Basic types of Bioremediation Techniques**

1. **Biostimulation**: Biostimulation provides nutrients and suitable physiological conditions for the growth of the indigenous microbial populations. This promotes increased metabolic activity, which then degrades the contaminants.
2. **Bioaugmentation**: Bioaugmentation means introduction of specific blends of laboratory-cultivated microorganisms into a contaminated environment or into a bioreactor to initiate the bioremediation process.

**Advantages of Bioremediation**

1. Bioremediation techniques are typically more economical than traditional methods such as incineration that are used for clean-up of hazardous waste. When compared to standard practices, effluent volumes generated by bioremediation are substantially smaller reducing the problem of sludge disposal. Additionally, since bioremediation is based on natural processes, the public considers it more acceptable and ‘green’ than other technologies.
2. Bioremediation also requires a very less effort and can often be carried out on site, often without causing a major disruption of normal activities. This also eliminates the need to transport quantities of waste off site and the potential threats to human health and the environment that can arise during transportation.
3. It is helps in complete destruction of the hazardous compounds and transformed to harmless products and this feature also eliminates the chance of future liability associated with treatment and disposal of contaminated material.
4. It does not use any dangerous chemicals. The nutrients added to make microbes grow are fertilizers commonly used on lawns and gardens. Because bioremediation changes the harmful chemicals into water and harmless gases, the harmful chemicals are completely destroyed.

**Limitations of Bioremediation**

1. Bioremediation is limited to those compounds that are biodegradable. Not all compounds are susceptible to rapid and complete degradation. Some contaminants, such as chlorinated organic or high aromatic hydrocarbons, are resistant to microbial attack.
2. It is difficult to extrapolate from bench and
pilot-scale studies to full-scale field operations. Research is needed to develop and engineer bioremediation technologies that appropriate for sites with complex mixtures of contaminants that are not evenly dispersed in the environment. Contaminants may be present as solids, liquids and gases.

3. Bioremediation often takes longer than other treatment options, such as excavation and removal of soil or incineration.

4. Regulatory uncertainty remains regarding acceptable performance criteria for bioremediation. There is no accepted definition of “clean”, evaluating performance of bioremediation is difficult.

References

12. MICROBIOLOGY
Microbial Oil: A Sustainable Fuel for Future
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Globally, fossil fuel resources are not observed as sustainable in ecological and environmental aspect. Till now, 90% of the energy carriers used is of fossil origin and their use is connected with the release of carbon dioxide to the atmosphere. The global CO$_2$ release from fossil fuel usage is now approximately 7 Gt of carbon per year and the atmospheric CO$_2$ concentration is 400 parts per million (ppm). If the current trend escalates, the CO$_2$ release rate is likely to double by 2050 (Pacala and Socolow, 2004). Evidently, the utilization of fossil fuels for electricity and heat production and for transportation alone accounts for 25% and 14% of the total greenhouse gas emissions, respectively (IPCC, 2014). Therefore, nowadays, world highest demand is production of economically feasible and eco-friendly renewable energy fuel.

Renewable energy is the energy coming from natural sources like wind, light, air, tide and biomass (Jacobson and Delucchi, 2011). Among the renewable energy sources biofuels are one of the promising options in the transport sector. It is estimated that by 2050, biofuels could provide 27% of total transport fuel and contribute in particular to the replacement of diesel, kerosene and jet fuel. This projected use of biofuels can avoid around 2.1 gigatonnes (Gt) of CO$_2$ emissions per year when produced sustainably (IEA, 2010). There are various types of biofuels available such as solid biomass, liquid fuels (bioethanol and biodiesel) and biogases (methane and hydrogen) (Fang et al., 2008; Fedosov et al., 2011).

Biodiesel is an alternative, clean renewable fuel with properties similar to conventional diesel produced mainly from several renewable resources such as dedicated energy crops from food and non-food origin, lignocellulosic biomass, biodegradable waste and microbial cultivation. Dependent on the origin of the oily feedstock, it is referred to as 1st generation, 2nd generation, or meantime 3rd generation biodiesel (Atabani et al., 2012). While 1st generation biodiesel uses plant oils such as rapeseed 84%, sunflower (13%), palm oil (1%), soyabean and others (2%), 2nd generation biodiesel is derived from, lignocellulosic biomass that underlies biological or thermochemical processing thus increasing the land use efficiency. Nevertheless, both approaches amplify the highly discussed competition with food production either due to the direct use of edible crops for energetic purposes thus causing worldwide rising commodity prices or because of shifting high-quality agricultural land away from food production to the cultivation of crops for energy production (OECD-FAO, Agricultural Outlook 2015-2024). Biodiesel production of the 3rd
generation tries to overcome this conflict by using fatty acids produced by oleaginous microorganisms for the transesterification into the fatty acid methyl or ethyl esterase (FAME/FAEE).

Oleaginous microorganisms are defined as microorganism with the content of microbial lipid excess of 20% which include different types of yeast, molds, and algae. Biodiesel production using microbial lipids, which is named as single cell oils (SCO), has attracted great attention in the whole world (Liao et al., 2016). In particular because of the metabolic diversity of different microorganisms that enables the production of biofuels from various substrates. For example, most of the bacteria can easily convert sugars into ethanol and cellulolytic microbes can utilize plant-driven substrates. Cyanobacteria and microalgae possess the potential to photosynthetically reduce the atmospheric CO2 into biofuels, and methanotrophs can use methane to produce methanol (Liao et al., 2016). The microbes producing various biofuel were listed in Table 1. The advantage of microbial oil over oil derived from other renewable sources includes 1. Higher production rate (100 fold/ha/year) 2. Non-seasonal based 3. Year-around production 4 no-depend on agricultural land. 5. Easy recovery process 6. Metabolic diversity. In conclusion, microbial oil has been proposed as a key element in future transportation fuel and can overcome the socio-economic disadvantages of current biodiesel technology and be able to address many of the challenges of climate change and the energy crisis.

Table 1. List of microorganisms producing biofuels or the precursors for biofuel production.

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Biofuel</th>
<th>Microorganism</th>
<th>Biofuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudomonas putida</td>
<td>Butanol</td>
<td>Yarrowia lipolytica</td>
<td>Fatty acids</td>
</tr>
<tr>
<td>Cryptococcus vishniacii</td>
<td>Lipids</td>
<td>Synechococcus sp.</td>
<td>Limonene, 1, 3-propanediol</td>
</tr>
</tbody>
</table>

References
In this era of highly mechanised farming, agricultural production depends on energy, primarily fossil fuels. The use of energy, directly and indirectly, for agriculture has been the traditional practice. Over the years agriculture used energy directly in the form of diesel, gasoline, liquefied petroleum (LP) gas, natural gas, and electricity fuel and indirectly through use of energy-intensive inputs, such as fertilizers and pesticides (Beckman, 2013). Besides fertilizer production, industrial agriculture consumes fossil fuels for water consumption, farm equipment, processing, packaging and transportation. The price of oil rose 262% and energy prices became much higher and more volatile during 2001-2012. Farmers have expanded the agricultural production (Corn production increased 13% from 2001 to 2012). On the other hand, the prices of all field crops increased by almost 40%. Report says the usage of energy in the agriculture sectors has remained constant or decreased during 2001-2011 (2).

Dependence on energy throughout the food chain raises concerns about the impact of high or volatile energy prices on the price of food, as well as about domestic food security and the Nation’s reliance on imported energy. Use of energy in the food chain could also have environmental impacts, such as through carbon dioxide emissions (3). However, direct and indirect energy inputs are critical to agricultural production. Higher and unstable energy prices can make agriculture unprofitable. As a result, agriculture may have to find ways to become more energy independent (4). The future of our agriculture will depend on more energy efficient practices, as fossil fuel is going to be limited in the near future.

The dominant energy source used in agriculture is solar energy as crops use it for photosynthesis, accounting for about 90% or more total energy inputs. Crops generally use this energy very inefficiently and very less successful improvement in the photosynthetic abilities of crops are made through genetic improvement (5).

Adoption of precision technology is one way to increase proficiency in agriculture. Precision agriculture uses information gathered during field operations, from planting to harvest, to calibrate the timing and location for applying inputs and economize on fuel and fertilizer use. Another way farmers can protect themselves against high and volatile energy prices while maintaining the environmental aesthetics is through the adoption of on-farm renewable energy systems such as wind, solar and methane digester. In third world countries, farmers are poor and they will not have enough money to afford mechanised farming due to high cost of fuel in future. In such areas, we have to use some low-cost energy for farming. Among the most obvious solutions is to simply improve the energy efficiency of food production and distribution. This can be accomplished by shifting from energy-intensive industrial agricultural techniques to less intensive methods (e.g., pasture-raised livestock, drip irrigation, non-synthetic fertilizers, no-till crop management, etc.), using more efficient machinery and equipment, reducing food processing and packaging, promoting decentralization of food production and improving the efficiency of food transportation (6).

References
Agriculture’s supply and demand for energy and energy products (USDA, 2013)
Soybean is the crop originated in China and known as a miracle crop having 40% protein and 20% oil. The crop is also known as "Golden Bean" as it gives edible oil and other nutritious health benefits. The crop provides high quality protein but only minimal saturated fat. These factors alone would earn soya foods a bigger place in western diets. The major producer countries of soybean are US, Brazil, Argentina, China and India. In India, Madhya Pradesh and Maharashtra are the largest producers of soybean in the country accounting for nearly 90% of the domestic production. However, the extraction industry in India is concentrated mainly in the State of Madhya Pradesh. It has been reported that more than 90 per cent of soya cake/meal comes from this State.

Nutritive Value of Soybean (per 100 gram)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>8.5 g</td>
</tr>
<tr>
<td>Potassium</td>
<td>1797 mg</td>
</tr>
<tr>
<td>Energy (416 kcal)</td>
<td>Sodium 2 mg</td>
</tr>
<tr>
<td>Energy (1741 kJ)</td>
<td>Zinc, Zn 4.9 mg</td>
</tr>
<tr>
<td>Protein</td>
<td>36.5 g</td>
</tr>
<tr>
<td>Fat (total lipid)</td>
<td>Copper 1.7 mg</td>
</tr>
<tr>
<td>Fatty acids, saturated</td>
<td>2.9 g Selenium 17.8 mg</td>
</tr>
<tr>
<td>Fatty acids, mono-unsaturated</td>
<td>4.4 g Vitamin C 6 mg</td>
</tr>
<tr>
<td>Fatty acids, poly-unsaturated</td>
<td>11.3 g Thiamin 0.87 mg</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>30.2 g</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.87 mg</td>
</tr>
<tr>
<td>Fiber</td>
<td>9.3 g</td>
</tr>
<tr>
<td>Niacin</td>
<td>1.62 mg</td>
</tr>
<tr>
<td>Ash</td>
<td>4.9 g</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>Vitamin B6 0.36 mg</td>
</tr>
<tr>
<td>Isoflavones</td>
<td>200 mg</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>0.36 mg</td>
</tr>
<tr>
<td>Calcium</td>
<td>277 mg</td>
</tr>
<tr>
<td>Folic Acid</td>
<td>375 µg</td>
</tr>
<tr>
<td>Iron Fe</td>
<td>15.7 mg</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>0 µg</td>
</tr>
<tr>
<td>Magnesium</td>
<td>280 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>2.0 µg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>704 mg</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>1.95 mg</td>
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</tbody>
</table>

Soybean Products

Soybean is a rich source of protein has applications in food as well as non food sector. In India, out of total production of soybean, 5% is used for food and feed, 10% for seed and 5% for oil extraction. In food category, Soya is used in bakery, meat, breakfast cereals, beverages and dairy segment, while soy candle and soy oil cake/meal, biodiesel come under non food category. The products like soy milk, soy paneer (tōfu), soy flour, soy nuts and soy oil are in great demand now-a-days and are easily available in the market.

1. **Soy meal:** Soy meal is the world's most important vegetable protein feed source accounting for nearly 65% of World protein feed demand. It is a product obtained after oil extraction from soy bean. About 98 percent of soy meal is used as an animal feed ingredient, with the remainder used in human foods such as bakery ingredients and meat substitutes. Soybean meal is considered a premium product because of its high digestibility, high energy content and consistency.

2. **Soybean oil:** Soybean oil is extracted through refining process and known as most traded edible oil in the international market after palm oil. About 97 percent of soybean oil is used in a wide range of products for human use, such as cooking oil, salad dressing, sandwich spreads, margarine, salad oils, coffee creamer, mayonnaise, shortenings, chocolate coatings, and a flour ingredient medicine. While in industry the oil is mainly used in manufacturing industrial products as printing inks, cosmetics, vinyl plastics paints, pesticides, glue, protective coatings, yeast, soaps, detergents and rubber.

3. **Soy flour:** This is another potential product from soybean which has the...
advantages of controlling blood pressure, cholesterol level, various kinds of cancers; it also helps in boosting immunity, curing gynecological problems and in weight reduction. Soy flour is widely used in meat products, cereals; ready to eat products, food, drink, high protein soups, protein concentrates, special diet food, food additives, bakery and confectionary products etc.

4. **Soy milk:** Soy milk is a water extract of soy bean and has nutritional benefits comparable to cow's milk. The nutritional components are more or less similar to cow milk as it doesn’t contain cholesterol and lactose. The limiting factor of marketing the soy milk is its odd flavor but which can be controlled by adding certain additives or even mixing soy milk with other compatible juices.

5. **Soya tofu:** Soya tofu is also one of the potential and profitable products obtained from soy bean. It appears like the paneer obtained from normal milk. It contains less fat and more proteins therefore, more popular in health conscious segment.

6. **Soy candle:** It proved to be a cheaper alternative to bee wax. Soy candle is prepared from Soy wax, which is hydrogenated soy oil. Soy wax is mixed with various fragrances to prepare scented soy candles. Soya candles are much more economically and environmentally friendly than paraffin wax candles.

7. **Future thrusts:** Indian processing industry is growing at a faster pace. Many Indian food as well non food products have great demand at international market. Soybean can be taken as commercially viable option in processing with respect to food as well as nonfood areas. Being relatively newer in processed, it holds equally good potential in research field. There is a great scope to innovate or manufacture new types of products which can be targeted against different demographic segments within the population and this will surely generate a good demand from the market.

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**15. AGRICULTURAL ENTOMOLOGY**

**Papaya Mealybug and its Management Strategies**

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The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) is a small polyphagous sucking insect pest attacking economically important fruits, vegetables and ornamentals. Mealybug’s infestation appear like a cotton mass on the above ground portion of plants with waxy filaments. Both nymphs and adults suck the sap from different parts of the plant and weakens it. The leaves become crinkled, yellow and wither. Lot of honey dew excreted by bugs leads to sooty mould development and impairs photosynthetic efficiency.

First report of papaya mealybug from India from Coimbatore in 2007, by 2009 it has assumed the major pest status and caused huge losses to agri-horticultural crops from south India.

