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NEWSLETTER

NUTRITIONAL AND PHYSIOLOGICAL DISORDERS IN HORTICULTURAL CROPS

NEW RELEASE

G. Pathmanaban
A.U. Thangavelu, S. Saravanan
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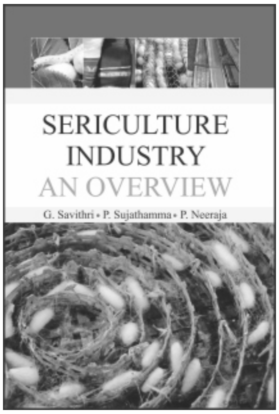

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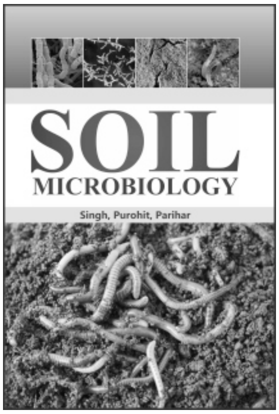

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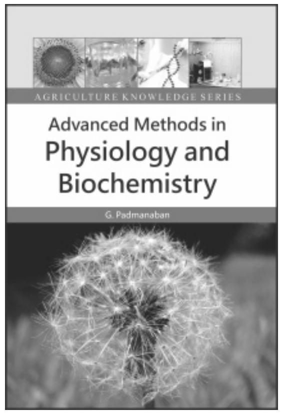

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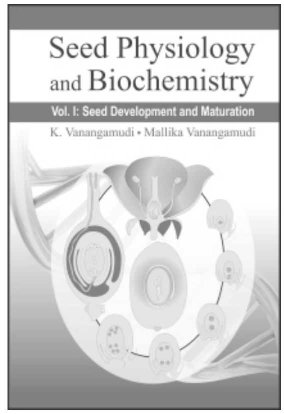

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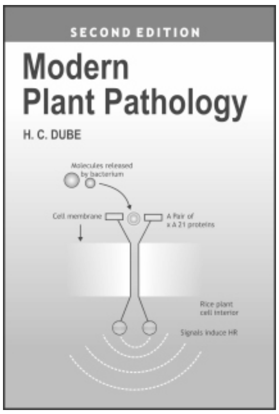

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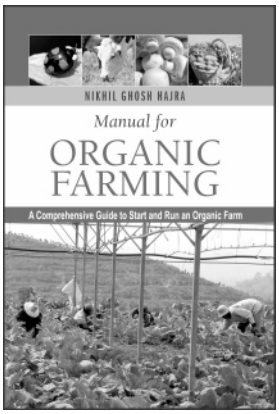

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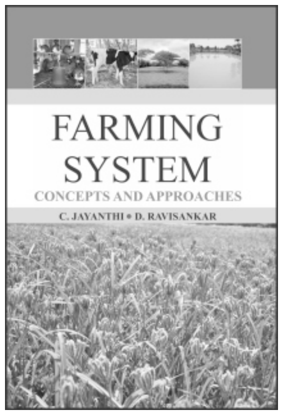

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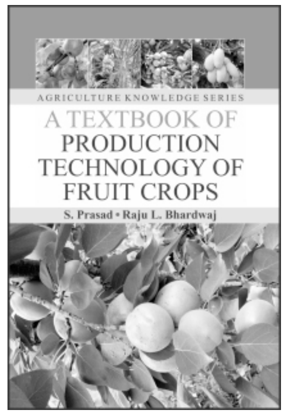

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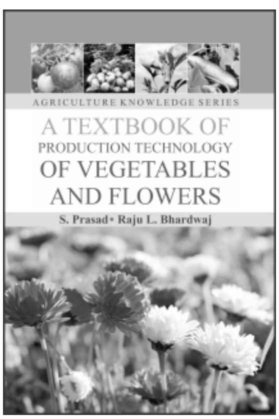

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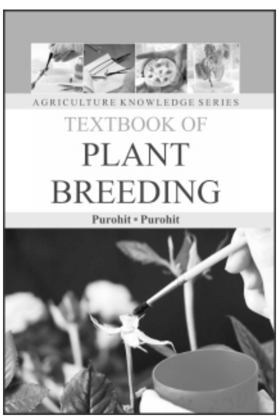

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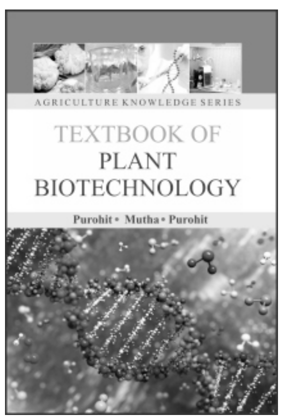

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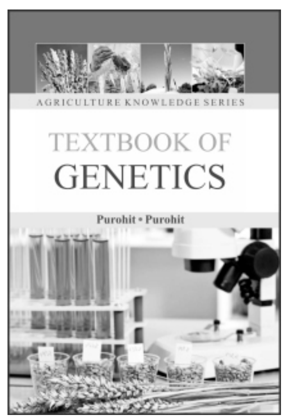

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1. BIOTECHNOLOGY 14862

Conservation of Genetic Resources

Savita Kanthi, Maktumsab M. Tahshildar, Ishwar Boodi Guljar Dambal and Laxmi Kamagond

RARS, Vijayapura, UAS Dharwad

Due to rapidly growing human population, plant and agriculture scientists have produced many new varieties to feed the population. Because the traditional and wild varieties cannot meet the demand of increasing population. But the traditional varieties need to be preserved because they are important for future breeding programmes. However, there is danger of erosion of genetic resources due to extensive use of newly introduced varieties. In 1972, conservation of habitats rich in genetic diversity was recommended in the UN conference. Then an International Board for Plant Genetic Resource (IBPGR) was established. This board has objectives to provide necessary support for collection, conservation and utilisation of plant genetic resources from anywhere in the world. India has also established the National Bureau of Plant Genetic Resources (NBPGR), Pusa Campus, and New Delhi for similar objectives.

1. Modes of Conservation

It has been estimated that about 9,000 wild plant species are threatened. Global climatic changes also affect the natural plant habitats, thereby contributing to rapid changes in agricultural strategies. There are two modes of conservation of plant species as given below:

a) **In Situ Conservation:** Since 1980, in situ conservation has received high priority in the world conservation strategy. The method of conservation is to preserve land races with wild relatives in which genetic diversity exists.

b) **Ex Situ Conservation:** It is the chief mode of conservation of genetic resources including both cultivated and wild ones. Under suitable conditions genetic resources are conserved for a long term as gene bank. Such gene bank is of two types:

   i) ***In Vivo* Gene Bank:** Generally plant seeds, vegetative propagules are used for storage for long time. The whole plants are preserved. This type of conservation strategy is called in vivo gene bank. In this approach, conservation method of storage is used for preservation of plant genetic resources,

   There are several limitations in germplasm conservation done by conventional methods. These includes: seed dormancy, seed- borne disease, short-life of seeds, high inputs of cost and labour and non-applicability to vegetatively propagated crops (*e.g.* Dioscorea, Ipomoea, potato, etc.).

   ii) ***In Vitro* Gene Bank:** This approach includes the conservation of genetic resources by non-conventional methods. In this approach explants are grown on medium. The genetic resources are conserved in the form of in vitro maintained plant cells, tissues and organs. By doing so the germplasm is made available to breeders so that new and improved varieties could be developed

2. Methods of Preservation

There are several methods for preservation of plant materials. A few of them are briefly discussed herewith.

a) **Free Preservation or Cryopreservation:** Cryopreservation (Latin Kuos means frost) means storage of materials at very low temperature. Plant cells and tissue cultures are brought to zero state of metabolism by subjecting them to ultra-low temperature *i.e.* -I96°C. It is done by using liquid nitrogen which provides approximately -496°C. Cryo-protectants (*e.g.* glycerol, proline, mannitol, dimethylsulfoxide, sorbitol) are also used to protect the viable cells from the damage during freezing and thawing (to become unfrozen or warm). Cryo-protectants minimize the harmful action of electrolyte concentration that results after conservation of water into ice. Applying cryopreservation plant cell and tissues can be cultured for indefinite time.

b) **Cold Storage:** Germplasm of some plants (in the form of shoot tips, nodal or meristem explant culture) are stored at low and non-freezing temperature (1-9°C). At low temperature, growth of plant material is slow down but not completely stopped as in cryo-preservation. In cold storage there is no risk of cold injuries. Cold storage is successful for in vitro derived shoots/plants of fruit species. About 800 cultivars of grape plants have been stored for over 15 years at 9°C by yearly transfer to fresh medium.

c) **Low-Pressure and Low-Oxygen Storage:** For conservation of cultured plant materials low-pressure storage (LPS) and low-oxygen storage (LOS) have been developed. There are alternative methods of cryopreservation and cold storage. In LPS, the atmospheric pressure surrounding the tissue cultures is reduced, while in LOS inert gases (especially nitrogen) are combined with oxygen to create low oxygen pressure.

2. BIOTECHNOLOGY 15431

Plant Molecular Pharming for Recombinant Therapeutic Proteins

K. Satish

Ph.D. Research Scholar, Department of Genetics and Plant Breeding, C.P.C.A., S.D. Agricultural University, S. K. Nagar-385506, Gujarat, India.

INTRODUCTION: Molecular farming is the production of pharmaceutically important and commercially valuable medicines, diagnostic proteins and/or industrial enzymes in plants. Molecular Farming combines biotechnology and agriculture to produce new goods for the world. The recent emerging field which relies on plant biotechnology and recombinant DNA techniques to produce recombinant proteins in plants. Plants have been a primary source for medicinal products for many centuries. Advances in molecular biology have resulted in the ability to produce some drugs by recombining the gene for the desired product within the genetic material of organisms. Molecular farming is one such strategy and can be defined as the use of whole organisms, organs, tissues or cells or cell cultures, as bioreactors for the production of commercially valuable products via rDNA techniques.

History of Molecular Farming

In 1986, the first plant derived therapeutic protein, rhGH was produced in tobacco. In 1989, first plant-derived recombinant antibody-full sized IgG was produced in tobacco. By 1990, first native human serum albumin was produced in tobacco and potato. Also in 1992, the first plant derived hepatitis B virus surface antigen and first plant derived industrial enzyme, -amylase was produced in tobacco. In 1997, a first clinical trial using recombinant bacterial antigen was delivered in transgenic potato and also the commercial production of avidin was done in maize. In 2000, Human GH was produced in tobacco chloroplast. By 2003, first marketed plant derived protein, bovine trypsin was produced in maize (Obembe *et al.*, 2011).

General Strategy in Molecular Farming

Vector Design   Vector Construction   Plant Transformation   Plant Regeneration   Selection of elite producer's   Protein Characterization   Downstream Processing   Pre-clinical and clinical trials

Why Plants for Molecular Farming

Plants have natural ability to make human and animal proteins. Low cost of production. Products produced in plants can be stored for long periods without refrigeration if they are expressed in seeds or leaves which can be stored dried. Plants had the potential to produce complex mammalian proteins of medical importance. Free from animal and human virus. Arabidopsis *thaliana* is used as a model plant. Easily reproducible; cereals, legumes, leafy crops, fruits, and vegetables are used (Sahu *et al.*, 2014).

Different Plant based Production Systems

- Stable nuclear transformation
- Plastid transformation
- Transient transformation
- Stable transformation for hydroponics

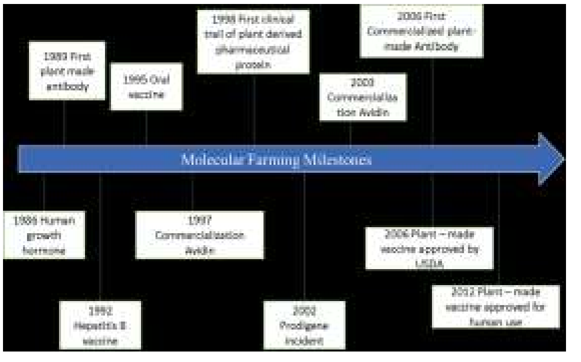

FIG. 1: History of molecular farming

Downstream Processing and Recovery

- It is the isolation and purification of the product from the raw biomass. Downstream processing represents up to 80% of overall production costs
- Basic steps: Removal of insolubles   Product isolation   Product purification   Product Polishing

Applications

1. Parental therapeutics and pharmaceutical intermediates,
2. Industrial proteins and enzymes
3. Monoclonal antibodies
4. Biopolymers
5. Antigens for edible vaccines

Monoclonal antibody (mAb): Antibody that is produced by genetically engineered plant *i.e.* insertion of antibodies into a transgenic plant;

referred to as plantibody. Traditional system of production is mammalian cell culture. Antibodies direct against arthritis, *cholera*, *E. coli* diarrhea, malaria, certain cancers, Norwalk virus, HIV, influenza, hepatitis B virus etc.

Edible vaccines: The concept of edible vaccine got incentive after expressed hepatitis B antigen in tobacco. A vaccine developed by engineering a gene for an antigenic protein into a plant. Due to ingestion, it releases the protein and gets recognized by the immune system. Stimulate both humoral and mucosal immunity. It is feasible to administer unlike injection, heat stable no need of refrigeration. Expressed in the edible portion like tubers, fruits etc.

Industrial enzymes: Includes hydrolases, encompassing both glycosidases and proteases. Enzymes involved in biomass conversion for producing ethanol are candidates for molecular farming. These products are usually characterized by the fact that they are used in very large quantities and must therefore be produced very inexpensively. Avidin and bacterial B-*glucuronidase* (GUS) from transgenic maize have been commercially produced.

Biosafety Issues in Molecular Farming

- Gene and protein pollution
- Product safety
- Vertical gene transfer
- Horizontal gene transfer

Conclusion

- Plants are proving to be effective and efficient bioreactors for the production of pharmaceutically valuable recombinant proteins. Variety of plant species that are being explored to serve as green bioreactors, each with its own advantages and disadvantages.
- Transgenic plant shows low production cost, high productivity, no risk of contamination and easy storage compared to transgenic animal. Thus it serves as an alternative to conventional fermentation systems that use bacteria, yeast or mammalian cells.
- There are several plant-based expression systems that are currently being explored to serve as production platforms, each offering specific benefits.
- PMPs have already achieved preclinical validation in a range of disease models like hepatitis B, rabies etc.