**Morphology**

- The adult female is yellow, approximately 2.2 mm long and 1.4 mm wide and is covered with a white waxy coating.
- A series of short waxy caudal filaments, less than 1/4th the length of the body exists around the margin.
- Adult males are pink, especially during the pre-pupal and pupal stages, but appear yellow in the first and second instars.
- Adult males are approximately 1.0 mm long, with an elongate oval body that is widest at the thorax (0.3 mm).
- Adult males have ten-segmented antennae, a distinct aedeagus, lateral pore clusters, a heavily sclerotized thorax and head, and well-developed wings.
- Two characteristics that are important in
distinguishing *P. marginatus* adult females from all other species of Paracoccus are: the presence of oral-rim tubular ducts dorsally restricted to marginal areas of the body, and the absence of pores on the hind tibiae.

- The female papaya mealybug can easily be identified by the presence of eight antennal segments, in contrast to nine in pink hibiscus mealybug, *Maconellicoccus hirsutus*.
- Ovisac is three to four times the body length and develops ventrally beneath the body of the female.
- When pressed, the body fluid of yellow colour comes out.
- Host plants: papaya, pigeon pea, cotton, jatropha, mulberry, guava, tomato, teak, wild mustard etc

**Biology**

Papaya mealybugs are most active in warm, dry weather.

Life cycle includes 24-26 days in females and 27-30 days in male @25°C and 65% Relative humidity. Females usually lay 100 to 600 eggs. Eggs are usually greenish yellow and are laid in an ovisac sac that is three to four times the body length and entirely covered with white wax. The ovisac is developed ventrally on the adult female. Hatching takes from one to two weak and crawlers start search for feeding sites. Adult males can be distinguished from other related species by the presence of stout fleshy setae on the antennae and the absence of fleshy setae on the legs. Females have 3 instars whereas males have 4 instars.

**Management strategies**

Ants which are attending honeydew play an important role in protection of pest from predators. Therefore, management of mealybugs often includes the control of ant species.

For management of mealybugs, it is important to know the species present as management programs for the various mealybugs may differ. Plant protection products are of limited effectiveness against mealybugs because of the presence of waxy covering of its body. Management of mealybug involves the following tactics:

**Cultural and Mechanical**

1. Monitoring and scouting to detect early presence of the mealybug
2. Pruning of infested branches and burning them
3. Removal and burning of crop residues
4. Removal of weeds/alternate host plants like Hibiscus, Parthenium etc. in and nearby crop
5. Avoiding the movement of planting material from infested areas to other areas
6. Avoiding flood irrigation
7. Prevention of the movement of ants and destruction of already existing ant colonies
8. Sanitization of farm equipment before moving it to the uninfested crop
9. Application of sticky bands or alkathene sheet or a band of insecticide on arms or on main stem to prevent movement of crawlers
10. Preventive: In tapioca, stems are stocked for propagative purpose in the farms. These planting materials often carry mealybug infestation, if the previous year’s crop was already infested. Generally, before planting, setts, in parts, are soaked for 1 hr in dichlorvos (76%EC; @10 ml/litre of water) to disinfect the mealybugs

**Biological control**

1. Conservation of natural enemies like ladybird beetles, lacewings, hoverflies and certain hymenopteran and dipteran species play a important role in reducing the mealy bug population
2. *Spalgius epius*: Lycanied predator of lepidoptera feed on ovisacs in their first instar.
3. Release of *Cryptolaemusmountrouzieri* @ 10 adults/tree or 5000 adults/ha
4. Release of exotic parasitoids like *Anagyrusloecki* Noyes and Menazes, *Acerophaguspapayae* Noyes and Schauff and *Pseudoleptomastrixmexicana* Noyes and Schauff (Hymenoptera: Encyrtidae) were given 95% to 100% control in south India.

**Chemical control**

1. Locate ant colonies and destroy them with drenching of chlorpyriphos 20 EC @ 2.0 ml/litre of water.
2. Regular monitoring of the crop for mealybug infestation and its natural enemies
3. Spot application of insecticide immediately after noticing mealybug on some plants in the crop field.
4. If the activities of natural enemies are not observed, use of botanical insecticides such as neem oil (1 to 2%), NSKE (5%), or Fish Oil Rosin Soap (25g/litre of water) should be the first choice.
5. Chemical control is only partially effective and requires multiple applications and their application should be judiciously
6. Apply recommended chemical insecticides as the last resort such as profenophos 50 EC (2 ml/litre), chlorpyriphos 20 EC (2ml/litre), buprofezin 25 EC (2 ml/litre), dimethoate 30 EC (2 ml/litre), thiomethoxam 25 WG (0.6 g/litre), imidacloprid 17.8 SL (0.6 ml/litre)
7. Spray profenophos @ 2 ml/litre on stumps immediately after pruning in mulberry followed by second spray, 15 days after pruning, with dichlorvos @ 2 ml/litre along with azadirachtin (10000 ppm) @ 1 ml/litre. Stickers should always be added in spray solutions.
8. Avoid repeating the use of the same chemical insecticide as there are chances for development of resistance in the pest.
9. Drenching soil with chlorpyriphos around the collar region of the plant to prevent movement of crawlers of mealybug and ant activity is useful.
10. Insecticide resistance and non-target effects on natural enemies make chemical control a less desirable control option.

**References**

Papaya mealybug and its management: Published by Directorate of Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore 641003.


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**16. ENTOMOLOGY**

### Maggot Therapy: An Alternate Way for Wound Healing

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Maggot therapy is the intentional introduction of live, disinfected fly larvae into non-healing or dead skin and soft tissue wounds of a human or other animal for the purpose of selectively cleaning out only the necrotic tissue within a wound in order to promote wound healing. It is also used to prevent infection and to speed the healing process.

Maggots have been used for wound healing in Folk Medicine by the aborigines and Mayan Indians for thousands of years. Maggots for cleaning wounds also occurred in the Napoleonic and American Civil Wars. However, maggot therapy only obtained wider recognition for treating infected wounds after its introduction into USA hospitals in the 1920s by Professor William Baer at John Hopkins University. The larvae of the blowfly, *Lucilia sericata*, are frequently used although other species have also been tried such as *Lucia cuprina*, *Phormia regina* and *Calliphora vicina*.

The use of *L. sericata* larvae for treating wounds has been recognized by the U.S. Food
and Drug Administration and the UK Prescription Pricing Authority. Sterile maggots can therefore be officially prescribed.

Maggot therapy can be divided into 3 processes:

1. Debridement of wounds; 2. Wound healing; 3. Disinfection of wounds.

Debridement of Wounds
Once maggots are applied to the wound then debridement or cleaning and removal of necrotic tissue and debris occur so that granulation and healing can begin. Maggots clean wounds by the extracorporeal production of enzymes that digest the debris which the maggots then feed upon. Initially, the main enzymes identified in the maggot excretions/secretion (ES) were chymotrypsin and trypsin-like serine proteases, an aspartyl proteinase and a metalloproteinase. The secretion of ammonia by the maggots increases the pH to activate the serine proteases. The most active enzymes are produced by first instar larvae.

Wound Healing
There is no doubt about the benefits of maggots in debriding chronic wounds but the outcome of clinical trials on their use in wound healing is more uncertain. The ES enzymes or other constituents have been shown to activate the fibroblasts and evidence is accumulating for an active role for ES in wound healing. Thus, specific amino acids derivatives and fatty acids extracts from L. sericata ES induce mitosis in human endothelial cells and activate angiogenesis and wound healing.

In addition, there is accumulating evidence that ES have an immunomodulatory role in the wound healing process and this has been reviewed in detail previously. In particular, neutrophils, macrophages, lymphocytes, and the complement system respond to exposure to the MS. With neutrophils, the ES inhibit elastase, the respiratory burst, hydrogen peroxide production, and migration of these cells. Elastase breaks down the extracellular matrix and delays epithelial repair, while oxygen radicals would probably have a similar effect. Concomitantly, the inhibition of neutrophil migration would help resolve the prolonged inflammatory response, to which they contribute, present in a chronic wound. Macrophages are similarly affected by the ES and show reduced migration and inhibited production of proinflammatory cytokines such as migration inhibitory factor and TNF-α. At the same time, the production of the anti-inflammatory cytokine IL-10 is increased so that the ES appear to be reducing the inflammatory response. In addition, in the presence of ES, macrophages develop into anti-inflammatory rather than proinflammatory forms. The anti-inflammatory macrophages suppress inflammation and secrete basic fibroblast growth factor (bFGF) and vascular endothelial growth factor (VEGF) which mediate mitosis and migration of endothelial cells resulting in angiogenesis and eventual healing of wounds. Recently, these results were confirmed by applying ES to acute skin wounds made in rats since levels of the acute inflammatory cytokines, TNF-α and IL-6, remained significantly lower than in the rats with untreated wounds. Lymphocytes activation too is inhibited by the ES so that the wound site would be protected from the induction of an adaptive response to the maggot proteins.

Disinfection of Wounds
There is good evidence that ES can kill bacteria infecting wounds, including antibiotic-resistant strains such as MRSA. There are reports of many different antibacterial factors in dipterans, including a range of AMPs such as Sarcotoxin 1A, a cecropin-like molecule from the flesh fly Sarcophaga peregrine, which is more active against Gram-negative bacteria than Gram-positive forms. However, focus is now on calliphorid flies used in wound healing in which one AMP, lucifensin has received particular attention recently as it is active against clinically relevant bacteria such as Streptococcus species. Most of the other antibacterial factors described from calliphorids are <1300 Da in size although Altincicek and Vilcinskas and Andersen et al. have shown that L. sericata has 65 immune-inducible genes including lysozyme- and transferrin-like genes and 3 proline-rich AMPs.

Conclusion
Since, the maggot therapy having great potential in healing of foot and leg ulcers in diabetic patients, future studies also must address the
cost-effectiveness of maggot therapy.

References

17. HORTICULTURE

Alarming Diseases and Physiological Disorders of Rose
Nellipalli Vinod Kumar* and Priyaranjan Koley
Ph.D. Scholar, Bidhan Chandra Krishi Vishwavidyalaya, West Bengal.

Diseases of Rose- Rose is one of the commercially grown flowers in India and all over the world. But the commercial value of Rose is decreasing because of some devastating diseases and physiological disorders which are discussed in this article along with their management practices. Important diseases and physiological disorders are discussed in this article.

Dieback: Diplodiarosarum

Symptoms- Older plants are more prone to disease. Infection enters from wounds caused especially during pruning. Infection rapidly spreads down resulting in drying of stems from top to bottom. Browning and rotting of inner stem portions and death of the complete plants.

Epidemiology- Hot humid days. External wounds caused by mechanical means or insect attack (Digger wasp). Plants already attacked by spot disease where the leaf fall is noticed. Improper use of fertilizers. Poor drainage, lack of sunlight and continuous attack by scale insects and red spider mites.

Control measures- Prevention is by avoiding injury to the stem. Slant cut during pruning to prevent water retention on cut surface. Removal of the infected portions and application of Bordeaux mixture on the cut ends. Avoid digger wasp damage by using insecticides at regular intervals (or) Mix B.H.C in the Bordeaux mixture. Alternatively, apply a mixture of 4 parts of Copper Carbonate, 4 Parts of Red lead and 5 parts of linseed oil on the cut end. Preventive dusting of Plants with sulfur dust at 10 days interval during favorable weather conditions.

Black Spot of Roses- Diplocarponrosae

Symptoms- Very serious disease of rose plants characterized by nearly circular black spots on leaves. The spots are distinguished from other leaf spot diseases by the fringed margins and consistently black color of the spots. The spots vary in size from less than 1/16 to 1/2 inch or more in diameter. Spots may merge to produce large irregular lesions. Yellowing often occurs over the entire leaf, but it may develop only around the spots. When plants are badly infected, leaves drop prematurely and canes may become completely defoliated, thereby reducing the quantity of the flowers and eventually killing the plant. Warm, wet weather favors the spread of pathogens. Spores of the fungus are spread mainly by splashing water or rain. They germinate in water and infection takes place only when water remains on the leaves for periods of six hours or longer.

Management- Remove and destroy infected leaves during the season; remove infected twigs when pruning. Avoid overhead watering. Plant roses in an area with good soil drainage and ventilation. Avoid shady spots in dense plantings. Prune out old and diseased canes in the fall or winter. Mulch soil around plants and sprinkle dusting sulphur on the mulch during the spring. During the dormant season, spray with lime sulphur. Sprays may be omitted during hot, dry periods in the summer.

Powdery Mildew (Sphaerotheca capannosa var. rosea)

Powdery mildew is one of the most widely distributed and common disease of roses.

Unlike many foliar diseases, it may be
Serious in dry climates as well as in humid regions.

**Epidemiology-** Generally, the most favourable conditions for powdery mildew infection. Daytime temperature near 27°C and
b) Relative humidity of 97-100%. Temperatures above 90°F and the presence of free moisture will inhibit spore germination. Air movement is important in dispersal of primary and secondary spores. Closely planted gardens with some air movement are ideal conditions for spread of this disease. Cool damp nights and warm sunny days favour the development of powdery mildew.

**Management-** Sanitation should always be the initial means of control. Fungicides in a wettable powder formulation provide better coverage if used with a spreader sticker. During seasons of low rainfall in the spring and very early summer when the daytime temperatures are below 27°C, control may not be needed until later. Thoroughly applied fungicides can effectively control powdery mildew. Fungicides will work best in the initial stages of disease development, not after massive infection taken place already.

**Crown Gall-**
Bacterial Disease caused by *Agrobacterium tumefaciens*.

Crown gall is characterized by formation of outgrowths (galls) which vary in form and size. At first, the galls are very small with rounded outgrowths on the plant surface. Development continues and the galls may become several inches in diameter. Galls generally form just below the soil surface on the crown. Galls can also occur on roots and occasionally on aerial parts of rose plants.

**Management-** Transplant only disease-free plants. Avoid wounding during transplanting. Remove infected plants as soon as galls are observed. Where possible, remove and discard all soil in and adjacent to the root system and replace with sterile soil to prevent reintroduction of the bacteria. Upon cutting across a gall, a disorganized callus type of tissue is commonly found. The portions closest to the exterior usually contain the actively growing bacteria. However, once the tumor inducing plasmid is introduced into a plant disease can occur without the presence of the vectoring bacteria. Always inspect new plants thoroughly before placing them in garden. Since wounds can be infected at the time of digging, some plants may have latent infections which could become evident several years after they were planted. If crown gall is detected, the plant may survive many years but could serve as a reservoir for the bacteria. Thus, removal of the infected plant as well as adjacent soil is recommended. In some cases, soil fumigation is used to kill the bacteria in the soil, but this is only effective where relatively porous and dry soils are involved.

**Physiological disorders of Rose**

**Bull head-** This condition is a result of flower petals not developing normally. Sometimes petals are shortened and produced in excessive amounts. Petals are thick and short and curl inward at margin. Causes are low temp during flowering/breakage or thrips.

**Water shoots -** These are vigorous shoots which arise from below bud joint, grow erect and produce succulent and dark leaves and fail to produce flowers.

**Blind shoots-** Failure of shoot to initiate flower bud or abortion of the flower bud. Instead of flower bud at top of a mature rose cane, there is a growth that looks like empty wheat husk

**Causes** – Frost damage, lack of nutrients, shortage of light

**Remedy** – If cane is cut back to about 1/2 to a healthy bud it will produce shoot which will flower

**Bent Neck** – (Storage Disorder) It occurs due to extreme temperature during shipping or storage impairs ability of flower bud to open normally.

**Limp Neck** – It occurs due to water stress in area just below flower bud. Insufficient food supply to the flower bud.

**Remedy** – Use of exogenous sugars and preservatives in vase solutions.

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New Association Biological Control: Concept and Application

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The term new association introduced by Pimental in 1963. The ‘new species association’ biological control approach is based on the ecological principle in which a natural enemy is used that has not coevolved with a pest. In addition to importing natural enemies from the native range of invasive pest, importation can be used in two important ways in which new combinations of natural enemies and pest brought together

1. Some important pest are native pest, these can be controllable with parasites and predators collected from relatives of the pest present in other biogeographic region.
2. In other case, a pest may be invasive but its origin unknown.

What is New Association Biological Control (NABC) agent

We consider new association between exploiter and it’s victim, when the attack strategy is exploiter different from native exploiter where there is no coevolution with victim. This can be applied to all such as pathogens, parasitoids, predators etc.

Some times similar feeding strategy of new association biological control agent susceptible to defensive system of host because host defensive system evolved with earlier natural enemy having similar feeding strategy. The defense of victim may be based on biochemical reactions at various sites or stages. They may depend on ecological or behavioral features of organisms.

Evolution and biological control

Opinions about the value of biological control are often extreme. Colloquially, biological control refers to classical biological control and new association biological control in which one species is introduced from another region to control pests such as arthropod herbivores in agricultural systems, or weeds in managed and natural systems. As such, biological control has the potential to be a low-cost, chemical free, means to control pests. Numerous biological control programs have been unqualified successes such as the control of cacti in Australia with the moth Cactoblastiscactorum, and of glassy-winged sharpshooters in French Polynesia with the egg parasitoid Gonatocerusashmeadi. Yet, new association biological control, as with any introduction of a species into a new area, necessarily involves the unknown and therefore carries some inherent risk.

Classical examples in new association biological control

NABC agents can be used to control native insects and plants and exotic insects and plants with unknown origin. In past, some scientists argued that economically undesirable native plants were appropriate targets for natural enemy introductions. However native plants never acceptable as targets for natural enemy introductions because

1. Native weeds are likely to be abundant species on which many native species depend.
2. Introduced biological control agents spreads to parks, bio reserves and may cause loss of flora and fauna in that area.
3. New association bio control agents would likely to have a broader host range, increasing the risk of non target native species.

But most of attempts of new association biological control done for controlling of native plants.

1. Prickly pear (Opuntiadellini) in Australia controlled by South American pyralid moth Cactus cactorum from Argentina which is previously associated with other cactus species like Opuntiasticta.
2. Control of zygaenid moth *Levuanairodescens* in coconut plantations in Fizi by importing tachinid *Bessaremotas* from Hawai. The origin of zygaenid moth unknown.

3. The native geometrid moth *Oxydiatrychiata* become major pest of Columbiatreeplantations after planting of exotic species. Control of native geometrid moth *Oxydiatrychiata* by importing North American egg parasitoid *Telenomusalsophila* which haveno association earlier.

4. Control of Mexican bean beetle (*Epilachnavarvestis*) by *Pediobiousfoveolatus*, whichis parasite of *Henacephilachnavigintioctopunctata* in south Asia.

5. Control California red scale (*Aonidiellaaurantii*) by *Aphytisriyadhi*, which is a parasite of *Aonidiellaorientalis* in Saudi Arabia.

Advantages of NABC

1. Use the advantage of lack of evolved commensalism which oftenoccur in the natural ecosystem.

2. By using NABC suppression of high density invasive species with unknown originimpossible.

3. NABC has the capacity to control native pest which make up to 60-80% of all pest.

4. Specificity of new association biological control agents is similar to other biologicalagents. But this is debatable issue among the bio control practitioners.


6. More efficient than pesticides and augmentive release, where well established situationgives better results.

Reference


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19. HORTICULTURE

Interiorscaping and its Benefits

**Nellipalli Vinod Kumar** and **Priyaranjan Koley**

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**Introduction**

Interiorscaping is the art and science of growing and arranging plants indoors. It involves the selection, placing and maintenance of plants to improve and enhance the appearance of the indoor environment. Using plants indoors or interiorscaping is not a new concept, plants have been used indoors ever since people moved indoors. The Scandinavians and the Americans are considered to be the pioneers in indoor gardening. In ancient civilizations of Egypt, India and Rome it was common to bring pot grown plants for indoor decorations. In Europe, particularly in Britain, during 17th to 19th century growing exotic house plants for interior decorations was a common practice. Plants in the past were used mainly for their aesthetic purpose, as a hobby or for fashion. Today, plants apart from their aesthetic benefits are used for economic, architectural, engineering and most recently for health benefits.

**Importance of Interiorscaping**

1. **Increasing Urbanization**—As a result of urbanization, people come to live in urban areas. Urban dwellers spend about 90% of their time indoors (at home, school or office). Urban air pollution is a world-wide health concern and it is estimated to cause some 1400 death per year in Metropolitan cities like Sydney (NSW EPA, 2006). Typically, urban air contains in the order of thousands of chemicals, approximately 10% of them are classified as carcinogenic.
2. **Mankind connection with nature**-
Humans have been living in close proximity with nature for centuries. And when they moved indoors, they took plants along as plants filled an emotional and spiritual need then. Researchers have now found that nearly two million years of development in natural environment has left its mark on modern humans in the form of a partly biological or genetic predisposition to respond positively to nature.

3. **Indoor air quality**- Good indoor air quality is essential for the health and well-being of building/ house occupants. A building’s/house’s air quality is therefore a major indoor environment issue. Indoor air pollution is typically even higher then outdoors. Indoor air can often contain contaminants. Researchers have pointed out that indoor air of good quality offers indoor occupants substantial benefits, while poor quality air causes adverse effects such as asthma, dizziness, physical fatigue and some allergic diseases in the eyes, nose and throat.

**Benefits of Interiorscaping**
For centuries it has been assumed, both in Western and Eastern Urban civilizations, that visual contact with plants or natural elements might stimulate psychological well-being and have beneficial effects on man. But in the past, plants were known and used only for aesthetic, emotional and spiritual benefits. Interiorscaping includes economic, architectural and health benefits.

**Health Benefits**
The effects of having plants in one’s immediate surroundings have been promoted for centuries, and now researches have documented that the benefits are not just a placebo effect. The benefits are-

1. Improves well-being and reduces stress by maintaining blood pressure and reducing muscle tension. Stress reducing responses also occur when people are in a room with a few containerized plants, even when their attention is not drawn to the plants.
2. Reduces noise levels – Plants can reflect or diffract sounds depending upon the frequency of noise. Plants reduce noise under certain conditions and this response was affected by many variables including sound frequency, plant placement and the specific room. Generally, it was found that plants worked best at reducing high frequency sounds in rooms with harsh surfaces (Freeman, 2003).

3. Cleans the air- Influence of interior plants on dust accumulation has also been explored. Adding plants to the periphery of a room reduces particulate matter deposition by as much as 20%, even in the center of the room many meters away from the plant.

**Aesthetic Benefits**
1. Plants add warmth, color and charm to the architectural beauty of the house.
2. Plants can be used to decorate walls, as sculpture and for line calligraphy.
3. Plants soften harsh architectural surfaces and compliments the interior settings and draw away attention from unwanted areas.

**Economic Benefits**
1. Plants are inexpensive alternative for home decoration and never go out of fashion.
2. Plants reduce energy consumption through heat reduction and wind modification.
3. Plants are portable, adaptive, self-regulating, beautiful and sustainable. They are adaptive to our environments and work well both in AC and non-AC conditions.
4. Natural humidifiers- Foliage plants can raise the relative humidity to healthier and more comfortable levels in interior spaces and thus, lowers the use of mechanical operators which consume electricity such as air conditioners, fans etc.

**Architectural Benefits**
1. Plants may fully or partially control glare from lights or windows.
2. Plants control privacy by screening the place from unwanted/ undesirable viewing.
3. Plants help in progressive realization of views by partially screening desirable views to entice and enhance the enjoyment of seeing the view.
4. Plants can be used for dividing space and guiding traffic and screening of unpleasant views.
References

20. AGRICULTURAL ENTOMOLOGY

Behavior of Blood Feeding Flies
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Flies are winged insects that are usually just an annoyance. However, they can transmit disease and cause problems in animals. They belong to a large, complex order of insects called Diptera. Flies vary greatly in size, food preference, development, and habits. As adults, flies may feed on blood, saliva, tears, or mucus. They also spread bacteria, viruses, and parasites. There are two types of flies. Biting flies feed on animal blood. This group includes mosquitoes, black flies, sand flies, biting midges, horse flies, and deer flies. Though the bites can be painful and may bring on allergic reactions. Many of these flies, including black flies and mosquitoes, will bite both animals and humans. Non biting flies include those that do not feed on blood and do not actually bite the host animal while feeding. Instead, these flies feed on bodily secretions. Both biting and non biting flies can transmit diseases to domestic animals.

Blood feeding flies

<table>
<thead>
<tr>
<th>Vector</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anopheles stephensi</td>
<td>Anopheles</td>
</tr>
<tr>
<td>Culex nigripalpus</td>
<td>Culex</td>
</tr>
<tr>
<td>Aedes aegypti</td>
<td>Aedes</td>
</tr>
<tr>
<td>Phlebotomus pappatasi</td>
<td>Phlebotomus</td>
</tr>
</tbody>
</table>
Vectors | Diseases
---|---
Mansonia | Lymphatic filariasis
Other biting flies | 
Tsetse flies (Glossina) | African sleeping sickness
Blackflies (Simulium) | River blindness, (Onchocerciasis), mansonellosis (usually symptomless)
Sandflies (Phlebotomus, Lutzomyia) | Leishmaniasis, sandfly fever
Horseflies (Tabanidae) | Loiasis, tularaemia
Biting midges (Ceratopogonidae) | Mansonellosis

Hematophagy (hematophagia) is the practice of certain animals of feeding on blood (from the Greek words "blood" and "to eat"). Since blood is a fluid tissue rich in nutritious proteins and lipids that can be taken without enormous effort, hematophagy has evolved as a preferred form of feeding in many small animals such as worms and arthropods. These hematophagous animals have mouth parts and chemical agents for penetrating vascular structures in the skin of hosts. This type of feeding is known as phlebotomy (from the Greek words, phleps "vein" and tomos "cutting"). Once phlebotomy is performed (in most insects by a specialized fine hollow "needle," the proboscis, which perforates skin and capillaries; blood is acquired either by sucking action directly from the veins or capillaries, from a pool of escaped blood.

Hematophagy can be classified into obligatory and optional. Obligatory hematophagous animals do not have any other type of food besides blood; one such species is *Rhodnius prolixus* (assassin bug). This contrasts with optional hematophages, like the many mosquitoes species, such as *Aedes aegypti*, which may also feed on pollen, fruit juice, and other biological fluids. Sometimes only the female of the species is a hematophage (essential for egg production and reproduction).

Types of behavior
1. Host finding behavior
2. Feeding behavior
3. Mating behavior
4. Resting behavior

Orientation towards the Host in Haematophagous Insects

Various behavior patterns involved in host location can be divided into three stages
1. **Appetitive search** - driven by hunger the insect indulges in non-orientated behavior likely to bring it into contact with stimuli derived from a potential host. This usually occurs at a specific time of day regulated by the insect's circadian rhythm.
2. **Activation and orientation** - upon receipt of host stimuli. The insect switches from behavior patterns driven by appetitive searching to oriented host location behavior. This is driven by host stimuli which are of increasing variety and strength as the insect and host come closer together.
3. **Attraction** - the final phase. Host-derived stimuli, such as the size, shape and color of the target, are used to bring the insect into the host's immediate vicinity and the decision of whether or not to contact the host is made.
Small RNAs – An Introduction

For a long time, it was thought that RNA molecules are essential for only carrying the genetic information from nucleus to the cytoplasm and help in protein synthesis. But recent discoveries indicate that all RNA molecules do not code for proteins. RNAs are actually more than the inactive molecules. A class of RNA (~21 nucleotides) molecules has involved in many of the cell functions starting from the defence mechanisms and up to regulation of the expression of genes of their own gene during their development. Among these 21 nt RNAs, micro RNAs (miRNAs) and short interfering RNAs (siRNAs) are two major types. The former one is endogenous small RNAs and latter one is derived from the exogenous dsRNA.

Origin of small RNAs

siRNAs are rarely conserved, while many miRNAs are conserved across species, underlining the potential evolutionary preservation of their role in gene regulation. By using computational approaches, it is now shown that miRNAs are highly concentrated in the pericentromeric regions of each chromosome. siRNAs generally derive from exogenous sources (introduced dsRNA, viruses, transgenes) and recognize targets with perfect complementarity. But miRNAs originate from capped and polyadenylated stem loops or hairpin primary RNA transcripts named pri-miRNA. The sequences and structure of small RNAs generated determine both their function and the identity of their target genes. Unlike siRNAs, the miRNAs generation is different that initially it is derived from the long, capped and polyadenylated RNAs transcripts named pri-miRNA that will be processed into pre-miRNA and then into miRNA.

Two distinct stages of RNAi initiator

DICER protein and initiator phase

Biogenesis and activation of small RNA are largely depends on the activity of several proteins. The initial synthesis of small RNAs are mediated by the DICER, but they can be only be activated and then recognize and interact with the target when they are associated with the RISC (RNA inducing silencing complex) protein complex.

DICER, an RNase enzyme, is a protein that converts long exogenous dsRNA, by endonucleotyic cleavage, to small RNAs. The sequences and structure of small RNAs generated determine both their function and the identity of their target genes. Unlike siRNAs, the miRNAs generation is different that initially it is derived from the long, capped and polyadenylated RNAs transcripts named pri-miRNA that will be processed into pre-miRNA and then into miRNA.

Each miRNA and siRNA duplex can potentially give rise to two single stranded active molecules but only the mature miRNA and siRNA ‘guide strand’ accumulated in vivo and enter the functional complex. miRNA and siRNAPassenger strand will be largely destroyed.

The Argonaute protein and the Effector phase

The argonaute type of proteins that plays a key role in the RNA silencing effector complex. The argonaute protein consists of two domains namely PAZ and PIWI domains. The PAZ domain is thought to bind with the single stranded RNA, while the PIWI domain is structurally similar to the endoribonuclease-H domain that cleaves RNA.