Future Thrust

- Plant-derived pharmaceuticals will need to meet the same safety and efficacy standards as those products obtained from non-plant sources.
- We must ensure that the potential benefits are not outweighed by risks to human health.
- Plant based recombinant therapeutics can neither commercially succeed nor be accepted without addressing proper biosafety and immunogenicity issues.
- Efforts are required to make this technology non-allergic and free from side effects.
- Downstream processes for this technology should be properly employed for more economic use.

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3. BIOTECHNOLOGY 15488

Bioleaching Technology

Saurabh S. Kadam and Devendra V. Rasam

College of Agricultural Biotechnology, Kharawate-Dahiwali

Bioleaching is a process that employs microorganisms to dissolve (leach) sulphide minerals. It finds application in the extraction of metals from their ores. Although bioleaching was used unknowingly by the ancients to extract metals (principally copper) from ores, the development of modern commercial bioleaching processes is relatively new. It began in the late 1940s, with the discovery of the role of bacteria in the formation of acid mine drainage. From there, research and development activities in the field flourished, and the earliest commercial applications of the process involved *in situ* leaching of uranium in Canada and dump leaching of copper in the United States.

The development of bioleaching and biomining technologies has been ongoing for several decades, and more recently is finding increased interest in commercial application. Advances in molecular microbiology and genomic sciences present new opportunities for discovering, characterizing and implementing microbial systems for the recovery of base, precious and strategic metals.

All microorganisms can excrete organic acids especially when growth is unbalanced. Lactic acid bacteria and acetic acid bacteria are well known and mineral weathering by fungi (and algae) largely occurs through organic acid production. Organic acids, such as oxalic, citric, gluconic, malic and succinic acids, together with amino acids, nucleic acids and uronic acids, can dissolve minerals via salt formation and complexation reactions. In many studies on the bioleaching of oxidized ores such as nickel laterites, the aim was to exploit organic acid production by selected fungi such as Aspergillus species to extract nickel and cobalt.

The Chemistry and Microbiology of Mineral Dissolution

The deliberate exploitation of microorganisms in the process of extracting metals (mainly copper) from ores under acidic conditions has an extremely long history, even though the roles of those microorganisms in both extraction and the generation of acid rock drainage (ARD) were not originally recognised. The summaries of the leaching chemistry and microbial characteristics that assist mineral dissolution are presented as following point;

1. *Mineral Dissolution in Acidic Environments:* Acid leaching of ores or sediments involves the dissolution of minerals. Some minerals dissolve congruently (*e.g.*, calcite, reaction), in which case the resulting soluble species have the same stoichiometry as the source material.
2. *Bio-Generation of Inorganic Acids:* Mineral structures can be weakened through the action of microbially-generated inorganic acids such as nitric and nitrous acids, sulfuric and sulfurous acids, and carbonic acid.
3. *Bio-Generation of Organic Acids and Chelating Agents:* All microorganisms can excrete organic acids especially when growth is unbalanced. Lactic acid bacteria and acetic acid bacteria are well known and mineral weathering by fungi (and algae) largely occurs through organic acid production.
4. *Biodegradation of Organo-Metallic Compounds:* Deposits of interest in this review include the black schists and shales, for which there are considerable data on ore geochemistry and ore genesis. Black schists in Finland encountered as interlayers in mica schists contain 1%–2% of non-carbonate carbon and those associated with serpentinite-quartz rock-skarn assemblages contain, on average, 7% non-carbonate carbon.
5. *Bio-Participation in Redox Reactions:* Some bacteria and archaea are able to oxidize reduced species of manganese (II), iron (II), cobalt (II), copper (I), arsenic (AsO^{2-}) or selenium (SeO^{42-} or SeO^{32-}) and others can reduce manganese (IV), iron (III), cobalt (III), arsenic (AsO^{42-}) or selenium (SeO^{42-} or SeO_3^{2-}), obtaining energy from the reactions. Well known examples are *At. ferrooxidans* and *Leptospirillum (L.) ferrooxidans*, both of which can obtain all of their energy for growth from the oxidation of iron (II) to iron (III).
6. *Microbial Growth under Element Stress:* A key challenge to microbial growth is solution chemistry. High concentrations of cations and anions build up in recycled process solutions during leaching. Thus, depending on the mineral concentrate and processing conditions, concentrations in stirred tank leachates may be up to ($g{\cdot}L^{-1}$): Zn 65, Fe 60, Cu 35, Ni 25, As 20, Co 5, Mg <1, and SO_4^{2-} 145.
7. *Technology Developments:* Different bioleaching technologies have been developed and/or refined during the last 65 years. They include some novel designs tested at laboratory and pilot scale but not finding wide industry acceptance: the flood-drain bioreactor, the aerated trough bioreactor, the airlift bioreactor and the rotating-drum bioreactor.

The chemistry of the bioleaching process is relatively straightforward. The bioleach microorganisms catalyse the oxidation of ferrous iron and sulphur, to produce ferric iron and sulphuric acid, according to:

$$Fe^{2+} + \frac{1}{4} O_2 + H^+ \quad Fe^{3+} + 1/2\, H_2O$$
$$S + 3/2 O_2 + H_2O \quad H_2SO_4$$

The ferric iron reacts with mineral sulphides to produce ferrous iron and sulphur, according to the following general scheme of reaction:

$$MS + 2Fe^{3+} \quad M^{2+} + 2Fe^{2+} + S.$$

The micro-organisms applied in bioleaching comprise consortia that are characterised principally by their useful range of operating temperature. The *mesophiles*, which are bacteria that operate well between 30 and 42 °C, include *Acidithiobacillus ferrooxidans*, *Acidithiobacillus caldus* and *Leptospirillum ferrooxidans*. Other *Acidithiobacillus* species also thrive in this temperature range. The *moderate thermophiles* are mostly bacteria that exist within a relatively narrow temperature range of 45 to 55 °C, and include several of the Sulfobacillus, Acidimicrobium and Ferroplasma species, as well as Leptospirillum ferriphilum and Acidithiobacillus caldus. The extreme thermophiles, which are dominated by archaea (as opposed to bacteria), and thrive at elevated temperatures of between 60 and 90 °C, include various species of *Sulfolobus*, *Acidianus* and *Metallosphaera*.

Benefits of Bioleaching

- Simple and inexpensive process. Substantially lower capex and opex than in traditional smelting and refining processes.
- No sulfur dioxide emissions as in smelters.
- No need for high pressure or temperature.
- Leaching residues less active than in physico-chemical processes.
- Ideal for low grade sulfide ores – lower cut-off rate possible.

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4. BIOTECHNOLOGY 15496

The Molecular Wires

Devendra V. Rasam and Saurabh S. Kadam

College of Agricultural Biotechnology, Kharawate-Dahiwali

The ability to utilize single molecules that function as self-contained electronic devices has motivated researchers around the world for years, concurrent with the continuous drive to minimize electronic circuit elements in semiconductor industry.

Macroscopic wires, namely ordinary metallic wiring, which pass the electron flow in refrigerators, televisions, stereos, computers, household lightning, etc., measure approximately 1 cm in diameter. Going beyond that first level of wiring much smaller wires (approx. 1 mm in diameter) are found on printed circuit boards as they connect smaller components, *e.g.* resistors, logic chips, rheostats, etc. The next step takes us inside logic chips, for instance. Here, we will come across wires, 10th of an l m wide, which are used to connect solid-state transistors carved out of silicon only. Connecting thousands of such transistors allows performing logic operations. Considering current technologies, this would be pretty much the end of our journey. Reaching beyond this obliges us to overcome the limits of present semiconductor manufacturing methods. Molecular wires would constitute a potential solution. Recent breakthroughs have produced molecular-scale wires, ranging in length from 1 to 100 nm and width from 0.3 nm on up.

Furthermore, we can tune the physical properties of such a wire in the same way as we can change the raw material used to make it. Thus, the small size, the synthetic diversity, the efficient synthesis of macroscopic amounts in small reactors are reason enough to prosecute molecular wire research and provide a rational motivation for this thesis: Characterizing several classes of molecular wires.

Generally speaking, the two basic requirements for electronic conduction in a material are: (1) a continuous system of a large number of strongly interacting atomic orbitals leading to the formation of electronic band structures and (2) the presence of an insufficient number of electrons to fill these bands. In inorganic semiconductors and metals, the atomic orbitals of each atom overlap with each other in the solid state creating a number of continuous energy bands and the electrons provided by each orbital delocalized throughout the entire array of atoms. The strength of interaction between the overlapping orbitals determines the extent of delocalization, giving rise to the band width. Likewise, in a molecule, a set of overlapping delocalized electronic states across the entire molecule is necessary for electronic conduction. A brief review of basic concepts underlying the physics and chemistry of conjugated oligomers as follows should help to understand electronic transport in molecular systems.

Bonding in Molecular Orbitals

The molecular orbitals (MO) of a molecule are created by the overlap of the atomic orbitals of its constituents. For instance, a bonding MO - bond is formed when two sp3 hybridized atomic orbitals form head-on overlap, with electron density localized between two bonded nuclei. It is a single bond and acts essentially as structure glue (a bond with no node). A bonding π bond is formed when remaining parallel p orbitals on two sp2 hybridized atomic orbitals combine with each other. Compared with a bond, a π bond is often weaker and less localized (two bonding regions above and below a nodal plane, because bond - the ground state has zero nodes, while π bond - the first excited state has one node). Together the bond and π bond make a double bond (*e.g.*, C_2H_4); whereas linear triple bonds (*e.g.*, in alkynes (C_2H_2) and nitriles) are the results of the formation of two π bonds using two mutually perpendicular p orbitals on each of the triple bonded atoms, with a bond in the middle.

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5. BIOTECHNOLOGY 15849

Blast (Basic Local Alignment Search Tool)

Pitambara[1] and Prachi Singh[2]

[1]*Department of Agricultural Biotechnology, Anand Agricultural University, Anand, Gujarat, India*
[2]*Department of Mycology and Plant Pathology, Banaras Hindu University, Varanasi, Uttar Pradesh, India*

BLAST (Basic *Local* Alignment Search Tool) is a set of similarity search programs designed to explore all of the available sequence databases regardless of whether the query is protein or DNA. "local" means it searches and aligns sequence segments, rather than align the entire sequence. It's able to detect relationships among sequences which share only similarity of some region. Currently, it is the most popular and most accepted sequence analysis tool.

The BLAST program was designed by Eugene Myers, Stephen Altschul, Warren Gish, David J. Lipman and Webb Miller at the NIH and was published in J. Mol. Biol. in 1990. The main idea of BLAST is that there are often high-scoring segment pairs (HSP) contained in a statistically significant alignment. BLAST searches for high scoring sequence alignments between the query sequence and sequences in the database using a heuristic approach that approximates the Smith-Waterman algorithm. The BLAST algorithm uses a heuristic approach that is less accurate than the Smith-Waterman algorithm but over 50 times faster. The speed and relatively good accuracy of BLAST are among the key technical innovations of the BLAST programs.

Why BLAST?

It is used to identify unknown sequences - The best way to identify an unknown sequence is to see if that sequence already exists in a public database. It help in gene/protein function and structure prediction – genes with similar sequences tend to share similar functions or structure. It identifies protein family – group related (paralog or ortholog) genes and their proteins into a family.

Steps while Performing BLAST

(1) Choose the sequence (query) (2) Select the BLAST program (3) Choose the database to search (4) Choose optional parameters. Then click "BLAST".

How does the BLAST Work

BLAST works through use of a heuristic algorithm. BLAST finds homologous sequences, by comparing sequences, and also by locating short matches between the two sequences. This process of finding initial words is called seeding. After this first match that BLAST begins to make local alignments and find homology in sequences. Sets of letters, known as words, are very important.

For example, Compare query sequence to every database entries. For each entry, if there are segments of certain length (word size) similar to part of the query sequence, they have a hit.

- Query: GTTGACCGTTAGCCGACGTTAAGCT
- DB entry: ACATAGCCCGTTAGCCGCTGATACGACCG T

Once both words and neighbourhood words are assembled and compiled, they are compared to the sequences in the database in order to find matches. These words must satisfy a requirement of having a score of at least the threshold, T, when compared by using a scoring matrix. The *threshold score* T, determines whether a particular word will be included in the alignment or not.

Once seeding has been conducted, the alignment is extended in both directions by the algorithm used by BLAST. Each extension impacts the score of the alignment by either increasing or decreasing it. If score is higher than a pre-determined T, the alignment is included in the BLAST result. If the score is lower the alignment is not included in BLAST results.

Different BLAST Programme

Nucleotide-nucleotide BLAST (blastn): This program, given a DNA query, returns the most similar DNA sequences from the DNA database that the user specifies.

Protein-protein BLAST (blastp): This program, given a protein query, returns the most similar protein sequences from the protein database that the user specifies.

Nucleotide 6-frame translation-protein (blastx): This program compares the six-frame conceptual translation products of a nucleotide query sequence (both strands) against a protein sequence database.

Nucleotide 6-frame translation-nucleotide 6-frame translation (tblastx): This program translates the query nucleotide sequence in all six possible frames and compares it against the six-frame translations of a nucleotide sequence database. The purpose is to find very distant relationships between nucleotide sequences.

Protein-nucleotide 6-frame translation (tblastn): This program compares a protein query against the all six reading frames of a nucleotide sequence database.

Position-Specific Iterative BLAST (PSI-BLAST): This program is used to find distant relatives of a protein. First, a list of all closely related proteins is created. These proteins are combined into a general "profile" sequence. A query against the protein database is then run using this profile, it find larger group of proteins. This larger group is used to construct another profile.

BLASTn and BLASTp are the most commonly used because they use direct comparisons, and do not require translations. Since protein sequences are better conserved evolutionarily than nucleotide sequences, tBLASTn, tBLASTx, and BLASTx, produce more reliable and accurate results when dealing with coding DNA.

Uses of BLAST

1. Identifying Species: With the use of BLAST, you can correctly identify a species and/or find homologous species. It can be used e.g. when you are working with a DNA sequence from an unknown species.
2. Establishing Phylogeny: Using the results from BLAST you can create a phylogenetic tree using the BLAST web-page, but phylogenies based on BLAST alone are less reliable than other computational phylogenatics methods.
3. Locating Domains: When working with a protein we can sequence we can locate known domains within the sequence of interest using BLAST
4. DNA Mapping: When working with a known species, and looking to sequence a gene at an unknown location, BLAST can compare the chromosomal position of the sequence of interest, to relevant sequences in the database(s).
5. Comparison: When working with genes, BLAST can locate common genes in two related species, and can be used to map annotations from one organism to another.

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6. BIOCHEMISTRY 15780

Insight into the Molecular and Physiological Mechanism of Salt Tolerance of Halophytes

Naresh Kumar, Raghavendra Midathala and Praveen Kumar

Ph.D. Scholar, Department of Biochemistry, CCS Haryana Agricultural University, Hissar
**Corresponding Author E. Mail: soninaresh2809@gmail.com*

Earth is the only planet where the surface is covered by 70 % oceans. These oceans contain a very high concentration of the Na^+ and K^+ which is about 500 mM and 9 mM. During evolution, the ocean plants retained their tolerance to high salt whereas the most of the plants living on the land lost their tolerance ability and accepted a glycophytic lifestyle. Most of the food producing crops are glycophytes which are sensitive to high salinity. High salt concentration causes the damage to plants which includes reduced photosynthesis, stomata closure biomass loss and reduction of leaf expansion due to water deficit caused by osmotic imbalance. Increasing salt salinization is now a problem that causes limitation of food production worldwide. Hence to improve the salt tolerance in important feeding crops is a major challenge to plant scientists.

Halophytes are the plants which can complete their life cycle in the extreme saline condition. Based on the salt demand, halophytes can be of two types-obligate and facultative halophytes. Obligate halophytes consistently require salt for their growth, but facultative halophytes have the ability to grow on the soil devoid of salt. These plants are well adapted to high salinity and mainly use two approaches, salt avoidance and salt tolerance. Under the approach salt tolerance, halophytes follow three mechanisms to survive *i.e.* excretion of Na^+, reduction of Na^+ influx and compartmentalization. While in salt avoidance approach, halophytes include adaptations such as shedding, secretion and succulence. Salt secreting structures such as salt glands and salt hairs are distributed in halophytes as in case of halophyte *Urochondra setulosa* and the secretion process is a complex mechanism. In some halophytes, shedding of the old leaves is another strategy to avoid the salt toxicity when grown under the high salt concentrations.

These mechanisms of salt tolerance are coordinately linked with ROS (Reactive oxygen species) generation and detoxification pathways, signal transduction, osmoregulation or ion homeostasis through osmoprotectants and differential expression of salt-responsive genes and transcription factors as displayed in the figure given below. ROS detoxification includes the antioxidative enzymes such as catalase, peroxidase, superoxide dismutase which play a protective role in scavenging toxic radicals. Halophytes maintain a high cytosolic K^+/Na^+ ratio by salt sequestration into cell vacuoles through transporters. Another key mechanism to cope with the salt stress is the accumulation of osmoprotectants such as glycine betaine, proline, polyphenols, soluble sugars and inorganic ions.

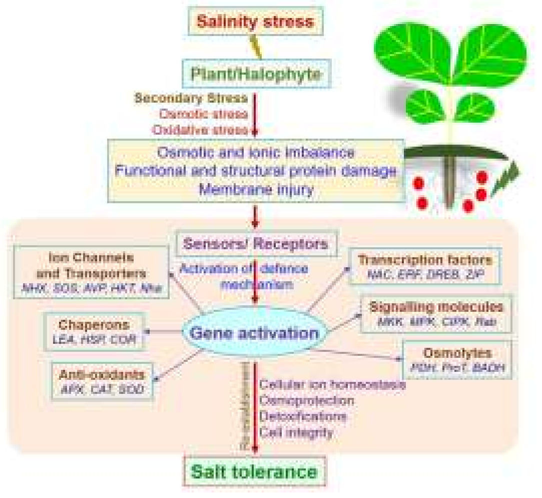

FIGURE 1: Schematic representation of salt tolerance in a plant

Halophytes, at the molecular level, regulates stress-responsive genes via ABA-dependent or ABA-independent regulation mechanism to impart salt tolerance. Generally, halophytic salt tolerance is a complex network which includes the interactions of a number of physiological responses caused by the several genes and gene products. Overall, salt tolerance in a halophyte involves the formation of osmoprotectants, changes in ion homeostasis, induction of antioxidants, activation of crosstalk genes and the developments of salt bladders or salt glands. A single species of halophyte cannot be considered as a model species as different halophytes use a different mechanism to respond the salt stress. Hence, the isolation and identification of salt-responsive genes and promoters from various halophytes can be explored for the genetic engineering of crop plants for salt stress tolerance using transgenic approach.

7. AGRONOMY 15729

Monsoon and its Impact on Indian Agriculture

Navya N. C.*, Akshatha M. K. and Pinki Seth

M.Sc. (Agri.) University of Agricultural Sciences, Bengaluru.
**Corresponding Author E. Mail: navyanc69@gmail.com*

In India, Monsoon refers to rainy season. The humid south-west monsoon winds cause plenty of rainfall during the period between early June and October. Large portion of Indian farmers still depend upon rainfall to carry out agricultural activities. Since, agriculture is one of the most important constituents of Indian economy (contributing around 16 percent of its total GDP), monsoon season has an indirect impact on its economy as well. South west monsoon, contributes to more than 75 per cent of the country's annual rainfall. Performance of *kharif* crops depend on south west monsoon. Good rains during the season result in bountiful crops which further benefit the farmers.

Monsoon can be categorized into two

branches based on their spread over the subcontinent:

1. Arabian Sea branch
2. Bay of Bengal branch

Southwest monsoon clouds over Tamil Nadu. Alternatively, it can be categorized into two segments based on the direction of rain-bearing winds:

1. Southwest (SW) monsoon
2. Northeast (NE) monsoon

Based on the time of year that these winds bring rain to India, the monsoon can also be categorized into two periods:

1. Summer monsoon (May to September)
2. Winter monsoon (October to November)

India has a tropical monsoon type of climate and here the temperature in the summer months is high and the rainfall is heavy. High temperature and heavy rainfall in the summer months are important for the growth of different types of *kharif* crops in different parts of India. Unlike other countries in high latitudes, India enjoys long hours of sunshine even during the winter months. So with winter rainfall (supplemented by irrigation) *rabi* crops are easily grown. The amount of rainfall is the most important determinant of the type of crop raised. Wet crops are raised in wet zone and dry crops in the dry zone.

- Crops like rice, jute, sugarcane, etc. require high temperature and heavy rainfall for their cultivation. So these crops are cultivated in summer.
- Crops like wheat, barley etc. require moderate temperature and rainfall. So these are cultivated in winter.
- Rubber trees require uniformly high temperature and regular rainfall all the year round.
- In the southern parts of the Deccan, the temperature is fairly high all the year round and the rainfall is well-distributed over 6 to 8 months. So rubber is grown in the southern parts of the Deccan.

Normal rainfall is essential for adequate agricultural output. Rainfall is said to be normal, if it falls between 96% and 104% of the average rainfall of the past 50 years. The average of recorded rainfall for the past 50 years is 80 cm. In spite of the introduction of improved irrigation methods, around 40% of our cropped area still entirely depends upon rain water. Further, a number of dams, reservoirs, rivers, and canals are rainfed and depend upon the monsoon.

How Monsoon is caused?

As a consequence of high temperature over the Tropic of cancer, the region develops low pressure. The winds from high pressure water-belts such as Bay of Bengal, **Arabian Sea** and Indian Ocean, starts moving towards the low-pressure belts. They shift their direction while crossing the equator and start blowing from the south-west direction. The wind gets moistened while passing along these seas. This moisture-laden wind causes heavy rainfall across the various places in India.

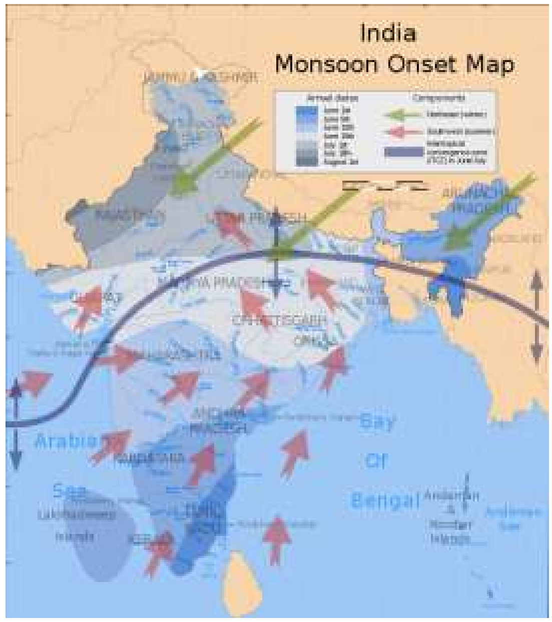

FIG.1. Map showing monsoon onset in India

Impact of Monsoon on Agriculture

A major portion of the country's crop area is completely dependent on Monsoon rains as they're not equipped with methods of manual irrigation. Simply speaking, the Indian economy gains due to good Monsoon rains in the country. On the other hand, weak Monsoon rains result in crop failure which affects the economy in a negative manner due to lower production. Later on, this translates into price-rise, low industrial output, and other issues. Normal Monsoon rains keep a check on food inflation due to the availability of food produce. However, in a situation of drought, prices soar significantly. Not only do the prices increase drastically but the cost of living also tends to reach a new height. Also, if poor Monsoon results in less crop output, the country may even need to import.

More than anything else, the failure of Monsoon has a huge impact on the life of the Indian farmer. Most Indian farmers rely on good crop produce during Monsoon to earn their living and in order to overcome debts incurred. Crop failure and/or deficient rainfall is one big reason for mass farmer suicides across the country. This further cements the importance of Monsoon in an agrarian economy like India.

Conclusion: Lastly, agriculture isn't the only sector which is affected by the performance of Monsoon. In fact, as many as a dozen sectors depend on Monsoon, either directly or indirectly. Thus it is safe to say that Monsoon does play a big role in India. The agricultural output of rain-fed crop areas in the country has social, political, as well as economic implications. The monsoon rainfall is very uncertain. It may arrive early and linger on for a long time or it may arrive too late. It may cause too heavy rainfall in some parts and too little in others. It may cause floods and droughts. So the Indian present lives are at the mercy of the monsoon.

8. AGRONOMY 15792

Millets for Food and Nutrition Security in the Light of Climate Change

*[1]Santosh Korav and [2]Premaradya N.

[1]M.Sc. (Agronomy), [2]Ph.D. Scholar (Agronomy), College of Post Graduate Studies Umiam, Meghalaya
*Corresponding Author E. Mail: santoshkorav@gmail.com

Millets are the small seeded short duration crop belonging to poaceae family and were first crop cultivated begin from the plough age. These are categorized as major and minor based on seed size and extent of its cultivation. The term millets used to referred as diverse group of small seeded annual C4 forage crop primarily grown on where the less rainfall, marshy land, low productive soil especially in dry land situation. These having short growing season it completes life cycle within the 60-80 days from after sowing. Moreover they can be stored long time up to 2 years under good storage condition. Many of the millets are highly nutrias, non-glutinous, non-acid forming easily digestible food. All millets are rich source of minerals like iron, zinc, calcium, magnesium, phosphorus and potassium. Finger millet and *Pennisetum spp*. are rich source of calcium and iron, respectively. These also contain appreciable amount of dietary fiber and various vitamins (carotene, niacin, vitamin B6 etc). Therefore regular consumption of millets can reduces malnutrition among majority of our Indian population. These have often been called as coarse grains, however dew to their nutritional status these are now referred as "nutri millets" or "nutri cereals". Based on their cultivation and size sorghum and pearl millet are considered as coarse cereal and rest are called minor or small millets (table 1).

TABLE.1 Cultivation of millets in India

Sl no.	Common name	Botanical name	Cultivation states
1	Sorghum	*Sorghum bicolor*	AP, MP, Rajasthan, Maharashtra, UP, Bihar
2	Pearl millet	*Pennisetum typhoides*	Dry land areas of Haryana, Gujarat, MP, Rajasthan, Maharashtra, Karnataka
3	Finger millet	*Eleusine coracana*	Karnataka, TN, AP, Orissa, Uttaranchal
4	Kodo millet	*Paspalum scrobiculatum*	MP
5	Foxtail millet	*Setaria italic*	Karnataka, TN, AP
6	Proso millet	*Panicum miliaceum*	Bihar, AP
7	Little millet	*Panicum sumatrense*	Orissa, MP, TN
8	Barnyard millet	*Echinochloa frumentacea*	Uttaranchal, Maharashtra

Nutritional Significance of Millets

Millets are highly nutrias being rich source of proteins, vitamins and minerals. About 80 % millet grains are used food while rest are goes to animal fodder and brewing industry for alcoholic products. Millets are recommended for infants, lactating mothers, and elderly convalescents. The grain release sugar releases slowly in to blood stream and thus it considered as gluten free and highly fibre and protein content which is good for dietary food and who are suffering from diabetes and cardiovascular diseases. Pearl millet is rich source of Iron, zinc and lysine as compared to other millets. Foxtail millets contain 11 % protein and 4 % fat in case of pearl millet 12.5 % protein which is highest protein among the millets while barnyard millet is the richest source of crude fibre and iron and low carbohydrate content among the millets.

Millets in Climate Change and Sustainable Agriculture

The importance of millets with regards to climate change is short life cycle, a trait which is very important for risk avoidance under rain fed farming due to waste rooting pattern which extracts moisture from deeper layers of soil it is advantageous to grow under water scares or low rainfall area. Their ability to afar a moderate yield under marginal farming condition poor soil, no or low input had made them attractive crop option in subsistence agriculture. The minor millets like foxtail millet and barnyard millet are the fastest growing and completes life cycle within 6 weeks as compare to other millets. Millets provide food, feed, and fodder under adverse climatic conditions of low rainfall and steep slope.