The Mechanisms

The mechanisms of action include the mRNA cleavage and the mRNA translational...
repression. It is actually decided by the complementarity between the small RNA and its target. A form helix must be formed with the target RNA at the centre of an siRNA guide strand for cleavage to occur. In the absence of that, the central region cannot be cleaved and leads to the translational repression. In translational repression, translational of mRNA to protein will be blocked either by degradation of polypeptide from the ribosome or by freezing the ribosome after the initiation so that the ribosomal scanning will be inhibited.

Another one type of mechanisms which was recently discovered is chromatin modification which is known as the epigenetic control. Thus chromatin modification leads to the gene inactivation.

A natural defence mechanisms
It has been now proved that this RNA silencing act as a natural antiviral defence mechanisms. But in plants this system is not triggered by the host but the features and sequence with the pathogen’s genome. Upon infection by the virus, viral DNA or RNA is used as template to generate the dsRNA that will then be recognized by the silencing machinery.

RNA Technology – future need of the hour
RNAi technology has emerged as an effective method in reverse genetics for silencing gene expression in eukaryotic cells. By timely knock down of the particular gene will leads the blocking the expression of that particular gene. Hence further research in the RNAi technology will surely pave the way for effective management strategies for the both the plant and human viral diseases.

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# 22. AGRICULTURAL ECONOMICS

Economic Implications of Biotechnology and Genetically Modified Crops

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Biotechnology and the introduction of genetically modified (GM) crops are providing new opportunities for increasing crop productivity and tackling agricultural problems, such as pests and diseases, abiotic stresses and nutritional limitations of staple food crops. Cultivation of GM crops is changing the practice of agriculture and there is an increasing trend in cultivation of GM crops worldwide. Plants with novel traits to produce pharmaceutical products are also being generated. The safety of GM crop cultivation and use is a topic of extreme international debate.

Transgenic crops are spreading more rapidly than any other agricultural technology in history, suggesting that farmers perceive important advantages in growing them.

Technologies for genetically modifying foods offer dramatic promise for meeting some of the 21st Century’s greatest challenges. Like all new technologies, they also pose some risks, both known and unknown. Controversies surrounding GM foods and crops commonly focus on human and environmental safety, labeling and consumer choice, intellectual property rights, ethics, food security, poverty reduction, — and environmental conservation(Brookes and Barfoot, 2012).

Biotechnology innovations appear to have taken world agriculture by storm. This spectacular success is attributable almost entirely to transgenic varieties of four crops: soybean, corn, cotton, and canola. It is noteworthy that in 2013, the number of countries cultivating biotech crops reached the historical milestone of 28 countries. In 2013, the global hectarage of biotech crops continued to grow strongly reaching 175 million hectares, up from 160 million hectares in 2011. In 2012, the global market value of biotech crops was US$14.84 billion, (up from US$13.35 billion in 2011) (http://www.isaaa.org).
India has only approved one GM crop, Bt (Bacillus thuringiensis) cotton. In May 2002, three cotton hybrids, MECH 12, MECH 162 and MECH 184 have been cleared by Genetic Engineering Approval Committee (GEAC). The major states which cultivate Bt cotton are Maharashtra, Andhra Pradesh, Gujarat, Madhya Pradesh, Karnataka and Tamilnadu. Area under Bt cotton in India increased from 10.6 m ha (2011) to 11 m ha in 2012 (James, 2012).

Innovations bring about sizeable economic benefits, which are typically shared across various agents, sectors of the economy, and countries. For the first time, developing countries grew more, 52 per cent, of global biotech crops in 2012 than industrial countries at 48 per cent. In 2012, growth rate for biotech crops was at least three times as fast, and five times as large in developing countries, at 11 per cent or 8.7 million hectares, versus 3 per cent or 1.6 million hectares in industrial countries.

Manjunath Kerur, (2012) conducted a study on comparative economic analysis of Bt cotton and desi cotton cultivation in Haveri district of Karnataka. The results on the per acre cost incurred and returns obtained from Bt cotton and desi cotton cultivation revealed that the variable and fixed costs were higher in Bt cotton producing farms (Rs. 11748) and (Rs. 4049) compared to desi cotton producing farms (Rs. 13202) and (Rs.3634) respectively. The gross returns and net returns from Bt cotton cultivation were Rs. 32096 and Rs. 15113 per acre, respectively as against Rs. 24140 and Rs. 6007 per acre from desi cotton cultivation.

Two new countries, Sudan (Bt cotton) and Cuba (Bt maize) planted for the first time in 2012. Germany and Sweden could not plant the potato “Amflora” because it ceased to be marketed; Poland discontinued planting Bt maize because of regulation constraints. Of the 28 countries which planted biotech crops in 2012, 20 were developing and 8 were industrial countries; this compares with 19 developing and 10 industrial in 2011.

We absolutely need genetically engineered crops to feed the world and meet the demands of ever growing population. India has the potential to become a global hub in all aspects of biotechnology. However, several gaps and challenges remain to be bridged and overcome. In India, policy of encouraging genetically modified cotton needs a complete review and critical examination from the point of view of environment, diversity and health.

References:
http://www.isaaa.org

## 23. HORTICULTURE

### Nursery Management Techniques for Ornamental Crops

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<sup>1</sup>Ph. D. Scholars, Department of Floriculture and Landscaping, HC&RI, TNAU, Coimbatore.<sup>2</sup>Ph. D Scholars, Department of Vegetable Crops, HC&RI, TNAU, Coimbatore.

**Nursery**

Nursery is consequently the basic need of horticulture. Plant propagation techniques and practices is the core of horticulture nurseries. The planting materials for horticultural plantations are raised from seeds and vegetative parts. Role of Mother Plants is very primary and important. The fate of nursery depends on quality and truthfulness of mother plants.

**Specific Importance of Plant Nursery**

1. Seedlings and grafts are produced in nursery and the ornamental gardens can be
established with minimum care, cost and maintenance.

2. The nursery planting materials are available at the beginning of the planting season. This saves the time, money and efforts of the farmers to raise seedlings.

3. There is a wide scope for ornamental and landscape Gardens at public gardens, highways and co operative housing societies.

Role of Nurseries
1. Production of Genetically Pure Nursery Stock
2. Export of Nursery Stock
3. Employment Generation

Ornamental Plant Nurseries
Ornamental and floricultural crops are numerous and are propagated vegetatively, like gladiolus, carnation, roses, lilies etc. There is a large group of ornamental plants, which is propagated by seeds and seedling; Asters, Marigolds, Salivas, etc. are some of them.

Propagation Structures
Propagation structures are very essential for production of grafts or seedlings. They are useful for multiplication of grafts and seedlings. Hardening of plants is done with the help of propagation structures. Commercial scale nursery cultivation can be taken up in low cost poly houses or shade houses are used

Plant Nursery Soil
Nurseries grow plants for resale to landscapers and to the general public. The type of soil needed for nursery production will depend upon what and how you intend to grow.

Mother Plant Selection and Maintenance
Mother plant is the most important factor of plant nursery. Mother plants provide bud sticks and scions for budding and grafting operations.

Criteria for Selection of Mother Plants
1. Mother plants should be vigorous, healthy and high yielding. It should have a regular bearing habit.
2. It should be free from pests, diseases and viruses.
3. The mother plants must necessarily be genetically pure and superior in quality. They must be obtained from Registered Farms, Agriculture Universities or Government Nurseries.
4. The purchase receipt of mother plant should be preserved to prove the origin and authenticity of the mother plants.
5. Mother plants should be selected corresponding to the regional demand of the nursery plants.
6. Ornamental mother plants are planted under protected conditions either under shade net or semi-shade conditions.

Seed beds
Beds should be in semi shade area to protect the tender seedlings from scorching heat. Beds may be covered by polythene sheets and green shade nets, if required. A suitable sowing medium may be filled to depth of 1’ or 2’which should be replaced in each season. Best sowing medium is a mixture of good soil and leaf mould or peat moss.

Layout of beds
Rectangular beds are preferred to other shapes. The width of the seed bed should be 1.2 to 1.5 m. The length of the seed beds should be not more than 12.5 m.

Types of seed beds
1. Raised beds: The nursery beds are raised to about 10-15 cm above the ground level.
2. Sunken beds: To avoid flow of water outside the beds in dry areas. These types of beds are used in high rainfall areas.

Sowing on Beds
Seeds should be sown in lines, so as to facilitate the interculture operations. Shallow furrows of 0.5-1.0 cm depth should be made at a distance of 12-15 cm. Seeds should be placed in furrows at an interval of 2 cm. After placing the seeds, the furrows should be covered with a thin layer of the soil and pressed so as to embed the seeds. If seeds are very small, seeds are sprinkled on the top of the bed. The surface is compacted by pressing the top soil or mulched with straw. It’s avoid the seeds from being flown away by water or picked by birds. After seed sowing irrigation should be given.
Media for propagation

Various material and mixture of material are used for germinating seeds and rooting cuttings as media are soil, leaf mould, compost, sand, peat, moss, coco peat, vermicompost, sphagnum moss, vermiculite, perlite, synthetic plastic aggregates may be used.

Growing medium quality

Proper drainage, aeration and water holding capacity. Container media used for most greenhouse crops should have at least 10-15% available water holding capacity by volume and 40-50% maximum air space by volume.

PH

Optimum pH of a container medium differs with plant species but generally a pH between 5.5 to 6.5 is desirable. The pH has a major role in the availability of nutrient ions.

Temperature

The temperature range for optimal plant development is 25–35° C. Additional heating needs to be provided to propagation beds where temperature drops below 20° C in winter. Heating cables or mats which provide bottom heat can easily be installed.

Light

Light is known to stimulate or inhibit germination of some seed. The light reaction involved here is a complex process. Some crops which have a requirement for light to assist seed germination are Begonia, Impatiens and Petunia.

Recommended Water Quality

<table>
<thead>
<tr>
<th>Bedding Plants</th>
<th>Plugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>alkalinity</td>
<td>80 - 120 ppm</td>
</tr>
<tr>
<td>EC</td>
<td>&lt; 1.2 mnhos</td>
</tr>
<tr>
<td>pH</td>
<td>5.5 - 6.5</td>
</tr>
<tr>
<td>SAR</td>
<td>&lt; 4.0</td>
</tr>
<tr>
<td>calcium</td>
<td>40 - 120 ppm</td>
</tr>
<tr>
<td>magnesium</td>
<td>6 - 25 ppm</td>
</tr>
</tbody>
</table>

Mulching in Nursery

Mulching is practice of covering soil surface with organic or inorganic materials to check the growth of weeds and loss of water through evaporation and regulate soil and media temperature.

Advantages of Mulching

1. Seeds in the beds are irrigated frequently and can be washed away easily. Thus, placing of some mulch material prevents the blowing away of the seeds from the nursery bed.
2. Covering of the nursery beds by any mulching material is equally useful to prevent the young seedlings from frost damage during winters and scorching sun during summers.
3. Mulching material also suppresses the growth of unwanted plants and weeds and also conserves moisture in the soil. It cools soil surface and stabilizes soil temperature.
4. It adds organic matter to soil, if mulch materials are organic in nature and reduces soil erosion on sloppy lands.

Nutrient Management

Common source of nutrients in nursery is fym, compost, vermicompost, leaf mold, cakes etc. The application is done by broadcasting or foliar spray @ 0.5 to 2 per cent. Fertilization should be avoided just before transplanting this causes diversion of plant energy toward root development and causes a negative impact on transplanted seedlings, common source of nutrients in nursery is fym, compost, vermicompost, leaf mold, cakes etc. Besides, primary nutrients like nitrogen and phosphorus are essentially applied through straight fertilizers as these play an important role in root and shoot development.
Protected Cultivation in Fruit Crops

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Introduction

Protected cultivation is most intensive horticultural production systems to minimise the chemical, pesticides residue with climate change and changing crop pattern. It is proving as a boon for marginal and small growers with limited land and water resources. Greenhouses were first introduced in India during 1960 for research purpose and commercial cultivation started in 1988. Protected cultivation or greenhouse or low poly tunnels production techniques are now available for growing selected fruit crops like strawberry to obtaining high quality fruits and it also helps in off season fruits production around the year. Low cost greenhouse technology developed for high quality fruit production in hilly states of Jammu and Kashmir, Himachal pradesh, Uttaranchal and North Eastern states. These structures are now used commercially for export of quality fruit production in plains of Maharashtra and Karnataka. The farmers of this zone have shifted to protected cultivation of another fruit crops including strawberry, grape, cherry, apricot, and plum to save their livelihoods. Recent estimates for the peach and nectarine segment of the protected cultivation industry in China suggest that approximately 80% is nectarine while 20% is peach. Therefore, accepting change and adaptation strategies seem to be the key for survival and prosperity of mountain as well as other region farmers.

Protected cultivation can be defined as a cropping technique where the micro climate surrounding the plant body is controlled partially or fully as per the requirement of the plant species grown during their period of growth.

Protected Cultivation Technologies:

The several technologies like high tunnels, mulching, bagging, drip fertigation, net houses, raise bed and Earth Tube Heat Exchanger (ETHE) for hot humid areas are help to successful fruit production and plant multiplication, Drip fertigation, Raised beds, Mulching, plastic covered tunnels and insect screen covered tunnels. Shade nets (Intensity & color) and insect-proof nets (Porosity). Protection against animals, birds, excessive radiation, wind and hails, Greenhouses, Mist chambers, IPM in Greenhouse. Greenhouse technology is the most practical way of achieving the goal of protected cultivation.

Greenhouse technology: Green houses are framed or inflated structures covered with plastic material or glass in which crops can be grown under partially controlled environment which is large enough to permit normal cultural operation manually. Green house technology was well adapted in Europe and USA by the end of the nineteenth century. Presently, China and Japan are the leading countries. Other countries where green house technology is being widely used are Netherlands, Israel, Canada, Spain and Egypt besides some Arab countries. Green houses are suitable for growing a variety of fruits and throughout year cultivation even under extreme climatic conditions is possible through green houses. Seedlings and cuttings preparation time is also reduced significantly with the application of green house technology.

India has varied climatic conditions in different regions, so the greenhouse and the supporting facilities have to be developed accordingly. The southern plateau will have mild climate and coastal regions need only naturally ventilated poly houses. The northern plains with extreme hot and cold climate need the cooling and heating facilities. In naturally ventilated greenhouse, the temperature is maintained 1 to 30ºC above ambient conditions due to wind and thermal resilience and here no need of any electric power for maintenance of temperature and R.H. Under Indian conditions naturally ventilated greenhouse are most suitable due to low operating costs. The naturally ventilated greenhouses are also
economical for cultivation in northern hilly regions during summer.

High tunnel technology is currently being explored for the feasibility to induce early flowering in blueberries. A profuse fruit set, almost doubled yield increase, and considerably higher returns to the growers are observed in the high tunnel blueberry production system (Coneva, 2010).

**Role of protected cultivation:** To get uniform and better quality production and fresh fruits availability, Higher productivity, early harvest, protect the fruits from the late frost, late summer rains, diseases and pests, Conservation of biodiversity, Check the losses from natural calamities, Create micro-climate for optimum plant performance, Employment generation from small holdings, Better insect and disease control with lesser use of pesticides, Round the year as well as off-season cultivation is possible in hostile climates, Regulate harvesting time to reduced post-harvest losses, Efficient use of resources, Weed free cultivation, Higher productivity, Uniform and better quality production and fresh fruits availability.