Thus mitigating climate change is a global issue appropriate adoption strategy being the immediate solution to ensure food security. The major concern should be on soil conservation, judicious use of natural resources including rain water harvesting. Raising population awareness regarding climate change on crop production is one of the prime most solutions for attaining food and nutrition security.

9. AGRONOMY 15823

Allelopathy in Crop Management

[1]Vandana G. Pai and [2]Poornima C. P.

[1]Ph.D. Scholar, Department of Agronomy, [2]Ph.D. Scholar, Department of Agricultural Extension
College of Horticulture, Vellanikkara, Kerala Agricultural University
*Corresponding Author E. Mail: vgpai.agri2008@gmail.com

The term "allelopathy", a combination of two Greek words, meaning "to suffer of each other" was coined in 1937 by a plant physiologist Hans Molisch to define harmful effect of one plant on another. Allelopathy can be defined as an ecological phenomenon, where one plant interferes with another plant by releasing certain chemicals in its environment, which may result in positive and/or negative impact on other plants. Majority of these chemicals are products of secondary metabolism, with fewer out of primary metabolism called, allelochemicals. Phenolics, alkaloids, flavonoids, terpenoids, momilactone, hydroxamic acids, brassinosteroids, jasmonates, salicylates, glucosinolates, carbohydrates and amino acids are the secondary metabolites with allelopathic effect. It's been observed both direct and indirect impact of allelochemicals on plant and soil. Allelochemicals causes indirect affects like altering soil physiochemical properties, changing microbial populations and nutrient availability to plants. Plants can release allelochemicals directly and continuously in their soil rhizosphere as volatiles, root exudates and microbial degradation products of plant left overs. These metabolites have basically four precursors such acetyl coenzyme A, shikimic acid, mevalonic acid and deoxy-xylulose phosphate. Based on these precursors, secondary metabolites can be grouped into three main chemical classes like, terpenoids, N-containing compounds and phenolic compounds.

Uses of Allelopathy

Allelochemicals interfere with growth of neighboring or succeeding plants. However, action of allelochemicals depends on its concentration. At lower concentrations allelochemicals promotes growth, and retards growth at higher concentration. Hence, these can play a potential role in overall crop production. Varied uses of allelochemicals are as follows.

Allelopathy in Weed Management: Water extracts of allelopathic plants (sorghum, black mustard, cucumber, *Parthenium sp. etc.*) are found to be potential herbicides, with reduced dose than that of chemical herbicides and can be successfully used for organic weed management. Application of allelochemicals at higher concentrations affects cell division, hormone biosynthesis, mineral uptake and transport, membrane permeability, stomatal opening, photosynthesis, respiration, protein metabolism, and plant water relations. However, these secondary metabolites are diverse in nature and structure, hence lack common mode of action.

Allelopathy in Insect Management: Repeated and irrational use of chemical insecticides lead to the development of resistance in insects against chemical insecticides. On the other hand, synthetic insecticides causes detrimental effects to ecosystems and environment and are also causing bio-magnification and related health issues in both human and animals. As a solution, recently allelochemicals have been identified as potential insecticide against certain insect pests. Allelochemicals are biodegradable, economically affordable, environmentally safe and easy to handle.

Allelopathy in Diseases Management

	Crop/plant	Effective against
Water extract	Cereals, canola	*Sclerotinia sclerotiorum* in beans
Flavones and Cyclohexanone	Rice	*Rhizoctonia solani* and *Pyricularia oryzae*
Leaf water extract	Jimson weed (*Datura stramonium*)	Wheat rust
Leaf water extract	Neem, eucalyptus and tulsi	growth of *Fusarium solani*

Allelopathy for Resistance against Abiotic Stresses: In plants, production of allelochemicals at higher rates can induce resistance against various stresses, helping them to grow vigorously under stress. Under stress conditions, plants uses allelochemicals as messenger in order to trigger their defense mechanism. However, its production depends upon age of plant, type and intensity of stress, and environment. Under drought, many of the drought resistant plants enhances biosynthesis of cyanogenic glucoside. In wheat, drought exposure lead to enhanced ferulic acid synthesis. Under stress due to heat, drought or salinity, plants initially produces reactive oxygen species (ROS); then antioxidant defense system is been activated. Allelochemicals involves in signaling mechanism inducing secondary oxidative stress in plants. A hormonal imbalance is created causing over production of some useful plant hormones essential for physiological processes.

Allelopathy for Crop Nutrition: Allelochemicals released by plants under stress facilitates their nutrient uptake by altering nutrient forms, microbial populations and/or microbial activities. Reports shows that, allelochemicals strongly influences biological nitrification inhibition (BNI), nutrient acquisition through solubilization, nutrient uptake and nutrient retention. Thus, reduces nitrogen losses via BNI, and improves NUE. They suppresses nitrification process of ammonium-oxidizing bacteria by inhibiting ammonium mono-oxygenase and hydroxylamine oxidoreductase enzymes. The basic function of is the solubilization of nutrients. Allelochemicals increases nutrient mobility and thus improve their uptake by plants. Sorghum water extracts (Sorgoleon) have good BNI potential. It reduces *Nitrosomonas* and *Nitrobacter* (nitrifying bacteria) populations.

Allelopathy for Plant Growth Promotion: Allelochemicals released at low concentrations by plants have growth promotory effects. Researches have elucidated that secondary metabolites, hormones and other natural compounds produced by plants supports plant. Among the secondary metabolites, phenolic compounds are most important and diverse class of allelochemicals. Allelopathic potential of phenolics has been experimented lot many times. Diterpenoid phyllocladane, an allelochemicals produced at lower concentration by *Callicarpa macrophylla* plant, suppressed growth inhibiting allelochemicals, thus stimulated growth.

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10. AGRONOMY 15841

Biofortification of Food Crops

Rajendran Sathishraj[1] and Dhivyapriya Dharmaraj[2]

[1]Department of Crop Physiology, GKVK, UAS, Bangalore

[2]Department of Rice, CPBG, TNAU, Coimbatore

Billions of people in developing countries suffer from an insidious form of hunger known as micronutrient malnutrition. Even mild levels of micronutrient malnutrition may damage cognitive development, lower disease resistance in children, and reduce the likelihood that mothers survive childbirth. Progress has been made to control micronutrient deficiencies through supplementation and food fortification, but new approaches are needed, especially to reach the rural poor. Biofortification (enriching the nutrition contribution of staple crops through plant breeding) is one option.

Biofortification

Biofortification is the process by which the necessary daily micronutrients are delivered directly through staple crops. Plants are versatile biochemical factories, capable of synthesizing a nearly full complement of essential dietary micronutrients (the exceptions being vitamins D and B_{12}). Regrettably, the plant-based foods (rice, wheat, cassava and maize) most abundantly consumed by at-risk populations contain levels of several micronutrients that are insufficient to meet minimum daily requirements. Furthermore, often these nutrients are unevenly distributed among plant parts. For example, iron content is high in rice leaves but low in the polished rice grain. Similarly, provitamin A carotenoids are only present in rice leaves. Biofortification efforts are directed toward increasing the levels of specific, limiting micronutrients in edible tissues of crops by combining crop management, breeding, and genetic approaches.

Biofortification through Fertilizer Application: Although simple and inexpensive, the application of fertilizers containing essential mineral micronutrients is complicated by several factors, such as the application method, soil composition, mineral mobility in the plant, and its accumulation site. Therefore, this strategy has been successful in only limited cases and in particular geographical locations. Iodine and selenium are mobile in soil and in plants, thus biofortification with iodine and selenium fertilizers has been particularly successful. Because Zn is also mobile in the soil, applications of $ZnSO_4$ can also increase yield and Zn concentrations in cereals and legumes.

Biofortification through Conventional Breeding: Plants often show genetic variation in essential nutrient content, which then allows breeding programs to be used to improve the levels of minerals and vitamins in crops. For example, different rice genotypes show a 4-fold variation in iron and zinc levels and up to a 6.6-fold variation has been reported in beans and peas. Given that this approach uses intrinsic properties of a crop, there are few regulatory constraints. Furthermore, this approach has the blessing of vocal opponents to genetic engineering. Because this approach is likely to be the most expedient method to improve plants, several international organizations have initiated programs to improve the nutritional content of crops through breeding programs. For example, Harvest-Plus is investing $14 million annually to boost three key nutrients - vitamin A, iron, and zinc - in 12 target crops, relying almost exclusively on conventional breeding.

Transgenic Approaches for Biofortification: In the absence of genetic variation in nutrient content among varieties, breeders have nothing to work with. This is where transgenic approaches can be a valid alternative. Nutritional genomics studies the relationship between genomes, nutrition, and health. The ability to rapidly identify and characterize gene function and then utilize these genes to engineer plant metabolism has been a driving force in recent biofortification efforts. This was made possible by the rapid development of whole-genome sequencing, high throughput physical mapping, global gene expression analysis, and metabolite profiling in a variety of organisms. Furthermore, pathways from bacteria and other organisms can also be introduced into crops to exploit alternative pathways for metabolic engineering. Thus, these technologies provide a powerful tool that is unconstrained by the gene pool of the host. In addition, the genetic modifications can be targeted to the edible portions of commercial crops (Fig 1 & 2).

Although the possibilities associated with transgenic approaches keep plant biologists optimistic, regulatory hurdles associated with this technology make commercial applications difficult. Nearly all transgenic plants have patented or patentable inventions associated with them; however, there has been a movement to work around patents to deliver biotechnology to the poor farmers of the world. Regrettably, the current political and economic landscape is not receptive to this technology being widely applied to a host of different crops. Even with these current limitations, the potential for genetic modifications to alleviate hunger warrants advocacy of this technology among both scientists and citizens.

Conclusion: Based on micronutrient deficiency rates, there is compelling evidence that biofortification can be a key objective for plant breeders, in addition to the traditional objectives of disease resistance, yield, drought tolerance, etc. Scientific evidence shows that biofortification is technically feasible. The challenge is to get consumer acceptance for biofortified crops, thereby increasing the intake of the target nutrients. With the advent of good seed systems, the development of markets and products, and demand creation, this can become a reality.

FIG 1. Enrichment of tomatoes with anthocyanins. Cross section of ripe wild-type and anthocyanin-enriched tomatoes (Hirschi, 2009)

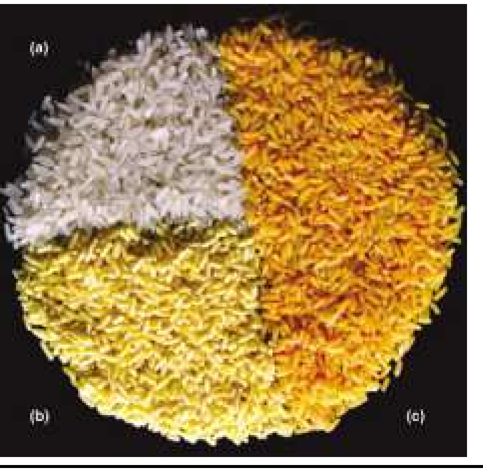

FIG 2. Golden Rice colors. (a) Wild-tape rice; (b) GR1, expressing the phytoene synthase from daffodil along with CRTI; (c) GR2 expressing the phytoene synthase from maize along with CRTI (Al-Babili and Beyer, 2005)

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11. AGRONOMY 15848

Bio Fortification: A Agronomic Approach

Manoj Kumar Dev and Sumit Biswas

College of Agriculture, AmbagarhChowki, Raj nandgoan
**Corresponding Author E. Mail: mkdev1111@gmail.com*

INTRODUCTION: Bio fortification derived from Greek word "**bios**" means "**life**" and Latin word "**fortificare**" means "**make strong"** Bio fortification is the development of nutrient-dense staple crops using the best conventional breeding practices and modern biotechnology, without sacrificing agronomic performance and important consumer preferred traits.

Bio fortification to develop the plants that have an increased content of bioavailable nutrient in their edible parts and micronutrient dense staple crops to achieve pro vitamins A, iron and zinc concentrations that can have a measurable impact on nutritional status. Bio-fortification differs from ordinary fortification because it focuses on making plant foods more nutritious as the plants are growing, rather than having nutrients added to the foods when they are being processed.

Need of Bio Fortification

1. **To reduce the percentage of hidden hunger:** The greatest concern lies with deficiencies in Vitamin A, iron, iodine and zinc. The agricultural soils in the world, 25-30% are alkaline with low Fe, Zn, Cu and Mn availability and In the world, 60-80% Fe deficient, 30% Iodine deficient and >30% Zn deficient Out of the 7 billion people.
2. **Increasing mineral concentrations in edible crops:** If mineral elements are absent from the soil they must be applied to crops as soil or foliar fertilisers. If mineral elements are present in the soil, either agronomic or genetic strategies can be developed to increase their acquisition, or mineral elements can be added as soil or foliar fertilisers.
3. **Trace elements need assessment to human being**: Some mineral that are only need in small amount, but essential for good health, normal brain growth, healthy ageing, strong immune system, good performance of human being.

Agronomic Bio Fortification

- Agronomic bio fortification of food crops is a strategy, along with breeding/genetic engineering, for increasing micronutrient concentrations to reduce dietary deficiencies.
- Agronomic bio fortification, especially in the case of foliar application, is highly effective for zinc and selenium, while also effective for iodine and cobalt.
- As an effective strategy for reducing micronutrient deficiency, zinc provides one of the best and quickest avenues for agronomic bio fortification, particularly within cereal crops.
- Agronomic bio fortification considered as short term solution, safe and accurate system to process fertilizers.
- Agronomic bio fortification is flexible, fast, and cheap and can be used for all crop species and cultivars.

Required of Agronomic Bio Fortification

- **Public acceptance of the bio fortified product:** In developing countries a part of daily diet, accepted texture and colour etc.
- **Monitoring of the content of bio fortified compound in the food chain:** In case of national health issues, development of monitoring systems.
- **Risk analysis:** Probability for overdose and negative health effect and accumulation in humans or animals, soil etc.

Advantages of Bio Fortification

- Bio fortification seeds can reach remote areas where commercial fortification or supplementation is not available.
- A one-time investment in breeding-based solutions can yield micronutrient-rich plants for farmers to grow around the world for years to come.
- The human eat high levels of food staples and control the malnutrition.
- Complements fortification and supplementation.
- Uses agriculture as an instrument to improve public health a new tool.
- Interventions by starting in rural areas and then reaching into urban area

Bio fortification: Limitation and Challenges

Bio-fortification requires a paradigm shift. Bio-fortification will be widely adopted only when proponents show these new foods improve nutrition. The amounts of nutrients that can be bred into these crops are generally much lower than can be provided through fortification and supplementation. The Nutrition specialist now focuses on the 9 to 24 month age group, when micronutrients are crucial for healthy development.

Conclusion: Bio fortification in crops like rice, maize, and wheat is essential to ensure food and nutritional security in the country. Even the bio-fortification is successful tool for nutritional security. The deficiencies of micro and secondary nutrients are telling adversely upon the soil health, crop productivity and farm profitability. The enhancement of soil health is also recognized as one of the essentials to full fill the United Nation Millennium Development Goals of eradicating hunger and malnutrition in Asian region through bio-fortification

12. AGRONOMY 15862

Smart Irrigation Controllers

[1]Sagar Khedkar and [2]Chetna Kumbhar

[1]M.Sc. (Ag), Department of Agronomy and [2]Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

INTRODUCTION: Today water has become one of the most precious resource on the Earth and one of the most important factors in agriculture is water availability. Water availability is also acritical variable for virtually every other economic activity, including industry, the energy sector, and public use. In recent years, water availability has become an issue. To schedule irrigation properly, a grower must know the environmental demand for surface water. Knowledge of exact amount of water required by different crop in a given set of climatological` condition of a region is great help in planning of irrigation scheme, irrigation scheduling, effective design and management of irrigation system. This is achieved by use of irrigation controllers.

Smart irrigation controllers are defined by the Irrigation Association as controllers that “estimate or measure depletion of available plant soil moisture in order to operate an irrigation system, replenishing water as needed while minimizing excess water use. A properly programmed smart controller requires initial setup and will make irrigation schedule adjustments, including run times and required cycles, throughout the irrigation season without human intervention” (Irrigation Association, 2007). Thus, smart controllers measure variables in the irrigated system and adjust irrigation control to maintain well watered conditions. There are generally two types of smart controllers: climatologically based controllers, also called evapotranspiration (ET) based controllers, and soil moisture sensor (SMS) based controllers. Rain sensors (RS) orrain switches are another type of control mechanism that is discussed in the context of control technologies that respond to weather conditions in the irrigated landscape but are not technically controllers.

How do Smart Controllers Help Conserve Water?

Smart controllers use site-specific information to adjust landscape irrigations. Smart controllers use either soil moisture or weather data to make these adjustments, changing either the amount of time to run the irrigation system or the frequency of irrigation. These changes reflect seasonal and short-term weather conditions and help prevent unnecessary irrigations.

A rain shut-off device added to the system can override the controller and shut the controller down after a significant rain event, resulting in even more water savings. Residential sprinkler controllers are typically set for highest summer irrigation application rates and are commonly not adjusted for seasonal changes or changing weekly or daily weather conditions. Water is over applied in spring and fall when landscape water demand is lower. Properly installed and programmed smart controllers can help conserve water in residential landscapes.

Types of Smart Controllers

a) Climate-based smart controllers
b) Soil-moisture based controllers

Climate Based Controllers: Climate-based smart controllers use weather information to adjust the controller settings, usually with on-site instrumentation that can include air temperature, humidity, wind, solar and/or rain sensors.

These weather instruments must be properly located to collect this information

Generally, climate-based controllers use this site-specific weather information to derive evapotranspiration (ET) values for the landscape.

Evapotranspiration is the combination of evaporation and plant transpiration. Other smart controllers collect weather or ET data from existing sources and disseminate it via a communication technology such as wireless, phone, Internet or other means. Usually there are means to further tailor or adjust the ET information to the specific site. Still other climate-based controllers use historic ET data from the local area to modify the controller irrigation settings.

Soil Moisture Based Irrigation Controllers: The second type of smart irrigation controllers includes soil moisture sensor controllers. Instead of using weather data, soil moisture sensor controllers utilize a soil moisture sensor placed belowground in the root zone of lawns to determine water need. The soil moisture sensor estimates the soil volumetric water content. Volumetric water content represents the portion of the total volume of soil occupied by water. The controllers can be adjusted to open the valves and start irrigation once the volumetric water content reaches a user-defined threshold. The appropriate threshold value depends on soil and vegetation type and usually ranges from about 10 percent to 40 percent. Soil moisture sensors must be installed in a representative area of the turf; far enough from sprinkler heads, tree roots, sidewalks and walls.

Similar to ET controllers, soil moisture controllers have been shown to reduce irrigation, while maintaining turf grass quality. Compared to homeowner irrigation schedules, soil moisture controllers had an average 72 percent irrigation savings and a 34 percent water savings during drought conditions (Cardenas-Laihacer et al., 2010; Cardenas-Laihacer et al., 2008). In some cases, studies have shown smart controllers will increase water use at sites that typically use less than the theoretical irrigation requirement (Mayer and Deoreo, 2010). Soil moisture-based irrigation controllers use an on-site, buried soil moisture sensor to keep track of the available moisture status in the root zone. One sensor can be used to control irrigations for all zones, provided that each zone can be adjusted relative to the soil water content of the sensored zone.

Soil-moisture based controllers have a soil moisture sensor that is installed in the turf and connected directly to the controller. Soil moisture sensors monitor the changes in soil moisture as the turf extracts water or as irrigation or rainfall replenish the soil water.

Smart irrigation technology may help reduce water waste, while also providing a healthy, attractive landscape Over a period of a little more than two and half months water use was reduced by 215,730 liters using automated irrigation. Based on EPA estimates, this is roughly equivalent to the amount of water used by two American families of four in the same amount of time. Previous studies have found up to an 83% reduction in the amount of irrigation water applied when utilizing a sensor-based automated irrigation system in nursery settings (van Iersel et al., 2009).

13. SOIL SCIENCE 14500

Soil Forming Factors

Mohitpasha S. Shaikh[1] and Savita B. Ahire[2]

[1]Assistant Field Officer in Soil and Land Use Survey of India, Baishnabghata Patuli Township, Block-E, Kolkata- 700 094 (W.B.) and [2]Agriculture Assistant in Department of Agriculture, Govt. of Maharashtra, 424 304 (M.S)

Define Soil Formation

The transformation of rocks into soil by the action of various soil farming factors and processes is called as **soil formation**.

Soil Forming Factors

Dokuchaiev: (1889) was the first person who established the equation related to soil formation

S = f (p, cl, o)

Where,
S = Soil
f = function of
p = Parent material
cl = Climate
o = Organisms

Further, **Jenny** (1941) formulated the revised soil formation equation

S = f (cl, b, r, p, t)

Where,
S = Soil
f = function of
cl = Climate
b = Biosphere
r = Relief / Topography
p = Parent material
t = Time

The five soil forming factors *i.e.* climate, biosphere, parent material, relief or topography and time, acting simultaneously at any point on the surface of the earth to produce soil.

Soil Forming Factors

Soil forming factors are grouped into two categories by ***Joffee*** (1949)

1) 1. Active Soil Forming Factors and 2) Passive Soil Forming Factors

	Active soil forming factors (*ASFF*)	Passive soil forming factors (*PSFF*)
1)	*ASFF* are those which supply energy that acts on the mass for the purpose of soil formation	*PSFF* are those which provide a base on which active soil forming factors work or act for the development of soil
2)	Climate and biosphere are the active soil forming factors	Parent material, relief or topography and time are the passive soil forming factors

Active Soil Forming Factors

1. Climate
2. Biosphere

Passive Soil Forming Factors

1. Parent material
2. Relief or Topography
3. Time

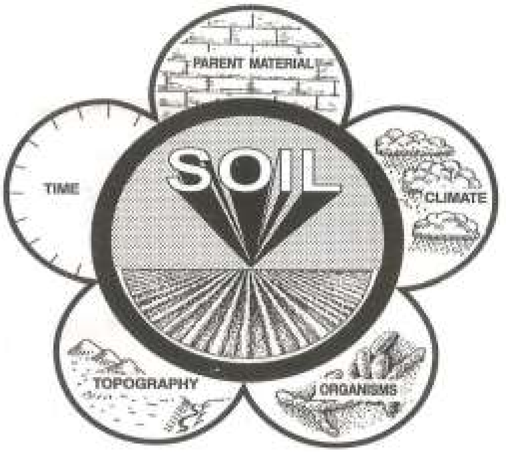

FIG. 1 Soil Forming Factors

Explanation

Active Soil Forming Factors

1) Climate

- Climate includes rainfall, temperature, humidity and wind
- Water and heat directly react with parent material
- Water and heat indirectly affects through its action on vegetation
- Rainfall affects the profile development through erosion, percolation
- temperature affects the rate of chemical reactions, colour of soil, decomposition of organic matter and control the rate of chemical and biological reaction
- Wind acts as a transporting agent of dust particles

2) Biosphere

- The activities of living plants and animals and the decomposition of their organic waste and residues markedly influence the soil development
- Chemical composition of various plants exerts a profound influence on the type and speed of soil forming processes
- The burrow and channels made by burrowing animals like rodents, termites promote soil disintegration and mix the material of the lower layers with the upper layers
- Micro-organisms help the soil development by decomposing organic matter and forming weak acids that dissolve minerals faster than water

Passive Soil Forming Factors

1) Parent Material

- Parent material is the mass of consolidated rock or unconsolidated material from which the soil has formed
- The nature of parent material influences the soil characteristics by their rate of weathering, nutrient content and particle size distribution

2) Relief or Topography

- The configuration of the land surface is known as topography or relief
- Topography influences the soil formation primarily through its effects on modifying water and temperature relation
- The soils on gentle slopes generally are deeper or thick, have more luxuriant vegetation and organic matter than i8n soils on similar materials on steep slopes
- Steepness of slope accelerates soil erosion and promotes drainage conditions in the hilly areas.

3) Time

- The period taken by a given soil from the stage of weathered rock upto the stage of maturity is considered as time
- Recent surface deposits show little soil development, whereas, land surface exposed for thousands of years may have well developed profiles
- Soil mature with time

14. SOIL SCIENCE 14922

Phosphorus Fertilizer Methods: For Improving P Use Efficiency

Prakash Tapkeer

Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra)

Phosphorus added to soil quickly becomes fixed in less available forms as the P reacts with other soil components. Fertilizer placement helps overcome fixation. However, P moves very little in most soils so application close to where root development occurs is often desirable.

Phosphorus Placement Options

Phosphorus placement can be broken into two general application methods: broadcast or band.

Broadcast: Application of fertilizer to the soil surface with or without subsequent incorporation. Broadcast is the simplest application method and is best suited for high-speed operations and heavy application rates. When plowed or disked in, broadcasting produces the most uniform P distribution within the root zone and provides more root contact with P. However, it also maximizes contact between the soil and fertilizer so the opportunity for fixation is higher.

Band: Applications that concentrate the fertilizer in narrow zones or bands that are kept intact to provide a concentrated source of nutrients. Banding is advantageous where soil test levels are low, where early season stress from cool or wet conditions is likely to limit root growth and nutrient uptake, and for soils that have a high tendency to fix P in unavailable forms. Phosphorus may be banded prior to, during, or after planting. Banding options include:

- **Deep band.** Applications 2 to 6 inches below the soil surface. Knifing a narrow concentrated band of fertilizer below the soil surface as a preplant or side-banding fertilizer to the side and/or below the seed row are forms of deep banding. Also included is dual banding, or double shooting, which is placement of two fertilizers, usually nitrogen (N) and P, together in the band.
- Surface band or surface strip. Application of solid or fluid fertilizer in narrow strips on the soil surface prior to planting (may be incorporated) or over the row after planting.
- Point injection. Use of a spoked wheel to inject fluid fertilizer into the rooting zone 4 to 6 inches deep at 8-inch intervals.
- Starter or seed placement. Applying small amounts of fertilizer in direct contact or close to the seed (*i.e.* 1 to 2 inches below and to the side) at planting. Starter P is especially helpful in promoting early plant growth and enhancing seedling vigor. This early stimulation of crop growth is often termed “pop-up effect”. However, starter fertilizer must be used cautiously because many crops are sensitive to seed placed fertilizer and can only tolerate low rates near the seed.

Band-applied P normally out performs broadcast P at low soil test levels and modest P rates. But the differences between methods usually decrease with increasing application rates or increasing soil test levels. However, even at high soil test levels, response to starter P often occurs. Cold soil conditions are usually a factor when high P soils respond to starter P, but the possibility of response on high P soils is good when any condition imposes stress early in the growing season or other production factors are optimized. There is no one best P application method. Field conditions, soil test level, soil P buffering capacity, crop, time of application, equipment, and other management factors all influence application choice. However, some general considerations follow:

1. Placement of P for small grains may be more critical than for row crops and forages. Limited root systems, shorter growing seasons, and cooler temperatures enhance the response to banded P over broadcast.
2. Placement of ammonium-N with P improves P uptake and slows fixation.
3. On high P soils, maintenance P applications may be effective regardless of placement method.
4. Reduced tillage crops, row crops, and spring-seeded small grains may require P placement close to the seed, regardless of P soil test.
5. Limited root systems in some specialty and vegetable crops make P placement an important management practice.
6. Where P fixation is an overriding factor, banding all the P is probably advisable. High P concentrations in bands help delay fixation reactions.
7. High yielding row crops, especially corn, may require relatively high P levels throughout the rooting zone for maximum yields. On low to medium P soils, banding at least some of the P may provide a yield advantage.
8. Where P use has been minimal in the past and resources are limited, banding moderate amounts of P on more acres will likely optimize returns.