**Production systems:** Hydroponics, Aeroponics, Soilless culture/Container system, Soil system/Geoponics. NFT, DFT.

**Hydroponics:** Growing of plants in a water and fertilizer solution containing the necessary nutrients for plant growth.

**Aeroponics:** A plant-cultivation technique in which the roots hang suspended in the air while nutrient solution is delivered to them in the form of a fine mist.

**NFT (Nutrient Film Technique) System:** Plants are grown in channels in which the nutrient solution is pumped through. The plant roots are kept moist by the thin film of nutrient solution as it passes.

**DFT (Deep Flow Technique) System:** Depth of nutrient solution is circulated around the roots either by gravity or by using a pump.

**Off-Season Fruit Production in greenhouses:** Off-season production is preferred both to meet the fruit demand of off-season and to sell the products with higher price. For example: Fruits produced in the world’s Southern Hemisphere countries are sold as fresh fruit to Northern Hemisphere countries in the winter months. In some countries of Northern Hemisphere are trying to making the off season production in greenhouses or protected areas to meet fruit demand of off season. In recent years, the fruit trees for the purpose of the off-season production have grown in pots in the open field or protected areas to make production in desired time. It is possible to obtain high density planting and dwarf growing by growing of fruits in small pots.

**Protected cultivation in Mango:** All Mango trees in Japan must be grown under plastic houses because protection from rain (Anthracnose disease, and from cold temperature). Pollination by honeybees. Two types of greenhouses are followed, Strong structure plastic house, Simple pipe structure vinyl film house to get perfect colour development and no scars from disease and insect on the fruit surface.

**Protected cultivation in Papaya:** The cultivation of papaya under this system is new on a national level. Allow cost to be brought down because it helps to avoid the propagation of viral illnesses transmitted by insects such as aphids. By preventing aphids from being in contact with the crop, the spread of viral diseases will be avoided. Consequently, the production period of the plants and the yield per plant per hectare will be increased at the same time lowering the costs of controlling pests.

**Protected Cultivation in Strawberries:** Strawberries are grown in greenhouses in many parts of the world. In Europe they have been grown successfully since the early 1970’s and farmers can get more than 120 tons/ha/year. In China, there are over 24,000 hectares of strawberries grown over the winter in energy-saving greenhouses which rely mostly on solar energy to heat the greenhouses. However, few strawberries are grown in greenhouses in North America.
Protected Cultivation in Grapevine: In grape greenhouse cultivation for particularly suitable varieties are Blue Muscat and Birstaler Muscat. The training usually occurs as oblique cordon, a form derived from the vertical cordon, the side shoot positions are spur pruned. Grapes are usually considered to be a warm climate fruit and it is true that they prefer long and hot summers in order to ripen fully. The best quality dessert grapes are grown in greenhouses in temperate climates. These shy-setting varieties of grape, particularly the Muscats, set fruit best in the artificial conditions of a greenhouse. Although can grow wine varieties of grapevines in a greenhouse, it is more sensible to use greenhouse for the sweeter more delicate dessert varieties producing high quality grapes which would not be able to grow successfully outdoors.

Conclusion: Protected cultivation of fruits is beneficial for producing quality production for export. PC production system offers great scope to produce organic fruit, minimize insect pest incidence, avoid fruit cracking and prevent frost injury, hardening of tissue culture as well as cutted, budded, layered and grafted plants. Lack of local varieties suited for growing under protected structures then breeding of specific varieties is must. Production technology of each crop should be standardized Great scope of employment for providing service support to the greenhouse growers. On an average, this would provide regular employment to 3 persons per hectare area under greenhouses/micro-irrigation

References

25. SOIL SCIENCE AND AGRICULTURE CHEMISTRY

Effect of Biochar on Soil Health
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Introduction
Crop residues are invaluable source of nutrients. However, their production in huge amount needs some effective disposal solutions. Burning of crop residues in the open field is one of the commonly adopted methods by farmers to get rid of this waste. This practice not only causes environment pollution due to emission of greenhouse gases and serious fine dust problem but also cause changes in air circulation and monsoon pattern. Alternatively, these crop residues can be used to produce compost and can also be processed to produce biochar whose application to infertile soil may benefit the agriculture production. Recently it has been proposed as one of the effective waste management strategy to improve crop productivity (Bajiya et al., 2017).

What is biochar?
Biochar is the product of thermal degradation of organic materials in the absence of oxygen (pyrolysis), and is distinguished from charcoal by its use as a soil amendment. Biochar is a fine grained, highly carbonaceous, pyrolysed (low temperature) product of biomass. The pyrolysis temperature strongly influences the stability of biochar in soil; the higher the pyrolysis
temperature higher would be the stability
Biochar is charred organic product which made up of biologically recalcitrant carbon that is not easily mineralized by the soil microbes. The carbon present in the biochar is in aromatic form which offer a higher degree of stability and resistant to decomposition, which making it a most important tool for carbon sequestration. Biochar is a carbon rich charcoal-like substance created by thermal decomposition biomass (organic matter) in low oxygen conditions at relatively low temperatures.

Incorrect production of biochar and its subsequent application to soil could be detrimental to both agricultural production and environment. Pyrolysis of biomass into biochar creates three primary benefits of waste management, soil improvement and mitigation of climate change. Biochar can be applied in soil as Deep banding with compost/ manures, through liquid slurries and Spreading by hand/machine and its incorporation in soil through tillage. Ideal biochar application rates are not known. However, its application rate may vary depending upon the soil type. A knowledge of appropriate application rates and biochar types that should be applied to different soil types under different climatic conditions is essential to prevent its adverse impact on agricultural production (Purakayastha et al., 2015).

**Impact on soil properties**

1. **Water retention:** Addition of biochar to infertile land reduces bulk density and increases its porosity due to its internal porous structure, nature of its particle size and shape. Increased soil porosity increases surface area of soil and water can penetrate easily.

2. **Ion exchange capacity:** The nutrient retention capacities of both biochars and soils depend on their cation and anion exchange capacity. However, the biochar produced at low temperatures have a high cation exchange capacity. As biochar ages or matures in the soil, its cation exchange capacity increases. High cation exchange capacity biochars have the ability to adsorb heavy metals and organic contaminants such as pesticides and herbicides from the environment. Therefore, the addition of biochar with high CEC can be used to alleviate the contaminant level in soil. Biochars to be used as soil amendment should not be produced at high temperatures. Soil with high CEC can hold the nutrients and increases their availability for plant uptake.

3. **Effect on soil pH:** pH is one of the most important characteristics of soil. In terms of nutrient availability to plants. Most of the biochars are alkaline in reaction (>9.0) and can exert a liming effect in soil where pH is lower than optimal for intended use. Therefore, their effectiveness is more under acidic soil. A small increment of pH has been recorded with all types of biochar applied to soil at different application rates. The increase in pH is due to high initial cation exchange capacity of biochar.

4. **Nutrient availability:** Type of feed stock, duration of pyrolysis and temperature during pyrolysis affect the composition and structure of biochar resulting in significant differences in nutritional content of biochar produced. Biochar produced from animal product feed stock, and manures is relatively rich in nutrients compared with plant and wood derived biochars. Biochar derived from crop residues have the high carbon exchange and water holding capacity. Biochar application results in reduced leaching of calcium, potassium, magnesium and nitrogen. This means higher availability of nutrients for plant uptake and low requirement for chemical fertilizer. Amendment of soil with biochar also reduces the runoff of phosphorus (P) into surface water and leaching of nitrate into ground water. Thus, it helps in reducing the pollution caused by chemical P fertilizer runoff. Biochars are not primary source of nutrients rather they are more important for their use as a soil amendment and driver of nutrient transformation. Microbial decomposition of organic matter regulate P (an important plant nutrient) mineralisation and hence its availability to plants. Several studies have demonstrated enhanced P uptake by plants in the presence of biochar. Biochar has also been reported to improve the availability of sulphur. The sorption capacity of some biochars for NH4+ ions is much higher than
activated carbon.

5. **Effect on soil biological activity:** Due to its high porous nature, high surface area, ability to absorb soluble organic matter and inorganic nutrients, biochar serves as a suitable habitat for millions of microorganisms. Small pores of biochar may act as niche for microbial flora and protect them from external competition and predation. Microbial diversity and abundance is strongly affected by pH of the biochar. Biochar application also increases soil microbial biomass carbon significantly compared with chemical fertilizers.

6. **Biochar and soil interaction:** Stability of biochar depends upon its specific properties and mineralogical composition of soil and soil properties. The organic carbon content and total nitrogen content of soil has been reported to increase with reduction in N\textsubscript{2}O emission, with no change in CO\textsubscript{2} emission in paddy. Integrated use of biochar and chemical fertilizer to acidic and nutrient poor soils can produce yields greater than either fertilizer or biochar alone. However, the effect of biochar on crop growth depends on application rates and the soil type to which it is applied. The key feature of biochar addition to soils is increased nitrogen use efficiency by plants. This suggests biochar application can reduce the nitrogen fertilizer input without reducing the crop yield. Currently there is high interest in biochar but the extensive risk analyses regarding the uncertainties associated with its application needs to be done. The positive effects of biochar application in soil are not universal as fertile soils have also recorded some negative impacts on plant growth. (Nelissen et al., 2017).

**References**


**26. SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**

**Soil Fauna: Role in Sustaining Soil Health**

Neelam Yadav and Poonam Yadav

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**Introduction**

Soil health can be defined as the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity and maintain their water quality as well as plant, animal, and human health. Soil is living because below our feet there is an immensely complex web of life that includes the smallest bacteria and fungi to burrowing mammals. Soil organisms play an important role in maintaining soil health and sustainable production year after year (Doran & Parkin, 1994).

Important groups of fauna commonly present in soil

1. Macrofauna (Termites, Ant, Earthworms)
2. Mesofauna (Collembolan, Acari)
3. Microfauna (Nematodes, Protozoa)

**Termites:** Termites are major decomposers in most tropical terestrial ecosystems, responsible for the mineralization of up to 30% of net primary production (mostly as CO\textsubscript{2}) in some systems and the breakdown of up to 60% of litterfall. Subterranean termites enhance macroporosity and infiltration with beneficial effects on soil water storage and primary productivity.
Ant: Ant species diversity declines with increasing latitude, altitude, and aridity. Soil ants (including mound builders) are representatives of predators, herbivores (granivores) and bioturbators, bringing about important changes in the physical and chemical properties of soils, as well as dispersing plant propagules. Networks of galleries and chambers increase the porosity of the soil, increasing drainage and soil aeration and reducing bulk density.

Earthworms: Bouche classified earthworms as epigeic, endogeic and anecic, depending on whether they inhabit litter, soil or both. Each group has particular morphological and behavioral adaptations, which in turn produce different pedological effects. Earthworm cast is a rich source of nutrients, particularly N, P, Ca, etc. and contains more bacteria and organic matter. Dead tissues of earthworm decompose faster due to their high protein content. Geophagous species of earthworms ingest material per day which is 5-36 times of their body weight. Casting rates of tropical earthworms are reported to be as high as 2600t/ha/yr. Earthworms do intimate mixing of organic matter with mineral matter which increases the stabilization of clay bound carbon, depending on soil type. Earthworm worked soils generally have high porosity, increased water holding capacity, higher water infiltration rate, more water-stable aggregates and increased availability of plant nutrients. These organisms may also affect microbial population as they ingest microbes along with soil and organic matter.

Collembolan: Collembolan or springtails are small wingless insects. They are well differentiated into ecomorphological groups occupying different soil horizons. Most are highly specialized feeders on soil microbiota (fungi, bacteria, actinomycetes, algae). Some mix small mineral particles with dead organic matter in their guts and contribute by their faecal pellets to soil microstructure.

Nematodes: Nematodes are a major component of all soil food webs and thus comparisons of abundance, biomass and community structure can be made across ecosystems. Functional groups are based on morphology and known feeding habits of a few species, and in most soils include plant parasites and plant grazers, bacterivores, fungivores, predators, and omnivores. Plant parasites and plant grazers are the best known of soil nematodes, due to the damage they cause to agricultural crops, i.e. decreasing plant production, disrupting plant nutrient and water transfer, and decreasing fruit and tuber quality and size. Soil disturbance, weather pollution, erosion, pesticides, or water quality, affects nematode species composition. For this reason they are used as indicators of soil health. Besides plant parasite nematodes there are some beneficial species also which play an important role in essential soil processes like nitrogen mineralization and distribution of biomass within the plants.

Protozoa: Protozoa are microscopically small, unicellular organisms. It is assumed that only 10% of soil protozoans are known. Vickerman suggested that the total number of species is close to 40,000. Protozoa are, with nematodes, the principal microbial grazers in terrestrial systems. By classifying protozoa based on feeding preferences (bacterial or fungal), habitat preferences (acidophilic or neutrophilic) or ecological weightings, it may be possible to relate changes in diversity and/or biomass to ecosystem functioning.

Conclusion
Current agricultural practices reduce soil biodiversity, mainly as a result of the overuse of chemicals, leading to compaction or other disturbances and hence irreversible adverse ecological alterations, resulting in loss of agricultural productivity. There is a need for a holistic consideration of soil health as well as trans disciplinary soil management approaches that integrate biological, chemical, and physical strategies to achieve soils supporting a sustainable agriculture.

References
Nutrient Use Efficiency

Nutrient use efficiency is mainly considered as dry matter produced per unit nutrient element concentration in dry matter. It is also termed as the internal nutrient requirement. Nutrient use efficiency in crops is a function of soil's capacity to supply adequate levels of nutrients, ability of plant to acquire nutrients, ability to transport in roots and shoot and ability to remobilize to other parts of the plant. Plants interaction with environmental factors such as solar radiation, rainfall, temperature and their response to diseases, insects and allelopathy and root microbes have a great influence on NUE in plants.

As a concept, NUE includes nutrient uptake, utilization or acquisition efficiency, expressed as a ratio of output (total plant nutrient, grain nutrients, biomass yield, grain yield) and input (total nutrient, soil nutrient, or nutrients applied through fertilizers). From one of the earliest definitions of NUE that considered the amount of plant yield in terms of either grain per unit of applied nutrients (NUE grain) or biomass per unit of applied nutrients.

Phosphorous use efficiency

Soils vary greatly in their capacity to fix phosphate. The organic content of the soil, pH, amount of Ca and Mg, amount and chemical nature of clay colloids are important factors which affect the nature of compounds formed. The availability of phosphorus also depends upon extent of fluorine present in the material applied as fertilizer. More the fluorine percentage lesser is the availability of phosphates. The fixed phosphates do not leach out of the soil but only they remain unavailable to plants. The fixed phosphate makes some complex compounds and prevent penetration of other fertilizers into the root zone. Due to conversion of phosphate into complex forms and also due to least mobile in nature, when applied as top dressing or broadcast it remains fixed on surface and does not move downwards or towards root zone.

Adaptation in Plants under low P soil

1. Increase of root to shoot ratio
2. Redistribution of growth among root types
3. Stimulation of root hair growth
4. Topsoil foraging
5. Soil exploration at minimal metabolic cost
6. Association with mycorrhizae and
7. Increased expression of high affinity P-transporters

Steps to increase availability of applied phosphates

To ensure regular supply of phosphate to plants following measures should be taken:

1. To make most efficient use of phosphorus the phosphatic fertilizers should be applied in bands or stripes, deep placement in root zone and in the form of pellets. The reversion can be minimized to certain extent by applying phosphatic fertilizers with organic manures.
2. Addition of organic manures in alkali soils produces organic acids like H$_2$CO$_3$, H$_2$SO$_4$ and HNO$_3$ during decomposition of organic compound which neutralize alkali and increase the phosphatic availability to plants.
3. Liming in acid soils increases phosphate availability to plants. Calcium replaces Al and Fe from complex compounds and forms calcium phosphate which becomes available to plants provided there is no overliming otherwise tri- and tetra-calcium phosphates are formed which are not available to plants.

Strategies for improving P acquisition efficiency of crop plants

1. Molecular assisted plant breeding for
enhanced tolerance to low P soils.
2. Development of transgenic plants.
3. Microbial inoculums to enhance P availability and plant growth in low P soils (VAM, PSB, PGPR)

**Increased expression of high affinity P-transporters**

The concentration of P in root cells can be up to 1000-fold higher than the P concentration in soil solution. In order to acquire P against this steep concentration gradient, P transport across the soil/root interface requires a specialized transport system. In plants, two P uptake systems have been identified, a high affinity system that is either increased or depressed under P deficiency and a low affinity system that is constitutively expressed. Plants can possess multiple P-transporters. For example, nine transporter genes have been cloned from Arabidopsis, at least five from potato.

**Inoculation of plant roots by arbuscular mycorrhizal fungi**

**Mechanism of P uptake by mycorrhiza:**

1. Increased surface area

2. Biochemical modification of rhizosphere

**Role of AM fungi**

1. Improved growth of many plant species
2. Increased nutrient uptake
3. Production of growth promoting substances
4. Tolerance to drought, salinity and transplant shock and synergistic interaction with other beneficial soil microorganisms such as N-fixers and P-solubilizer.

Symbiotic association of plant roots with VAM fungi often result in enhanced growth because of increased acquisition of P and other low mobility mineral nutrients.

**References**


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### 28. AGRONOMY

**Biodegradable Plastic Mulches: Impact on Soil Quality and Microclimate**

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Plastics were first introduced on a commercial scale in 1939. These include polyethylene, polyvinyl chloride, and ethylene vinylacetate. Polyethylene plastic is made from polyethylene resin, which is in the form of pellets. The pellets are heated and processed into bendable sheets of plastic film. The widespread use of polyethylene (the principal type of plastic used today) is due to easy processibility, excellent chemical resistance, high durability, flexibility, and freedom from odor and toxicity. The most commonly used mulch films include low-density polyethylene, linear low-density polyethylene, and high-density polyethylene. Linear low-density polyethylene resins have high puncture resistance and mechanical stretch properties. High-density polyethylene resins have reliable moisture and vapor barriers. An ideal plastic mulch film should be flexible and rigid enough for easy removal from various growing environments. Poly hydroxyl butyrates (PHBs) are macromolecules synthesized by bacteria. They are inclusion bodies accumulated as reserve materials when the bacteria grow under different stress conditions. Because of their fast degradability under natural environmental conditions, PHBs are selected as alternatives for production of biodegradable plastics. They help to control weeds and insects, increase soil and air temperature, reduce evaporation, minimize soil erosion and prevent soil splashing on fruits or vegetables.
Agricultural plastic mulch films are often contaminated with soil, and therefore are not accepted by many recycling facilities. This limits disposal options for polyethylene mulches, which often have to be land filled. Costs of land filling are high, causing many producers to amass mulches or even burn them on-farm.

Introduction
The use of plastic mulch in crop production is an important management practice that helps to control weeds, conserve water, reduce nutrient loss and also to maintain conducive microclimate. Currently, polyethylene-based mulches are the most commonly used plastic mulches. Biodegradable plastic mulches are now commercially available, and they are designed so that they can be tilled directly into the soil to degrade. Their adoption could alleviate the disposal problem of polyethylene mulch, but there is the need to evaluate how well they degrade under different environmental conditions.

Biodegradable plastic mulch
Biodegradable plastic mulch is desirable alternatives to traditional black polyethylene plastic for use as mulches in agro ecosystems. Efforts are ongoing to engineer biodegradable plastic mulches that could be incorporated into the soil at the end of the crop season, and decomposed by microorganisms, ultimately to CO₂, H₂O and biomass.

Plastic products that are biodegradable are desirable because they can reduce non-recyclable waste, conserve resources and decrease environmental pollution. In agriculture, biodegradable plastic mulches offer an alternative to polyethylene mulch production and disposal. This publication explains how biodegradable plastic mulches are made, what constitutes biodegradability, and the advantages and disadvantages of plastic mulch in general. It will also inform agricultural professionals, farmers, and policy makers about the current research on the suitability of biodegradable plastic mulches for agricultural uses.

Benefits of plastic mulch
They help to control weeds and insects, increase soil and air temperature, reduce evaporation, minimize soil erosion and prevent soil splashing on fruits or vegetables.

1. These benefits translate into reduced pesticide use, early planting in spring, water conservation and increased crop yield.
2. Growth and need for more food, the use of plastic mulch film in agriculture has great potential to increase food production and security.
3. Dark mulches and clear mulches applied to the soil intercept sunlight warming the soil allowing earlier planting as well as encouraging faster growth early in the growing season.
4. Plastic mulches prevent sunlight from reaching the soil which can inhibit most annual and perennial weeds.
5. Plastic mulches keep ripening fruits off of the soil. This reduced contact with the soil decreases fruit rot as well as keeps the fruit and vegetables clean.

Impact of plastic mulch on microclimate
1. Soil temperature under plastic mulch depends on their physical and thermal properties.
2. Soil temperature under plastic mulch depends on their physical and thermal properties.
3. Color affects the surface temperature of the mulch and the underlying soil temperature.
4. The white on black mulch caused the lowest soil temperature, because it reflects back 85% of the incoming solar radiation and only 1 to 2% of the total radiation is transmitted.
5. Black plastic mulch caused the highest soil temperature under high tunnels.
6. The green mulch is considered photo selective mulch; it absorbs the PAR and transmits the infrared radiation to soil.
7. This plastic mulch warmed the soil the same way as clear mulch, but without the accompanying weed problems.
8. White on black and green plastics mulches caused cooler air temperatures in the canopy in summer.

Conclusions
There is an increasing interest in the use of degradable plastic mulching for protected cultivation. Determining the effects of biodegradable synthetic polymer mulch in crop
production with regards to microclimate modification, physical, chemical and biological properties of soil, weed control and pest and disease management requires many studies. Little is known about how biofilm covering affects physical and chemical soil parameters, however soil quality has been of increasing concern in recent years.

Reference


29. BIOTECHNOLOGY
Doubled Haploids: A Quick Way for Homozygous Line Production
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INTRODUCTION
The development of plants from the male gametophyte is known as androgenesis. Guha and Maheshwari, (1964) first time developed haploid plant from male gametophyte of Datura inoxia. Generally, two in vitro methods viz., anther culture and microspore culture are used for androgenesis. Haploids are autonomous, sporophytic plants that have gametophytic chromosome number. Doubled haploid plant has cells containing two gene sets which are exactly identical. For example, one gene set has the tall height gene the other gene also having tall height gene. A doubled haploid cell is produced by spontaneous or induced (colchicine, nitrous oxide, amiprophos-methyl (APM), oryzalin, caffeine etc.) chromosome doubling, which can be grown into a doubled haploids plant. Doubled haploidy is the fastest route to achieve homozygosity in plants. Once developed, breeders can evaluate DHs lines swiftly with better accuracy and confidence, especially with respect to quantitative traits such as yield because of homozygosity. Each cell contains two sets of genetic information which are similar most.

Androgenesis can be of two types 1) Anther culture: Culturing of anthers in culture medium is called as anther culture. 2) Microspore culture: It deals with culturing the isolated microspores from anthers in culture medium, is referred as microspore or pollen culture. But anther culture is more applicable than pollen culture because anther culture is very quick and sometimes anther wall also influence on the microspore development.

STEPS FOR ANther CULTure
1) Identification of developmental stage of pollen, 2) Pre-treatment, 3) Bud surface sterilization, 4) Culture of anthers for callus induction, 5) Shoot regeneration on callus, 6) Root regeneration on shoots, 7) Assessment of ploidy level, 8) Chromosome doubling, 9) Hardening and 10) Progeny test.

Anthers are best cultured when the pollen is unicellular and uninucleate, or just entering the first pollen mitosis. Developmental stage of pollen is checked by acetocarmine squash method. Anthers at proper stage are pre treated at low or high temperature for short duration to change the fate of microspores from gametophytic to sporophytic generation. After pre-treatment, the anthers are inoculated into suitable medium for development of callus, shoot and finally root. Assessment of ploidy level helps to identify haploid plants. Diploid plants are developed from somatic cells such as anther wall cells or filament cells. The best tissue for chromosome count is root tips because of rapidly dividing cells or tips of young leaves. Various approaches to determine ploidy level:

1. Chromosome counting: Root tips are used for chromosome counting. Fixed root tips are hydrolyzed in 1 N HCl at 60 °C for 10 min followed by staining with
acetocarmine. Count chromosomes under microscope.

2. Flow cytometric analysis: Leaves of potential haploid plants are finely chopped and intact interphase nuclei are freed from the cell. At this stage nuclear DNA content reflects the ploidy state of the donor which is determined by flow cytometry. This method is very quick.

Once haploid plants have been identified, they are ready for diploidization treatment. Different chemicals are used for this purpose viz., colchicines, nitrous oxide, amiprophos-methyl (APM), oryzalin, caffeine etc. These chemicals inhibit the formation of spindle fibres and thereby no polar migration of chromosomes. They do not affect DNA replication. Cells at meristematic stage are very sensitive to this treatment. The diploidized plantlets are further analysed for ploidy level through chromosome counting or flow cytometry. The doubled haploid plantlets are grown in green house for primary and secondary hardening. The well developed plants are evaluated with respect to agronomic characters.

FACTORS AFFECTING ANDROGENESIS


APPLICATIONS

Homozygous line is developed within few months to year. The repeated self pollination is an extremely long process for conventional breeding. Haploid embryos have high regenerative capacity therefore act as excellent recipient cells for Agrobacterium-mediated transformation. After diploidization gene is expressed homozygously. In vitro androgenesis provides a unique opportunity to screen the gametophytic variation, caused by recombination and segregation during meiosis, at the sporophytic level. The gametoclonal variants being hemizygous express even the recessive traits in the R0 plants. Haploids are used in production of aneuploids e.g. monosomic in wheat. Haploids also give evidence of basic chromosome number in a species or a genus. For molecular mapping, a much smaller sample of double haploids is required for desirable recombinants. In DH population, the identification of markers is more secure, because heterozygous lines are removed. For example: rice, barley etc. Haploids are used for mutation study. Majority of mutations are recessive, cannot be expressed in the diploids because of dominant gene. By diploidization this trait is fixed in plant. These mutants are antibiotic, herbicide, toxins etc. resistance.

LIMITATIONS

High level of management and expertise is required to operate the tissue culture production of haploids. Diploids and tetraploids are often regenerated from other unwanted diploid tissue at the same rate as the haploids. Callus formation is spontaneously or induced by regulators is usually detrimental. The relatively high incidence of albinism is found in some types of anther and pollen cultures. Little chance of isolating haploids from the mixture of haploids and higher ploidy levels because latter ones are over grown. Frequency of homozygotes production is less through doubling of haploids.

CONCLUSION

The production of DHs lines provides an efficient way to generate plants with identical genotypes where all loci are fixed in a homozygous state. The genotypes are more important factor than medium in androgenesis ability. Androgenesis is more favourable in stress condition like, sugar, PEG temperature etc. Albinism in plant is mainly dependent on genotype of plant. But it can be reduced by external environment factors, like light, addition of adjuvant (CuSO4) in media etc. Diploidization through colchicine is very critical with respect to the concentration and duration of treatment.

FUTURE THRUST

Further research is needed to increase the percentage of responding microspores and to improve the plant regeneration rates. The improvement of general procedure for recovering more doubled haploids through in vitro anther culture will help breeders to generate lines from various genetic backgrounds. Future studies should analyze
transcriptome in microspores and microspore derived structures. The studies of genes involved in androgenesis will help to select the plant material for DHs production.

REFERENCES

30. PLANT BREEDING
Heterosis Breeding in Maize
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Introduction
The mating or crossing of two plants or lines of dissimilar genotype is known as hybridization. In plants, crossing is done by placing pollen grains from one genotype, called the male parent, onto the stigma of flowers of the other genotype, referred to as the female parent. It is essential to prevent self-pollination as well as chance cross-pollination in the flowers of the female parent. At the same time, it must be ensured that the pollen from desired male parent reaches the stigma of flowers of the female parent for successful fertilization. The seeds as well as the progeny resulting from hybridization are known as hybrid or F₁. Hybrids are the first generation (F₁) from crosses between two purelines (Self-pollinated crops), inbreds (cross-pollinated crops), open pollinated varieties, clones or other populations that are genetically dissimilar.

History of hybrid development
There is evidence that Babylonians and Assyrians hand-pollinated date palm as early as 700 B.C. for metexenic effects of pollen. In 1717, Thomas Fairchild produced the first artificial hybrid, the Fairchild’s mule, by crossing sweet William (Dianthus barbatus) with carnation (Dianthus caryophyllus). Joseph Koelreuter made many crosses in tobacco during 1760-1766 and emphasized hybrid vigour in F₁. Thomas Andrew Knight developed several varieties of apples, pears, peaches, grapes and currants during 1759-1835. Maize is the most extensively studied crop species with respect to heterosis and inbreeding depression. In 1878, Beal showed that certain varietal crosses showed substantial (up to 52%) heterosis. He suggested that such varietal hybrids may be used as varieties.

The commercial maize hybrids are produced by crossing inbred lines rather than open-pollinated varieties. This technique has been successfully used in many cross-pollinated species. In 1909, Shull suggested inbreds development from open pollinated varieties by continued self fertilization. Inbreds that combine well was used to produce superior hybrids (single cross hybrid). In 1912, East and Hays advocated heterosis breeding as an alternative plant breeding strategy. The concept of double cross hybrids was proposed by Jones in 1918, while that of top cross hybrids was advanced by Davis in 1927.

Different types of hybrids-Single, Double and Multiple cross hybrids
One of the first things the plant scientists noticed when they began crossing different pure lines was that hybrid plants were usually more vigorous than their parents. The simple act of crossing different strains resulted in higher yields and stronger plants. They had discovered “hybrid vigor”. Corn (Maize) was the first hybrid seed crop to be marketed extensively. It is still the most important economic crop grown in the world.