15. SOIL SCIENCE 15118

Effect of Fertilizers on Yield and Quality of Soybean

Dhanalakshmi D.[1] **and Srinivasa Prasad L.**[2]

[1]*Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India*

[2]*M.Sc (Agri), Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India*

**Corresponding Author E. Mail: dhanalakshmiagri@gmail.com*

Soybean (*Glycine max* L.) is an important oilseed crop and finds its place in policy agenda of industrial, medical and food sector in India due to wide spectrum of its chemical composition. The beans contain significant amounts of phytic acid, alpha-linolenic acid, and isoflavones. In India, the crop contributes 33 and 21 per cent of our commercial oil seeds and total pulse production, respectively. Soybean being a potentially high yielding crop can play a greater role in boosting oil seed production in the country. It is a source of high quality protein for human consumption containing about 40 and 20 per cent protein and oil, respectively and is also rich in lysine (6 %), vitamins (A, B and D) and mineral salts. The quality of protein in soybean is equal to that of animal protein and is also a good source of dietary fiber, calcium, magnesium and phosphate. Soybean exerts considerable residual effects on the succeeding crop; leaves the soil with better physical conditions and improves soil fertility by adding residual nitrogen to the extent of 35-40 kg ha^{-1} through fixation of atmospheric nitrogen. As soybean is an exhaustive crop, optimization of mineral nutrition is a key to maximize its production. Soybean is a major oil seed crop of the world grown in an area of 118.01 million hectare with production of 315.06 million tonnes and productivity of 2.67 t ha^{-1}. The main producers of soybean are the United States (36 %), Brazil (36 %), Argentina (18 %), China (5 %) and India (4 %). In India, the crop is grown over an area of 10.02 million hectare with production of 11.64 million tonnes and productivity of 1062 kg ha^{-1}. Predominant soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka and Gujarat. In Karnataka soybean occupies an area of 0.29 million hectare with production of 0.24 million tonnes and productivity of 868 kg ha^{-1} (Anon., 2015).

The foliar application of nutrients constitutes one of the important milestones in the progress of agricultural production. It is gaining more importance in recent years due to availability of soluble fertilizers and is of great significance in rainfed areas and under changing climatic conditions. Research studies have indicated positive effect of foliar nutrition in enhancing yield and quality of crops. Nutrients applied through the fertilizers at the time of sowing are not fully utilized by the crop and are lost through leaching, fixation etc. and the crop may suffer from want of nutrients at the later stage. Hence, supplemental foliar fertilization is one of the techniques to increase productivity and quality of crops. The nutrient 19:19:19 fertilizer is a hundred per cent water soluble complete fertilizer containing nitrogen in three forms of namely, NO_3-N (4.0 %), NH_4-N (4.5 %) and NH_2-N (10.5 %) including water soluble phosphorus and potassium each containing 19 per cent with low salt index. Therefore, it causes rapid and healthy crop growth and alleviate nutrients deficiencies quickly. It increases resistance against pest and diseases by keeping plants healthy, ultimately causing reduced use of pesticides and fungicides and uniform flowering with their reduced droppings resulting in higher crop yield. It is made of high quality ingredients providing balanced and complete nutrition to plants and virtually free of chloride, sodium and other detrimental elements. Potassium nitrate is a water soluble potassic fertilizer suitable for foliar application containing 44 and 32 per cent K_2O and NO_3-N, respectively. This is especially the case when foliar analysis shows lower nutritional levels than the desired optimum levels. Urea contains 46 per cent nitrogen in amide form. It is usually taken up rapidly through the leaf cuticle. It can be supplied to plants through the foliage, facilitating optimal nitrogen management, which minimizes nitrogen losses to the environment. Foliar application of nutrients for increasing and exploiting genetic potential of the crop is considered as an efficient and economic method of supplementing the nutrient requirement of crop. Application of inorganic nutrients through foliage will enhance the nutrient availability due to quick absorption through leaves and in turn increases the crop productivity.

Lalitha *et al.* (2008) recorded higher number of seeds per capitulum (35.33), 1000 seed weight (5.95 g) and seed yield (102 kg ha^{-1}) with foliar application of potassium sulphate and boric acid along with RDF (20:40:20 N: P_2O_5:K_2O kg ha^{-1}) to niger at 50 DAS compared to control.

Gill and Bal (2009) at Punjab Agriculture University, Ludhiana (Punjab) revealed that foliar application of KNO_3 (1.5 %) resulted in higher ascorbic acid (102.01 mg 100 g^{-1}) content in ber compared to control (84.7 mg 100 g^{-1}).

Jabeen and Ahmad (2011) studied the effect of foliar application of KNO_3 in sunflower (*Helianthus annuus* L.) and safflower (*Carthamus tinctorius* L.) crops grown under different levels of salinity. Results showed that in sunflower crop, area, fresh and dry weight of leaves were increased respectively, 32, 36.40 and 43.40 per cent and in safflower corresponding values were 31.30, 41 and 43.10 per cent, respectively.

Amal *et al.* (2011) carried out field experiments at the Agricultural Production and Research Station, National Research Centre El-Nubaria province (Egypt) to study the response of two wheat cultivars to foliar application of urea and potassium. Results revealed that application of urea (2 %) + KNO_3 (2 %) gave the highest values for grain yield over control.

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16. SOIL SCIENCE 15123

Real Time Nitrogen Management (RTNM) in Major Cereal

Srinivasa Prasad L.[1] and Dhanalakshmi D.[2]

[1]*M.Sc (Agri), Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, Raichur-584 104, Karnataka, India*

[2]*Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India*

**Corresponding Author E. Mail: seenadhanagere@gmail.com*

Current nitrogen management systems for major cereals have resulted in low nitrogen use efficiency (NUE), with fertilizer N recovery averaging only around 33%. This has led to environmental contamination and concerns regarding use of N fertilizers. The major causes for low NUE are, poor synchrony between soil N supply and crop demand, field uniform N applications to spatially variable landscapes having spatially variable crop N need and failure to account for temporal variability and the influence of weather on mid-season N needs. Fertilizer N recommendations must be based on the crop demand and supply capacity of the soil. Therefore, the difference between the nitrogen supply from the soil and crop need must be mitigated to increase the crop productivity as well as to maintain soil health. The chlorophyll content in leaves can indirectly measure the N status of the crop and thus helps in season fertilizer N topdressing in accordance with need of the crop. Thus, RTNM is an important technique where in it is possible to correct the in-season N deficiencies with different gadgets of RTNM like leaf colour chart, chlorophyll (SPAD) meter and green seeker. Leaf colour chart is a high quality plastic strip with different shades of green colour. Chlorophyll meter instantly provides an estimate of leaf N status from measurements of chlorophyll content in the leaves. Green seeker is a hand held optical sensor which estimates plant biomass, total nitrogen in the crop.

Solari *et al.* (2008) concluded that sensor readings acquired during vegetative growth and expressed as CI590 have the greatest potential for assessing canopy N content and directing spatially variable in-season N applications.

Bijay *et al.* (2011) observed that robust relationships between in-season sensor-based estimates of yield at Feekes 5–6 and 7–8 stages and actual wheat yields. Sensor-guided fertilizer N applications resulted in high yield levels and high N-use efficiency. Application of 90 kg N ha^{-1} at planting or in two equal doses at planting and crown root initiation stage was the appropriate prescriptive fertilizer N management.

Pasuquin *et al.* (2012) evaluated a range of N-fertilizer treatments on irrigated maize grown on medium-textured soils in Indonesia and Vietnam during the dry seasons of 2008–2009 and found no advantage in more than two splits in terms of yield or agronomic efficiency. Adjusting applications according to leaf color gave 0.80 t ha^{-1} more grain than fixed rates. N-use was highly efficient in the range of 30–65 kg ha^{-1} N.

Varinderpal *et al.* (2012) found that a dose of at least 25 kg N ha^{-1} should be applied at planting. Fertilizer N management strategy based on application of prescriptive doses of 25 kg N ha^{-1} at planting and 45 kg N ha^{-1} at 1st irrigation and then a dose of 30 or 45 kg N ha^{-1} at 2nd irrigation stage depending on colour of the leaf to be ≥LCC 4 or <LCC 4 resulted in high yield levels as well as improved agronomic and recovery efficiencies.

Ghosh *et al.* (2013) analyzed the effect of chlorophyll meter (SPAD meter) based N management on growth, productivity and agronomic N use efficiency of rice (cv. IR 36) and reported that among RTNM treatments, SPAD 36 with 35 and 25 kg N ha^{-1} top-dressing could save N fertilizer by 20 to 35% compared to fixed time nitrogen management without reducing grain yield. Agronomic N use efficiency can be increased at high yield level using SPAD meter based N management.

Conclusion: There are opportunities to increase the yield of crops with improved N management strategies that accounts to the dynamic relationship between soil N supply and crop N demand in time and space. The farmers practice of applying blanket N doses at fixed growth stages does not take care of spatial and temporal variability in soil N supply and this should be gradually replaced with need based fertilizer N management strategies like leaf colour chart, chlorophyll meter and green seeker.

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17. SOIL SCIENCE 15505

Soil Erosion

Dhangada J. B.

Ph.D. Scholar, Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahmednagar (MS).

Definition: According to Fox (1950), “the term soil erosion covers a wide range of physical and chemical actions, such as removal of soluble matters, chemical changes, disintegration by frost or by rapid changes of temperature, attrition by dust charged wind, scouring by silt laden currents, alternate impact and succession by storm waves, landslides and so on”. Thus, soil erosion is the removal of soil from its upper part.

Two Main Types of Erosions

1. **Geological erosion or normal erosion:** When the top soils are gradually removed under normal conditions of physical, biotic and hydrological equilibrium it is called normal erosion. Sometimes, it is also called geologic erosion. It is very slow process in which complete equilibrium is maintained between soil removing and soil forming processes. The normal erosion tends to produce wavy or undulating land surface with alternating ridges and depressions. This is accomplished chiefly by means of slow migration of soil particles from soil surface in successive rains. In arid region, wind during the long dry season is an important factor for normal erosion.
2. **Accelerated soil erosion:** When the removal of soil does not keep harmony with the soil formation and it is much faster than the latter, it is called accelerated soil erosion.

Soil Erosion is caused by the following Two Agencies

- Climatic.
- Biotic.

Climatic Agencies Causing Erosion of Soil

Water: Water is an important factor in soil erosion. Snow and melting ice also remove the top soil to considerable extents. Soil is directly affected by heavy rainfall, rapidly running water and by wave action.

Erosion caused by water may be of the following types:

1. **Splash erosion**: The impact of a falling raindrop creates a small crater in the soil, ejecting soil particles. The distance these soil particles travel can be as much as 0.6 m (two feet) vertically and 1.5 m (five feet) horizontally on level ground.
2. **Sheet erosion**: Uniform removal of a thin layer of soil from large area is called sheet erosion. It is affected by run-off effect of rain water.
3. **Rill erosion:** In this type of soil erosion, heavy rainfall and rapidly running water produce finger-shaped grooves or rills over the entire

field.

4. **Gully erosion:** It is more prominent type of erosion in which heavy rainfall, rapidly running water and transporting water may result in deeper cavities or grooves called gullies. Gullies may be 'V shaped or 'U' shaped. Gullies cut the fields into small fragments and make them uncultivable (Fig. 25.2). Continuous flow of water through gullies further deepens the grooves and may ultimately result in ravines. Ravines are 15 to 30indeep and with steep vertical sides.
5. **Landslides or slip erosion:** This type of soil erosion is caused by heavy rainfall and it occurs in sloppy lands, such as mountains and hills. In this type of erosion when the running water percolates through the crevices of rocks great masses of soils and loose rocks lying on the steep slopes slip downward.
6. **Stream bank erosion:** On the banks of swollen rivers it is most active. During the rainy season when fast running water streams take turn in some other directions, they cut the soil and make caves in the banks. As a result of this, quite often large masses of soils become detached and washed away from the banks and are deposited at places in course of streams.

Wind Erosion: Removal of soil by wind is called wind erosion. Stormy winds carry the soil particles to distant places and sometimes form sand-dunes. Wind currents usually remove the top soil which is fertile and frill of humus and minerals. Wind causes the following three types of soil movements, viz., Saltation; Suspension; and Surface creep.

Saltation: Under the influence of direct pressure of stormy wind small soil particles of 1 to 1.5 mm diameters move up from the soil surface, generally in vertical direction. Major part of wind carried soil is moved in a series of bounces, called saltation.

Suspension: In this, fine soil particles (diameter less than 1 mm) are suspended in air. These suspended particles are kicked up when particles of saltation strike on the soil. The soil particles are deposited at distant places.

Surface Creep: In this, there are larger particles ranging from 5 to 10 mm in diameter. Because they are too heavy to move in saltation, they creep on surface of soil.

Biotic Agencies Causing Soil Erosion

Excessive grazing, deforestation, undesirable forest biota, and mechanical practices by man are important factors which cause soil erosion. Deforestation is the commonest factor which is responsible for soil erosion. Grazing is yet another destructive biological factor for the soil erosion.

Factors Affecting Soil Erosion

1. Nature of soil.
2. Amount of precipitation.
3. General slope of the soil.
4. Vegetative cover.
5. Soil management.
6. Land use practices. Consequences of soil erosion:
7. There are several serious effects of soil erosion which are as follows:
8. Due to uprooting of trees the shortage of timber and fuel wood results.
9. Formation of sand dunes.
10. Greater frequency of floods and threat to communication channels.
11. Silting of river bed, lakes and dams.
12. Higher temperature and scanty rainfall.

18. SOIL SCIENCE 15674

The Potential Effect of Biochar for Sustainable Soil Health

Nitesh Kumar Singh and Yukti Verma

Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, India

INTRODUCTION: 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 (Lehmann and Joseph, 2009). Biochar addition to the soil causes alterations in soil health (Paz-Ferreiro and Fu, 2013; Chintala et al., 2014a). Soil health, encompassing physical, chemical and biological features maintaining the functions of both natural and managed ecosystems, is essential for sustainable agricultural fertility and productivity (Enriqueta-Arias et al., 2005). On the basis of several researches it has been found that biochar has potential to increase the total carbon content, fertility status and microbial activity of soil. Other than this it is very helpful for increasing the total water holding capacity of soil and improving the soil structure. The effects of integrating biochar into soils are diverse and long-lasting. Figure 1 displays the immediate and long-term impacts on soil hydrology (Lehmann & Joseph, 2015).