Single cross hybrids
A hybrid plant results from a cross of two genetically different plants. The two parents of a single-cross hybrid, which is also known as a F₁,
hybrid, are inbreds. Each seed produced from crossing two inbreds has an array (collection) of alleles from each parent. Those two arrays will be different if the inbreds are genetically different, but each seed contains the same female array and the same male array. Thus, all plants of the same single-cross hybrid are genetically identical. At every locus where the two inbred parents possess different alleles, the single-cross hybrid is heterozygous.

Double cross hybrids
Producing a double-cross hybrid requires two stages of crossing involving two pairs of inbreds. Four-way (4W) or double crosses (DC) are the crosses of two different F1’s, AB *CD = (A*B) *(C*D) so that the hybrid is the result of equal contributions from four different lines.

Three way cross
Triple or three-way crosses (3W) crosses involve an F1 crossed to a third line, e.g., A*(B *C), which is often written as A*BC. The resulting individuals have 50% of their genes from line A, and 25% from each of lines B and C. main drawback in this cross is low pollen production.

Double top cross
It refers to the hybrid progeny between a single cross and an open pollinated variety.

Multiple cross
It is also known as composite cross. Involves more than four inbred lines.

PolyCROSS
It is the open pollination of a group of selected genotypes in isolation from other compatible genotypes to promote random mating among selected genotypes.

Modified cross
Modified cross involve two closely related populations (say A and A’).
- Modified single cross is (A*A’) *B.
- Modified triple cross is (A*A’) *(B*C).

Maize hybrids in India
In 1956, ‘Punjab Hybrid No. 1’, the first hybrid in India was released for general cultivation in Punjab. All the four parents of ‘Punjab Hybrid No. 1’ were from indigenous open - pollinated varieties. All India Coordinated Maize Improvement Project (AICMIP) was established in 1957. The initial emphasis was on development of double crosses. In 1961, four double-cross hybrids, viz., ‘Ganga 1’, ‘Ganga 101’, ‘Ranjit’ and ‘Deccan’ were released for commercial cultivation in India. Later there is a shift from the double crosses to open pollinated varieties in 1967. Thereafter, the shift from composites to three-way crosses and from three-way crosses to double-crosses and then combinations of composites, three-way and double crosses was continued till 1996.

In 1996, the first single cross hybrid ‘Paras’ was developed and released from Punjab Agricultural University, Ludhiana. After that several private research and development organizations came forward to develop and release hybrids in maize. Even after 1996 the emphasis on composites was continued but at the same time the several single cross hybrids were also released. The improvement gained through double, double top, three-way crosses and composite varieties were not significant as compared to present day single cross hybrids. However, the strategy to switch over to single cross hybrids started in 2006-07 which paid rich dividends.

In India, only about 30 per cent of the area is under Single Cross Hybrids (SCH). As per the Indian Maize Cultivar Database (IMCDB) maintained by DMR (now ICAR-IIMR) from 1961 to 2017, 226 hybrids were released for cultivation in different parts of the country. Of these, 117 hybrids were emanated from public sector and 109 notified hybrids from private sector. The database also highlights the development of 81 and 41 SCHs by public and private sector, respectively.
31. ENTOMOLOGY

New Invasive Pest of *Tuta absoluta* (Meyrick) and Their Management

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**Introduction:** Alien species are non-native species that occur outside their natural adapted ranges and dispersal potential. Some of the alien species become invasive when they are introduced deliberately outside their natural habits into new areas where they express the capability to establish, invade and out compete native species. Invasive alien species is an alien species which becomes established in natural or semi-natural ecosystems, an agent of change and threatens native biological diversity. These pests are not native in areas in which they cause problems and they are considered “invasive” because they invade and establish populations in new areas and the resulting uncontrolled population growth and spread causes economic or environmental problems. South American tomato pin worm, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) also known as the tomato leaf miner is one of the destructive invasive pest observed for the first time infesting tomato crop in Maharashtra, India. This pest has been classified as the most serious threat for tomato production worldwide. The pest has spread from South America to several parts of Europe, entire Africa and has now spread to India. Plants are damaged by direct feeding on leaves, stems, buds, calyces, young fruit, or ripe fruit and by the invasion of secondary pathogens which enter through the wounds made by the pest. It can cause up to 90% loss of yield and fruit quality under greenhouses and field conditions. The pest was initially observed in Pune on tomato plants grown in polyhouse and fields during October 2014. The specimens were collected, identified and deposited at National Pusa Collection (NPC), Division of Entomology, ICAR-IARI, New Delhi by P.R. Shashank and K. Chandrashekar, ICAR-IARI scientists. Subsequently the pest was observed in the farmer’s fields in major tomato growing districts of Maharashtra viz., Pune, Ahmadnagar, Dhule, Jalgaon, Nashik, and Satara. Severe infestation (>50% plants affected) was observed in several tomato fields. Following the reports of Maharashtra, recent surveys conducted by researchers of Network Project on Insect Biosystematics (NPIB), University of Agricultural Sciences, Bengaluru and ICAR-NBAIR, Bengaluru in January, 2015 observed the presence of this pest in Kolar and Bengaluru districts of Karnataka. The current report of *T. absoluta* from India is alarming because this pest is oligophagous and can attack several suitable solanaceous host plants. Present information is useful for adaptation of rapid response strategies against its invasion by educating farmers, extension entomologists and other stakeholders.

**Host Range:** It is serious pest of tomato, potato, brinjal and legume crops.

**Identification:** The moth has a grey-brown colour, is approximately 6 mm in size and has a wingspan of about 10 mm. Newly-hatched caterpillars are approximately 0.5 mm
in size and have a yellowish colour. When maturing, caterpillars turn yellow-green and a black band develops behind the head. Fully grown caterpillars are approximately 9mm in size with a pinkish colour on the back. The pupa is light brown and approximately 6mm in size.

**Nature of damage and Symptoms**

Although they prefer food plant like Solanaceous vegetable (1) Larva feeds on leaves, stems, buds, calyces, young fruit or ripe fruit (2) On leaves, acts as miner and on stem and fruit acts as borer (3) Affected leaves exhibit white patches which later dries up leading to burnt appearance (4) Affected fruits shows fine pin holes on the site of entrance and exit which lead to secondary infection and rotting (5) Affected stem dries up and droops down (6) Damage causes 50 to 100 per cent loss in yield and fruit quality (7) ETL level 2-5 miner per plant.

**Management Strategies**

IPM strategies for control *Tuta absoluta*. The integrated control method recommended employs the following (1) Use light traps and pheromone traps for monitoring (2) Deep summer ploughing to expose the resting stage of pests (3) Removing of crop residues and alternate hosts, (4) Crop rotation with non-solaneaceous crops (5) Destroy the affected plants and damaged fruits (6) The application of imidacloprid in the irrigation water 8-10 days after planting, chlorantraniliprole 20 SC (Rynaxpyr) @ 0.35 ml/l or cyantraniliprole 10 OD (Cyzapryl) @ 1.8 ml/l or indoxacarb 14 SC @ 75 (g a.i./ha) or dimethoate 30 EC @ 275 (g a.i./ha) sprayed at 10 days interval for control of this pest.

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**32. AGRI. BIOCHEMISTRY**

**Finger Millet: A Nutracereal**

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**Introduction**

Millets are the most important cereals of the semi-arid zones of the world. For millions of people in Africa and Asia it is a staple crops. Among millet crops, finger millet figures prominently; it ranks fourth in importance after sorghum, pearl millet and foxtail millet. Finger millet cultivation is more widespread in terms of its geographical adaptation compared to other millets. It has the ability to withstand varied conditions of heat, drought, humidity and tropical weather. It is an important staple in many parts of eastern and southern Africa, as well as in South Asia (ICRISAT, 2012). The name is derived from the seed head, which has the shape of human fingers. Locally, the crop is called *ragi* in India and *nageli* in Gujarat.

**Nutritional status of finger millet:**

Among the major food grains, finger millet is one of the most nutritious crops for protein, minerals (calcium and iron) and amino acids (methionine, an amino acid lacking in the diets of hundreds of millions of the poor who live on starchy foods such as cassava, plantain, polished rice, and maize meal) and provides 8-10 times more calcium than wheat or rice. Finger millet carbohydrates are reported to have the unique property of slower digestibility. The excellent malting qualities have added to the uniqueness of the grain in expanding its utility range in food processing and value addition. The crop is productive in a wide range of environments and growing conditions from southern Karnataka state in India, the foothills of the Himalayas in Nepal and throughout the middle-elevation areas of Eastern and Southern Africa (ICRISAT, 2012).

**Nutritional potential of millets in terms of protein, carbohydrate and energy values are**
comparable to the popular cereals like rice, wheat, barley or bajra. Finger millet contains about 5–8% protein, 1–2% ether extractives, 65–75% carbohydrates, 15–20% dietary fiber and 2.5–3.5% minerals. It has the highest calcium content among all cereals 344 mg/100 g. However, the finger millet also contains phytates, polyphenols, tannins, trypsin inhibitory factors and dietary fiber, which were once considered as “anti-nutrients” due to their metal chelating and enzyme inhibition activities but nowadays they are termed as neutraceuticals. The seed coat of the finger millet is an edible Component of the kernel and is a rich source of phytochemicals, such as dietary fiber and polyphenols. It is now established that phytates, polyphenols and tannins can contribute to antioxidant activity of the finger millet based foods. This is an important factor in health, aging and metabolic disease ((Devi et al., 2014).)

**Medicinal properties existing in finger millet:**

Finger millet is rich in calcium which helps in strengthening bones. Finger millet consumption helps in development of bones in growing children and in maintenance of bone health in adults. Finger millet keeps diseases such as osteoporosis at bay. Finger millet’s phytochemicals help in slowing digestion process. This helps in controlling blood sugar level in condition of diabetes and also helps in lower ability to increase blood sugar level. Finger millet contains amino acid methionine which helps in bringing down cholesterol level by eliminating excess fat from liver. Finger millet also contains threonine amino acid which hinders fat formation in the liver, which brings cholesterol level of the body down. Finger millet is a very good source of natural iron. Finger millet consumption helps in condition of Anemia. It is beneficial in conditions of anxiety, depression and insomnia. Finger millet is rich in amino acids which are vital in normal functioning of body and are essential for repairing body tissues. Finger Millet contains tryptophan, threonine, valine, isoleucine and methionine amino acids. Sulphur is essential for production of glutathione body’s natural antioxidant. If consumed regularly, finger millet could help in keeping mal nutrition, degenerative diseases and premature aging at bay. Green finger millet is recommended for conditions of blood pressure, liver disorders, asthma and heart weakness Finger millet is an extremely nutritious cereal and is very beneficial for maintaining a good health. However, its high intake could increase the quantity of oxalic acid in the body. Therefore, it is not advised to patients having kidney stones (Mall and Tripathi, 2016).

**Use of finger millet in human diet:**

Finger millet is considered as a coarse grain because of its fibrous and tough outer layer that irritates the tongue and not readily accepted for people accustomed for the consumption of wheat and rice. Apart from palatability it lacks gluten characteristic of wheat and hence does not lend itself for the preparation of chapathis or baked products. It has remained as the food of the lower socio-economic groups and traditional consumers, because of its coarse texture and intense colour of seed coat. Finger millet contains a large proportion of carbohydrates and thus provides bulk of energy in diets. It is also rich in proteins, sulphur containing amino acids and because of its low glycemic index with high fiber it is recommended for diabetic patients. Apart from the major nutrients, it also contains iron and calcium, which is deficient in most Indian women, high soluble fiber and low fat. It has proved to be very effective in controlling blood glucose level of diabetics. Consumption of finger millet prevents constipation and cholesterol. (Hittalmani, 2004)

Finger millet contains an amino acid called tryptophan. This lowers appetite and helps in keeping weight in control. Finger millet gets digested at a slower rate thus keeps one away from in taking excessive calories. Also, fibers present in finger millet give a feeling of fullness thus controls excessive food consumption. (Mall and Tripathi, 2016).

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Micropropagation

Micropropagation is the growing of plants from meristematic tissue or somatic cells of superior plants on nutrient suitable media under controlled aseptic physical conditions.

Objectives of Micropropagation

1. Production of virus free stock
2. To multiply plants whose multiplication rate is very low
3. To produce progenies which are genetically identical to their parents
4. To obtain genetic variability
5. Recovery of distant hybrids
6. Germplasm conservation
7. Germplasm exchange
8. Genetic transformation - addition or deletion of gene

Methods of Micropropagation

1. Micropropagation by axillary and apical buds
2. Micropropagation by axillary shoots (buds, bulbs and protocorms)
3. Micropropagation through callus culture
4. Artificial seeds
5. Somaclonal variations

Procedure - Steps of Micropropagation

Micropropagation procedure is divided in stages for the sake of understanding. Murashige proposed three (I to III) stages, Debergh and Maene added stage ‘o’. Currently we have accepted five stages procedure (0 to IV).

1. Stage 0
2. Stage I
3. Stage II
4. Stage III
5. Stage IV

Stage 0

Selection and maintenance of stock plants for culture initiation

This stage was basically introduced to overcome the problem of contamination. Stock plants are grown under more hygienic conditions to reduce the risk of contamination.

Stage I

Initiation and establishment of aseptic culture

Explant isolation - Virtually any part of the plant can be used as explant like vegetative parts (Shoot tip, meristem, leaves, stems, roots) or reproductive parts (Anthers, pollen, ovules, embryo, seed, spores). Shoot tip and auxiliary buds are most often used. Size of explant, age of the stock plant, physiological age of explant, developmental age of explant these are some of the factors which decide the success rate of stage I.

Surface sterilization - Explants are surface sterilized by treating it with disinfectant solution of suitable concentration for a specific period. Ethyl alcohol, bromine water, mercuric chloride, silver nitrate, sodium hypochlorite, calcium hypochlorite etc. can be used as disinfectant.

Washing - Washed with water.

Establishment of explant on appropriate medium - There is no one universal culture medium; however modifications of Murashige and Skoog basal medium (Murashige and Skoog, 1962) are most frequently used.
Stage II

Multiplication of shoots or somatic embryo formation

In this stage, rapid multiplication of the regenerative system is carried out for obtaining large number of shoots. About 4.3 X 10^7 shoots can be produced from a single starting explant in a year.

Cultures obtained from stage I are placed on a suitable medium. Normally, medium for stage I and II is same, but cytokinin proportion is increased for stage II to produce numerous shoots. This stage can be repeated a few cycles until an desired number of shoots are developed to carry out for rooting. Factors which can affect shoot multiplication are physiological status of plant material, culture media, and culture environment.

Stage III

Rooting of regenerated shoots or germination of somatic embryos in vitro

In this stage, shoots or shoot clusters from stage II are prepared to transfer to soil. Shoots are separated manually from clusters and transferred on a rooting medium containing an auxin. Elongation of shoots prior to rooting, rooting of shoots (individual or clumps), and prehardening cultures to improve survival are some of the activities carried under this stage. Sometimes, shoots are directly established in soil as micro-cuttings to develop roots.