Effect of Biochar on Soil Biological Properties

Soil is the natural habitat for most of the microorganism like bacteria, fungi, actinomycetes, algae, archaea, arthropods, nematodes, protozoa and other invertebrates which play a very important role for increasing the fertility status of the soil. Biochar is thought to improve the physical and chemical environment in soils, providing microbes with a more favourable habitat (Krull et al., 2010). According to several researches, biochar plays a positive effect on mycorrhizal fungi which increases the root colonization of plants. Biochar can also increase the mycorrhizal plant associations, enhancing P availability. According to some researches, certain toxic compounds such as catechol that would otherwise inhibit microbial growth may get adsorbed on biochar surface causing increases in microbial abundance (Chen et al., 2009).

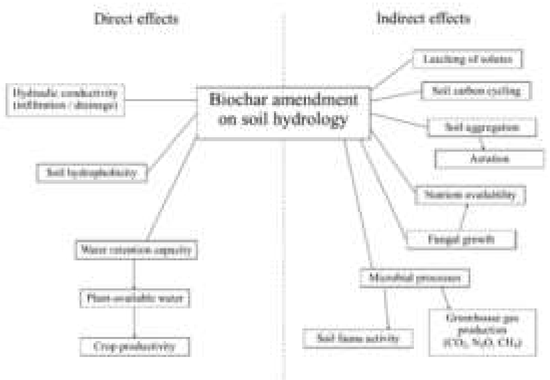

FIG. 1: Immediate and long-term effects of biochar amendment on soil hydrology

Effect of Biochar on Physical Properties of the Soil

Due to its unique physical properties, biochar has the potential to improve the physical properties of the soil like surface area of the soil, water holding capacity, pore size distribution, bulk density and penetration resistance of soil. It has been found that bulk density of the soil decreases by the addition of biochar. Thus, the decrease in BD of biochar amended soil could be one of the indicators of enhancement of soil structure or aggregation, and aeration, and could be soil-specific. The higher the total porosity (micro- and macro-pores) the higher is soil physical quality because micropores are involved in molecular adsorption and transport while macropores affect aeration and hydrology. The water holding capacity of soil is depend on surface area, porosity, BD and aggregate stability of the soil.

Effect of Biochar on Chemical Properties of the Soil

Several researches says that biochar plays a very important role for improving the chemical properties of soil like it improve the soil pH, cation exchange capacity, nutrient availability and soil fertility status. Other than this it is also helpful for increasing the nutrient use efficiency, reducing leaching and nitrogen volatilization and helpful for immobilization of contaminants.

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19. SOIL SCIENCE 15765

Accumulation of Arsenic in Rice and its Remediation

Hari Mohan Meena

Ph.D. Research Scholar, Department of Soil Science & Agricultural Chemistry

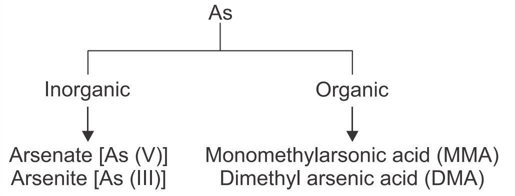
Arsenic (As) is one of the most hazardous elements in the environment. It comes from both anthropogenic and geogenic sources. According to the US Environmental Protection Agency (EPA), arsenic is classified as a group a human carcinogen. It was discovered by Albertus Magnus (1250) and has atomic number 33 and molecular mass 74.92.

Arsenic Chemistry

Arsenic structure that is similar to phosphate. It has oxidation states of As: +3 and +5. In aerobic soil, Arsenate (As^{5+}) dominant and in anaerobic (reduced) soil it was dominant as Arsenite (As^{3+}). Arsenate is strongly absorbed by FeO–OH and precipitated. An increase in the pH to an alkaline condition will cause both arsenite and arsenate to desorb. As (III) compounds are more toxic, more soluble and more mobile than As (V).

WHO permissible limit of 0.01 mg l^{-1} for drinking water, FAO permissible limit of 0.10 mg l^{-1} for irrigation water and WHO permissible limit of arsenic in rice 1.0 mg kg^{-1}.

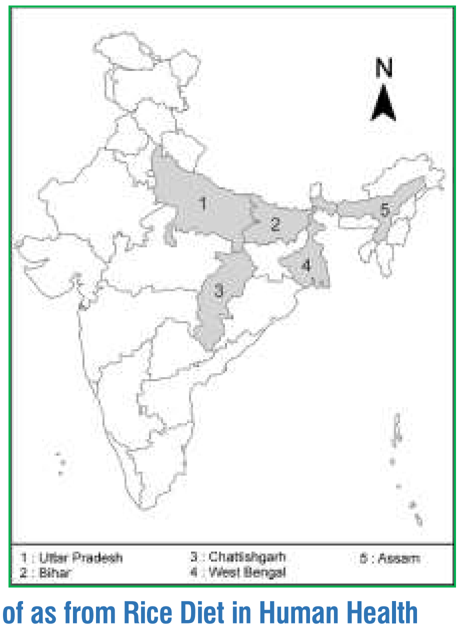
Species of Arsenic



As^{3+} is about 60 times more toxic than As^{5+}. Inorganic arsenic compounds are about 100 times more toxic than organic arsenic compounds (Jain and Ali, 2000).

Arsenic Contamination in Soils of India

Arsenic contamination first detected in West Bengal (1983). Area and population of these states are 88688 km^2 & about 50 million, respectively arsenic contamination (Bhattacharya *et al.*, 2007).

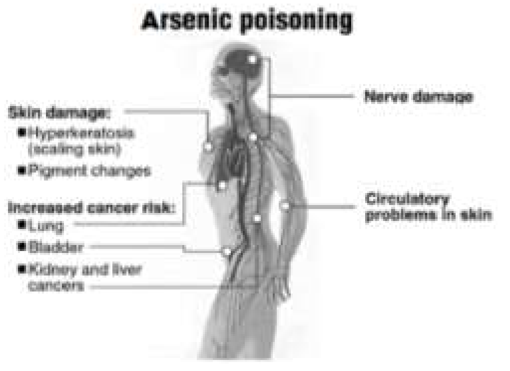


Risk of as from Rice Diet in Human Health

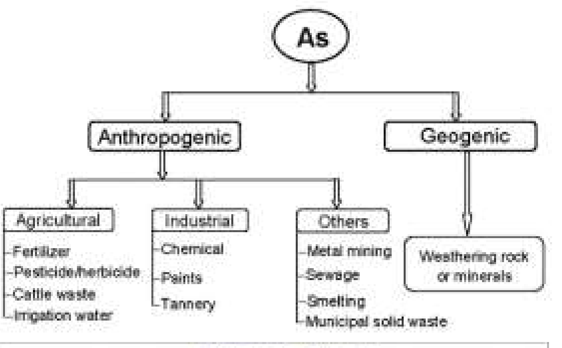
High consumption cereal based foods with high Arsenic concentrations. In many developing countries, rice contributes nearly 75 per cent of the daily calorie intake. Rice grain contribute about 95 per cent of arsenic, with respect to the dietary intakes of arsenic from the food samples. A wide range of other rice products are used as baby foods such as cereal dust, biscut, nudels and rice krispies etc. which are significantly sourse of arsenic content in babies.

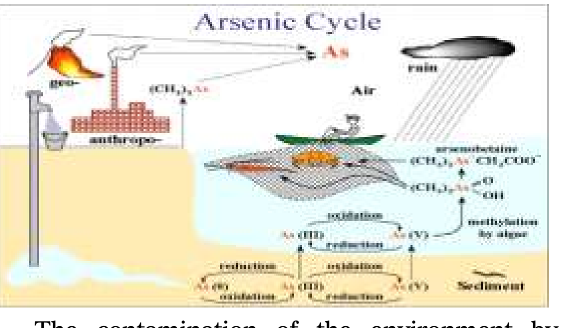
As Affected Diseases in Humans

Melanosis-palm, melanosis-body, keratosis-palm, keratosis-sole, Gangrene-head and Gangrene-foot-toe.



Source of Arsenic into Paddy Field



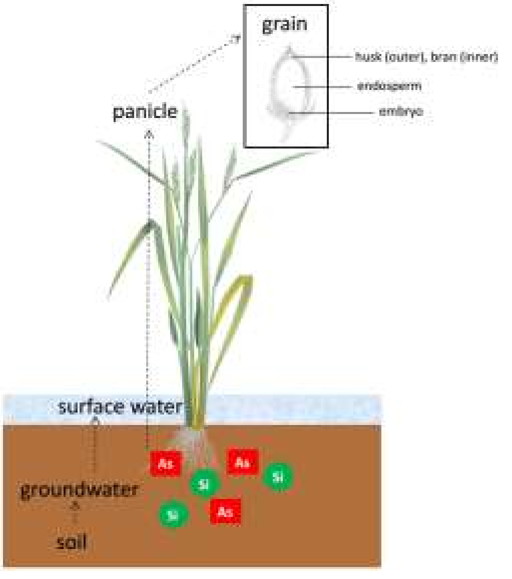


The contamination of the environment by arsenic through the various processes viz., geological and anthropogenic. This atmospheric arsenic comes into the earth's surface through rainfall. The weathering of arsenic contains minerals and sediments release arsenic into ground water.

Accumulation of Arsenic in Rice Plant

Globally, over 400 million metric tons of milled rice is consumed each year, which accounts for around 50 % of total cereal consumption of the world (IRRI, 2007). Rice is generally grown in submerged flooded condition, where arsenic bioavailability is high in soil. Rice is much more efficient at assimilating arsenic into its grain than other staple cereal crops (Williams *et al.*, 2007).

Roots of rice plant take up Si to fortify the plant and the same mechanism transports arsenic present in the water and soil. The arsenic from soil to ground water and through roots to the panicle and finally to the grain.



Mechanisms of Arsenic Uptake in Rice Plants

The arsenic accumulation in the rice grain although plants grow in arsenic contaminated environments. Rice plants can translocate arsenic rapidly and efficiently to the tillers via the xylem. This implies that the xylem is loaded with arsenic, passes it on to the vacuoles due to the characteristics of the root cell tonoplast. The root absorbs arsenic (As) as As^V and As^{III}. Arsenate penetrates because it is highly similar to the phosphate transporters. Arsenite is absorbed through the aquaglycoprotein NIPs (nodulin-like intrinsic proteins) and by silicon transporters. The methylated forms of As such as DMA and MMA are absorbed through the aquaporins and use the same glycerol mechanism. Arsenate in the root cells is reduced by arsenic reductase (AR) to As^{III} and leads to the conversion of glutathione (GSH) in its oxidized form (GSSG). Arsenite is transformed into trimethylarsenic oxide ($TMAO^V$) and trimethylarsine oxide ($TMAO^{III}$). The final product of the methylation route and the arsenic volatile species are released into the environment. Another arsenic detoxification route occurs by PC synthesis because of the condensation of three amino acids: cysteine, glutamate (Glu), and glycine (Gly). Finally, the sequestration of the As^{III} -PC compound occurs within the vacuole through the activity of the ABC transporters.

Factors Influencing Arsenic Mobilization and Uptake in Rice

- Redox Condition and Fe-Plague
- pH
- Organic Matter
- Soil Texture
- As Bound to Fe-Mn Oxides
- Irrigation Practice
- Seasonal Variation
- Elements like Phosphate, Silica and Sulfate

Possible arsenic mitigation methods:

Type	Methods
Alternative irrigation supply	Deep aquifer River/lake Reservoir/pond (tank)
Agronomic methods	Grow crops on raised bed Use arsenic –tolerant varieties Provide drainage Grow aerobic rice
Soil amendment	Add ferric iron Add phosphorus
Soil rehabilitation	Grow hyperaccumulator plants Remove top soil
Food preparation	Cook in excess water

Conclusion: Arsenic (As) is one of the toxic compounds which pose a high risk to human populations. The arsenic concentration in rice was found to be high in Asian rice. Arsenic-contaminated irrigation water could increase the arsenic level in soil and it's subsequently accumulation in rice grains. The root of the rice crop is able to absorb and accumulate large amounts of arsenic, but only small amounts are translocated to the grain and tillers. Arsenic concentrations in rice tissues decrease from the root to the grain. The possible mitigation or remedial measures need to be undertaken in each country over the range of environmental conditions present in As-affected areas. Because it may take several years to provide results that can safely be extended to farmers, such trials need to be organized as soon as possible.

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20. SOIL SCIENCE 15825

Soil Rhizosphere: A Store House of Nutrients for Plants

Yumnam Bijilaxmi Devi[1] and Thounaojam Thomas Meetei[2]

[1]Department of Soil Science, Assam Agricultural University, Jorhat, Assam
[2]Department of Soil Science and Agricultural Chemistry, Sriniketan, Visva Bharati, West Bengal
*Corresponding Author E. Mail: bijilaxmiyumnam@gmail.com

Introduction: The rhizosphere is a micro-ecological zone in direct proximity of plant roots. It is functionally defined as the particulate matter and microorganisms that cling to roots after being gently shaken in water. The extent of rhizosphere is dependent on the zone of influence of the plants and associated microorganisms. The activities of the microbes are faster and competitive than the surrounding soil. Rhizosphere zone is 2 mm away from the root surface and is a vital region in plant ecosystem. The chemistry of plant nutrients is governed by rhizosphere thus affecting the growth of plants.

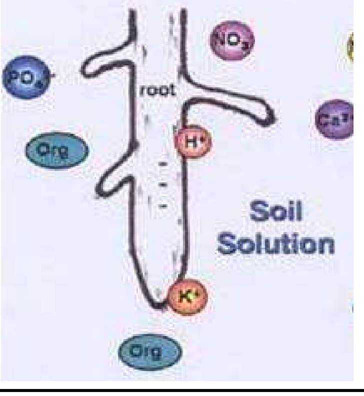

FIGURE 1: Soil rhizosphere

Nutrient requirement in agriculture has been rising and is likely to increase further to enhance the agriculture productivity across the globe in order to keep pace with growing food demand. Rhizosphere is the most important phase in soil which is directly involved in transformations of nutrients, thus enhancing the ability of nutrients.