Stage IV

Hardening

Transfer of plantlets to sterilized soil for hardening under greenhouse environment.

Advantages of Micropropagation

1. High multiplication rates (10^6 plants/year from a single explant).
2. Very small size explants can be used for micropropagation. This is impossible with conventional technique. Important when limited explant is available.
3. Material multiplied by micropropagation can be maintained in small place, packing and transport is also easy due to small size.
4. Micropropagation is the only viable method of multiplying genetically modified cells.
5. In case of dioecious species, where one of the sex is more desirable then under such circumstances plants of desired sex can be selectively multiplied by this technique.
6. The output is clean, healthy and pathogen free, as during micropropagation, fungi and bacteria are usually eliminated.
7. Easy export, no quarantine problem, as plants obtained is pathogen / virus / disease free.
8. Independent of the season; can be carried out throughout the year.

Limitations of Micropropagation

1. Requirement of sophisticated facilities
2. High production cost
3. Requirement of skill in handling and maintenance.
4. Somaclonal variations may arise during in vitro culture when a callus phase is involved.
5. For many valuable species suitable micropropagation techniques are not available (e.g. mango).
6. Vitrification can be a problem in some species.

34. AGRICULTURE

Sustaining Rice Productivity through Efficient Silicon Management

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The irrigated rice ecosystems account for 55 percent of the total harvested rice area, contributing 76% of the global rice production. Rice is the staple food for 67% of Indian population and there is need to add 2.5 million tons of milled rice every year to sustain self-sufficiency. India has the largest area under rice cultivation (44.6 mh) and occupies second
position in production (87.0 mt) only next to China among the rice growing countries of the world.

Scientists are reporting declining trends in the productivity of irrigated rice system and apparent decline and/or stagnation in growth of rice production has been observed not only in India but most of the Asian countries as well. The work conducted so far has failed to establish the positive correlation between declining rice yield under irrigated systems and available nutrients as well as deterioration in soil physical properties under long term fertility experiments in continuous intensive cropping system. For proper exploitation of yield potential of rice, plants nutritionists consider improving the management of N, P, K, S & micronutrients. Of late they are including silicon, due to rice being silicon accumulator. Rice removes about 400-500 Kg silicon from 5-6 tons rice grains/ha. Silicon is the second most abundant element after oxygen and makes out to 28% to the weight of earth’s crust. In India the traditional rice growing belt is located in north eastern and southern part. These regions are characterized with hot summer followed by heavy rainfalls which result in basic hydrolysis in the soil forming process coupled with leaching of silicon surface soil. Due to synergistic effect, silicon application has the potential to raise the optimum nitrogen rate leading to enhance rice productivity. Fertilization with nitrogen tends to make rice leaves droopy whereas silicon kept them erect which could easily account for a 10% in photosynthesis with similar increase in yield.

Among fertilizer use efficiency for various nutrients applied, phosphatic fertilizer use efficiency increased from 26 to 34% when it was applied along with silicon fertilizer, because silicon application reduces phosphorus retention capacity of soils leading to increased water soluble phosphorous level. Silicon application @ 140 to 280 kg/ha increased rice yield in response to applied potassium. Silicon and potassium balance in upland rice get upset when plants were grown at low soil moisture and high humidity and thus, plants were more susceptible to abiotic and biotic stress. Besides an excess of anion over cations due to silicon addition in soil increase the pH in the rhizosphere and decrease the availability of toxic elements i.e. Al, Fe, Mn, and Cd etc under acidic condition. Thus, high concentration of silicon in plant grown under acidic soil serve to create an alkaline rhizosphere that could decrease the availability of Fe in the acidic soil and at the same time it mobilizes insufficient available Fe, Zn as well as other micronutrients more efficiently through phytosiderophore based strategy of plant Fe acquisition in calcareous soil.

Visualize the removal of silicon from soil due to intensive rice cultivation; a stage has reached where rice is responding. Silicon should be incorporated as a component of INM as basal application @120 kg/ha. Silicon application as 50% through rice straw compost has given best response. Basal application is the best mode of silicon application for sustaining rice productivity.

35. GENETICS AND PLANT BREEDING

Green Super Rice

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Introduction

Rice [Oryza sativa (L.) (2n=24)] belongs to family Gramineae, Sub family Bumbusoideae, Tribe Oryzeae and Sub tribe oryzineae. This tribe has 11 genera of which Oryza is the only one with cultivated species. The genus Oryza has two cultivated species Oryza sativa (Asian rice) and Oryza glaberrima (African rice). Cultivars of O. sativa viz., indica, japonica and javanica are the result of centuries of selection by man and nature for desired quality and adaptation to new niche.

Green Super Rice (GSR)

It is bred to perform well in the toughest conditions where the poorest farmers grow rice.
GSR is actually a mixture of more than 250 different potential rice varieties and hybrids adapted to stress tolerance, less fertilizer and with rapid establishment rates to out-compete weeds. Green super rice—"Green" means environment friendly because it yields more even with low inputs; and "Super" because it is able to tolerate drought, flooding, salty water, and insect-pests. GSR varieties retain their stable, sustainable yield potential even when grown with lower inputs or under unfavorable environmental conditions (Ali et al. 2013).

**Objective**

1. To develop GSR inbred and hybrid rice varieties through shuttle breeding approach and molecular marker-assisted breeding.
2. In India, 13 GSR varieties are nominated in national coordinated trials and several of these promising GSR materials will be released soon. In Bangladesh, a weed-competitive GSR variety called BRRIdhan69 has just been released. The variety can produce up to 8.2 t/ha and can thrive over weeds in the early nursery stage. It is also suitable for north-eastern regions of India during the boro (dry) season.
3. To test and release newly developed and promising GSR varieties in target countries.
4. To improve GSR breeding technology and seed production for countries.

**Biological feature of GSR**

Besides continued yield increase and quality improvement, Green Super Rice possesses resistance to multiple insects and diseases, high nutrient use-efficiency, drought resistance, promising great reduction in the consumption of pesticides, chemical fertilizers, and water. Large efforts have been focused on identifying germplasms and discovering genes for resistance to diseases and insects, N- and P-use efficiency, drought resistance, grain quality, and yield. Grain yield in different GSR genotypes were positively correlated with leaf area at an early stage of the crop. Genotypes with a larger leaf area could be integrated with other weed management strategies to achieve sustainable weed control in dry-seeded rice systems (Bhagirath et al. 2015). The approaches adopted include screening of germplasm collections and mutant libraries, gene discovery and identification, microarray analysis of differentially regulated genes under stressed conditions, and functional test of candidate genes. Genes for almost all of the traits have now been isolated in a global perspective and are gradually incorporated into genetic backgrounds of elite cultivars by molecular marker-assisted selection. It is anticipated that such strategies and efforts would eventually lead to the development of Green Super Rice (Zhang et al. 2007).

**Advantages**

1. The variety can produce up to 8.2 t/ha and can thrive over weeds in the early nursery stage.
2. Yield benefits from GSR varieties could improve rice food security and help alleviate poverty in the country.
3. It is also suitable for north-eastern India during the boro (dry) season.
4. Breeding of rice varieties with low carbon dioxide equivalent (CO$_2$) emission is essential in reducing global greenhouse gas (GHG) emissions. Increasing grain yield per unit area with shorter growth duration decreased CO$_2$ emission of rice per unit of weight. Cultivation of rice varieties GSR8 and GSR2 emitted 37.0% lower CO$_2$ than the popular inbred varieties (Taghavi et al. 2017).

**Challenges**

1. Increasing severe occurrence of insects, diseases and indiscriminate pesticide applications.
2. High pressure for yield increase and over use of fertilizers.
3. Water shortage and frequent occurrence of drought.
4. Extensive cultivation in marginal lands.

**References**

36. VEGETABLE SCIENCE (HORTICULTURE)

Mukibat System of Grafting: An Innovation to Increase Productivity in Cassava

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'Mukibat' is a grafting system for cassava seedling production. It uses rubber cassava (Manihot glaziovii), a perennial tree cassava as a scion and a superior or local cassava variety (M. esculenta) as the rootstock.

The technology was developed in 1952 by a farmer named Mukibat in Kediri District, East Java, Indonesia to increase productivity. According to villagers from Ngadiloyo, where Mukibat lived, Mukibat got the idea of combining tree cassava with ordinary cassava after following a course given by the Agricultural Extension Service in which participants had to do some individual grafting work. Though initially Mukibat budded the cassava tree onto the stock, grafting became more popular later on. Mukibat planted the budded cuttings in his farm yard on spots where organic matter had been put in the soil before planting. This creates a favorable situation for the cuttings to grow.

Mukibat cassava grows well in medium-shaded environments where normal cassava would not produce tubers. Technology includes: Scion – tree cassava i.e. cea rubber tree (Manihot glaziovii), rootstock – superior or local cassava variety of M. esculenta, bamboo stick to strengthen the grafting, plastic to wrap the connection and seedlings shelter. Planting material should be prepared during the dry season and be ready for planting when the rainy season starts. At present the most common way of applying the Mukibat system is as follows: a scion of tree cassava, length 10-15 cm, is grafted on a piece of stem of ordinary cassava, length 20-30 cm, diameter 2-4 cm, serving as a stock. Scion and stock, which have to be exactly of the same diameter, are cut slantwise. A thin piece of bamboo is put into the pith of both scion and stock to facilitate the connection, and both stem pieces are connected often with banana leaf fibre. The cuttings are put under shade and watered daily. After about 8 days sprouts start to grow. Sprouts are removed from the stock. When the sprouts from the scion are about 2 cm long the grafted cuttings can be planted in the field. A hole normally is made before planting in which organic matter is mixed with the soil, after which the holes are filled up with soil and hilled up. The grafted cuttings, one per hill, are planted in a vertical position. Plant care is rather similar to the way in which ordinary farmers protect their plants by supporting them with bamboo. Plant spacing is very variable, especially under intercropping conditions. But normally a spacing of 1.25 m x 1.50 m is quite common. Cassava usually does not need irrigation and can be a rainfed crop. Mukibat cassava needs sufficient water during the first growth so the planting should be done at the beginning of the rainy season. The growing period may vary from 8 to 18 months; harvesting mostly takes place about 12 months after planting.

Plants are usually spaced 1.25 x 1.50 m but spacing can vary, especially with intercropping. The cropping period can vary from 8 to 18 months; most farmers harvest about 11-12 months after planting, once a year. Older roots may become too fibrous and woody for human varieties. Journal of Agricultural Sciences 9:107-123

consumption. Grafted plants can be used again for a second and third year. The technology is expected to last for 36 months with 3 harvests. The second and third planting will reduce the cost of seedlings as these can be obtained from first and second harvests. The technology has a potential to yield 80-100 tonnes per hectare. Returns can be increased despite higher production costs. The practice is steadily expanding, mostly for home yard production.

37. CROP PROTECTION

An overview on Entomopathogenic Nematodes

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Entomopathogenic nematodes (EPN): The nematodes which infect insect pests and complete their development at host’s expense

Steinernema spp and Heterorhabditis spp.

The infective juveniles of Steinernema spp and Heterorhabditis spp. have symbiotically associated bacteria in their gut which cause pathogenicity in wide variety of insect pests (larvae/pupae and adults) of agricultural and horticultural crops.

Symbiotic bacteria associated with EPN

1. The bacteria of the genus Photobacterium and Xenorhabdus are associated with the infective juveniles of Heterorhabditis spp. (Heterorhabditidae) and Steinernema spp. (Steinernematidae) respectively.

2. Photobacterium spp has bioluminescent activity and emits the light under stationary phase and in the infected host cadavers.

Infective juvenile (IJ)/ Dauer juvenile

1. The infective third stage juvenile of EPN which initiates the infection in the respective host. It is the only free living and non feeding stage lies outside the insect host and all the other stages (fourth stage, adult and egg stage) are completed inside the host.

2. Infective juveniles/dauer juvenile are enclosed in a second stage cuticle which arrests further development.

3. Survive in the soil environment, capable of withstanding low or high temperature and desiccation.

4. Enters the perspective insect host through natural openings - mouth, anus, spiracles and intersegment region of host cuticle

(Heterorhabditis spp.)

Life cycle of EPN

1. The infective juveniles infect insect host through natural openings and get access to hemocoel. In the hemocoel IJs release associated symbiotic bacteria and it multiplies very rapidly. During the process of multiplication plethora of toxins/metabolites produced by nematodes and symbiotic bacterium kills the host usually with in 48 hrs. After the depletion of nutrients the infective juveniles leave the host cadaver seeking new hosts.

2. When IJs infect the hosts, generally 2-3 generations are completed within the host cadaver and after the completion of nutrients IJs emerge from the cadaver to seek new hosts. The penetration of IJs to emergence of new IJs from the host cadavers usually completes in 12-15 days at room temperature.

3. Steinernema spp infected larvae turns creamy/dark brown colour and Heterorhabditis spp. infected larvae turns reddish colour due to metabolites produced by the respective symbiotic bacterium

Production of EPN

There are two techniques of production of EPN viz., in vitro and in vivo method. For a small scale production of EPN, in vivo method is employed whereas for the large scale production in vitro method is followed. Since in vitro technique is costly and needs thorough knowledge on bioreactor technology, biology of entomopathogenic nematode and symbiotic bacteria, in vivo technique is quite popular in India. In in vivo technique production of EPN is...
carried out in insect hosts mainly wax worms *Galleria melonella*.

(Source: Prabhuraj A, 2016, Lecture on Biological Control, Agmoocs.)

**In vivo production of EPN**

In this method the host larvae are inoculated with infective juveniles of EPN in dishes or in trays lined with a filter paper or any other absorbent substrate. The host will die within 24-48 hours of EPN infection. After 48-72 hours, the cadavers are transferred to the White traps. These White traps are then held in an incubator for 10-12 days at optimum temperature (24-28°C). After 10-12 days infective juveniles of entomopathogenic nematode start emerging from cadavers and moving into water in the White trap. Emerged infective juveniles are then harvested from the traps, cleaned and concentrated by gravity settling. These cleaned nematodes are ready for laboratory use or field applications.

**EPN as safe biological control agents**

The EPN *Steinernema* spp and *Heterorhabditis* spp are considered as safe biological control agents for the management of insect pests mainly soil dwelling pests of many economically important crops. The following are the important attributes to consider them as most beneficial.

1. Wide host range (> 200 insect species of 10 orders)
2. Quick mortality of the host (24 – 48 hr)
3. Infective stage (3rd stage) is non feeding, free living and capable of withstanding adverse climatic changes
4. Can be easily mass produced both *in vivo* and *in vitro* methods
5. Good shelf life and easy to apply
6. Compatible with most of the greener chemical pesticides and bio-pesticides,
7. No resistance build up in insect pests
8. Safer to non target organisms
9. Exempted from registration and regulation requirement

**References**