Soil Rhizosphere System

Soil rhizosphere system constitute of plant roots, soil solution, soil colloids, organic matter and microorganisms. All these components affect availability of macro and micro nutrients to the plants.

Plants modify the physico-chemical properties and biological composition of the rhizosphere through a range of mechanisms, which include acidification through proton extrusion and the release of root exudates. Plants can release carbohydrates, amino acids, lipids and vitamins through their roots to stimulate microorganism's activities in the soil. Nutrient availability in soil solution is enhanced by irrigation and fertilizer application. Soil colloids add clays, organic amendment and bio-charcoal which facilitate nutrient transformation in the soil rhizosphere. Organic fertilizer, organic amendment and residues constitute organic matter in rhizosphere.

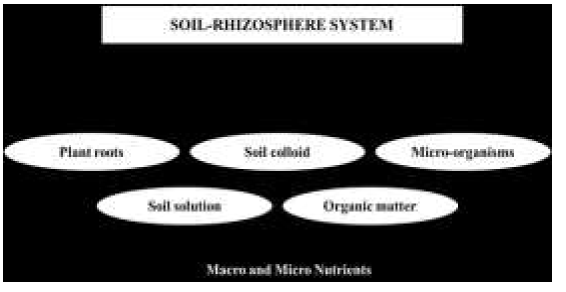

FIGURE 2: Soil-Rhizosphere system

Microorganisms present in the rhizosphere are most important component of soil rhizosphere which transforms the macro and micro nutrients in the soil solution, thus affecting the availability of nutrients. Rhizospheric bacteria participate in the geochemical cycling of nutrients especially nitrogen, phosphorus and micronutrients such as iron, manganese, zinc and copper, and determine their availability for plants and soil microbial community. It enhances crop yield by increasing plant availability, producing growth hormones and also acts as a bio-agent for control of pathogens.

Rhizobacteria and its Interaction with Roots in Soil Rhizosphere

Rhizobacteria are root-colonizing bacteria that form symbiotic relationships with many plants. Plant growth promoting rhizobacteria are the soil bacteria inhabiting around/on the root surface and are directly or indirectly involved in promoting plant growth and development via production and secretion of various regulatory chemicals in the vicinity of rhizosphere.

Microbial interactions with roots may involve either endophytic or free living microorganisms and can be symbiotic, associative or casual in nature. Beneficial symbionts include N_2-fixing bacteria (*e.g.* rhizobia) in association with legumes and interaction of roots with mycorrhizal fungi, with the later being particularly important in relation to plant P uptake. Associative and free-living microorganisms may also contribute to the nutrition of plants through a variety of mechanisms including direct effects on nutrient availability (*e.g.* N_2 fixation by diazotrophs and P-mobilization by many microorganisms), enhancement of root growth (*i.e.* through plant growth promoting rhizobacteria, or PGPR), as antagonists of root pathogens or as saphrophytes that decompose soil detritus and subsequently increase nutrient availability through mineralization and microbial turnover.

Biochemical changes in the rhizosphere and interaction with microorganisms are also significant. However, the importance of different root traits and rhizosphere-mediated processes is dependent on the nutrient in question and other factors that include plant species and soil type. For example, for nutrients present at low concentrations in soil solution and/or with poor diffusivity (*e.g.* P as both HPO_4^{2-} or $H_2PO_4^{-}$ and micronutrients, such as Fe and Zn), root growth and proliferation into new regions of soil and release of root exudates are of particular importance. In contrast, nutrients present in either higher concentrations (*e.g.* K^+, NH_4^+), or with greater diffusion coefficients (*e.g.* NO_3^-, SO_4^- and Ca^{2+}) are able to move more freely toward the root through mass flow, where root distribution and architectural characteristics that facilitate water uptake are of greater relative significance. The rate of root growth and the plasticity of root architecture along with development of the rhizosphere, through either root growth or extension of root hairs, are clearly important for effective exploration of soil and interception of nutrients.

Root induced changes in rhizosphere pH are also related to the nutritional status of plants. Most of the nutrients present in soil solution vary with the change in pH. It can be concluded that nutrient availability in rhizosphere zone is more compared to non rhizosphere soil as many biochemical changes and interaction of microorganisms are going on in this zone. Therefore, rhizosphere zone may be stated as the storehouse of nutrients for plants.

21. SOIL SCIENCE 15840

Managing Soil Organisms for Sustainable Soil Health

Dr. Eazhilkrishna N[1] and P. Rajesh Kumar[2]

[1]Dept. of Soil Science and Agricultural Chemistry, AC&RI, TNAU, Coimbatore - 641 003
[2]Dept. of Plant Pathology, AC&RI, TNAU, Coimbatore - 641 003

Soils vary in physical and chemical composition. The average handful of soil contains billions of different living organisms that carry out various functions to help facilitate plant health, regardless of the soils property. These organisms play a critical role in maintaining soil health. This article briefly explains the beneficial role of soil organisms in enhancing soil health by effectively improving the soil microbial environment.

Soil Organisms

There are four levels of organisms: microflora, microfauna, mesofauna and macrofauna. The microflora, bacteria and fungi, make up 75-90% of the soil living biomass and are the primary decomposers of organic matter. They transform organic molecules into mineral nutrients (*e.g.* nitrate, ammonium, phosphate) that are then available for uptake by plants. The microfauna, single cell animals such as protozoa and nematodes (simple worms), prey on the microbes. The mesofauna group of collembola (springtails) and mites also prey on bacteria and fungi. The larger organisms or macrofauna include earthworms, beetles, ants and termites

What do Soil Organisms do?

In both natural and agro-ecosystems, soil organisms are responsible for performing vital functions in the soil. The important functions in soil that are being carried out by the soil organisms are presented in Table 1.

Plant Growth: Microorganisms being minute and microscopic, they are universally present in soil, water and air. Besides supporting the growth of various biological systems, soil and soil microbes serve as a best medium for plant growth. Soil fauna and flora convert complex organic nutrients into simpler inorganic forms which are readily absorbed by the plant for growth. Further, they produce variety of substances like IAA, gibberellins, antibiotics etc. which directly or indirectly promote the plant growth

Soil Structure: Soil organisms play an important role in soil aggregation. Components such as organic matter, polysaccharides, lignins and gums are synthesized by soil microbes which help in cementing / binding of soil particles. Further, cells and mycelial strands of fungi, actinomycetes and vermicasts from earthworm are also found to play important role in soil aggregation.

Organic Matter (OM) Decomposition: Microorganisms are also involved in the process of organic matter decomposition and release of plant nutrients. Organic matter substances include cellulose, lignins and proteins (in cell wall of plants), glycogen (animal tissues), proteins and fats (plants, animals). Cellulose is degraded by bacteria and fungi while lignins and proteins are partially digested by fungi, protozoa and nematodes.

Humus Formation: Humus is the organic residue in the soil resulting from decomposition of plant and animal residues through micro organism. Humus helps the soil retain moisture, encourages the formation of soil structure and enhances cation exchange capacity of the soil.

Nitrogen Fixation: Agriculture depends heavily on the ability of certain microbes (mainly bacteria) to convert atmospheric nitrogen (N_2 gas) to ammonia (NH_3). Some are free living while others live in association with plant roots – the classic example is *Rhizobium* bacteria in the roots of legumes. The process of conversion is known as nitrogen fixation. Biological nitrogen fixation contributes about 60% of the nitrogen fixed on Earth.

TABLE 1. Important functions in soil being carried out by soil micro-organisms

Functions	Organisms involved
Maintenance of soil structure	Bioturbating invertebrates and plant roots, mycorrhizae
Soil hydrological processes	Most bioturbating invertebrates and plant roots
Gas exchange	Mostly microorganisms and plant roots
Soil detoxification	Mostly microorganisms and plant roots, some soil and litter feeding invertebrates
Decomposition of OM	Various saprophytic and litter-feeding invertebrates (detritivores), fungi, bacteria, actinomycetes
Suppression of pest and diseases	Plants, mycorrhizae and other fungi, nematodes, bacteria, Collembola, earthworms and predators
Sources of food and medicines	Plant roots, various insects (crickets, beetle larvae, ants, termites), microorganisms and their by-products
Relationships with plants	Rhizobia, mycorrhizae, actinomycetes, and various other rhizosphere microorganisms
Plant growth control	Mycorrhizae, actinomycetes, plant growth promoting rhizosphere microorganisms, biocontrol agents

Soil Microbes as Biocontrol Agents: Several eco-friendly bio formulations of microbial origin are used in agriculture for the effective management of plant diseases, insect pests, weeds etc. eg: *Trichoderma* sp and *Gleocladium* sp are used for biological control of seed and soil borne diseases while the fungi *Entomophthora, Beauveria* etc are used in the management of insect pests.

Decontamination of Soil: Soil receives different toxic chemicals in various forms. Various microbes present in soil act as the scavengers of these harmful chemicals in soil. The pesticides/chemicals reaching the soil are acted upon by several physical, chemical and biological forces exerted by microbes in the soil and are then degraded into non-toxic substances. Bacteria like *Pseudomonas, Clostridium,* etc, and fungi like *Trichoderma, Penicillium* play an important role in the degradation of the toxic chemicals / pesticides in soil.

Biodegradation of Hydrocarbons: Natural hydrocarbons in soil like waxes, paraffins, oils etc are degraded by fungi, bacteria and actinomycetes. *E.g.* ethane (C_2H_6) a paraffin hydrocarbon is metabolized and degraded by *Mycobacteria, Nocardia* and several fungi.

What do Soil Organisms Need?:

Almost all soil organisms (except some bacteria) need the same things we need to live – food, water and oxygen. They eat a carbon-based food source which provides all their nutrients, including nitrogen and phosphorus. They require a moist habitat, with access to oxygen in the air spaces in soil. These reasons explain why 75% of the soil organisms are found in the top 5cm of soil. There are other factors that determine whether species can survive and grow, including pH, temperature, salt content, type of carbon and heavy metals.

What you can do to Encourage Soil Organisms?

Maintain Ground Cover: Bare ground is prone to moisture loss, high temperatures and lacks supply of organic material to feed soil organisms. Keeping the soil covered with mulch, straw or leaf litter is the first step in promoting soil biota. A living ground cover of plants is even better. Plants devote considerable energy to encouraging soil organisms by secreting sugars, vitamins and other organic compounds into the soil.

Minimize Physical Disturbance: Use reduced tillage or no-tillage to minimize destruction of soil organisms and their habitat, and reduce the rate of organic matter breakdown. Reduce compaction by machinery and animals so that there is space in the soil for air and water to move. Minimize bare surface abrasion by animals and machinery as this leads to damage to organisms.

Build Soil Organic Matter with Green Manure Crops, Mulch or Pasture: A diversity of carbon sources will provide food for a wide range of soil organisms. Adding mulch or compost is particularly useful when these materials can be concentrated rather than spread thinly. The carbon: nitrogen ratio determines the rate of breakdown and therefore the release of nutrients into the soil.

Maintain Adequate Moisture: Shelter belts, ground cover and soil organic matter will all help to retain soil moisture. Improving the poor drainage by building good soil structure is another aspect as water logging encourages anaerobic bacteria that can damage plant roots.

Rotate Crops or have Mixed Species Planting:

Soil organisms need different root types to maintain a diverse community. They are then better able to resist disease organisms, decompose residues, cycle nutrients and maintain their activity throughout the seasons. Consider introducing a legume species with its associated rhizobia bacteria in the root nodules to convert atmospheric nitrogen to soil bound nitrogen.

Reduce the use of Chemicals: Insecticides and fungicides applied to plants also affect insects and microbes in the soil. Some species may be eliminated with frequent use. Some chemicals leave long term residues. Copper from some fungicides can accumulate in soil and affect other organisms such as earthworms.

Apply Fertilizer in Optimum doses: Apply fertilizer in optimum doses when the plants need it rather than in large doses as it reduces the amount of excess nutrients that may end up below the root zone or lost in waterways.

Use Organic Fertilizers (E.g. Manures): Organic fertilizers provide microorganisms with a stable food source which then provides long term slow release of nutrients to the plants. Organic fertilizers have less adverse impact on soil populations but they should not be considered a substitute for mulching or ground cover.

Check the pH and modify it if necessary: The ideal pH range (water) for most organisms is 5-8. Strongly acidic soil discourages important organisms such as nitrogen-fixing bacteria and earthworms.

Conclusion: Living soil organisms have an important role in supporting all plants in their ecosystems. In order to build a healthy population of these soil microbes you must provide them with an environment that favours their growth.

22. AGRICULTURAL CHEMISTRY 15533

Pesticide Application Methods

*Govardhan D. Temak and Prakash B. Tapkeer

Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri

**Corresponding Author E. Mail: entolatur@gmail.com*

Pesticide Application Methods

The desired effect of a pesticide can be obtained only if it is applied by an appropriate method in appropriate time. The method of application depends on nature of pesticide, formulation, pests to be managed, site of application, availability of water etc.

1. **Dusting:** Dusting is carried out in the morning hours and during very light air stream. It can be done manually or by using dusters. Sometimes dust can be applied in soil for the control of soil insects. Dusting is cheaper and suited for dry land crop pest control.
2. **Spraying:** Spraying is normally carried out by mixing EC (or) WP formulations in water. There are three types of spraying.

	Spray fluid (litre per acre)	Droplet size	Area covered per day	Equipment used
a) High volume spraying	200-400	150	2.5 ac	Knapsack, Rocker sprayers
b) Low volume spraying	40-60	70-150	5.6 ac	Power sprayer, Mist Blower
c) Ultra low volume spraying	2-4 lit.	20-70	20 ac	ULV sprayer, Electrodyn sprayer

3. **Granular application:** Highly toxic pesticides are handled safely in the form of granules. Granules can be applied directly on the soil or in the plant parts.

The methods of application are:

a) **Broadcasting:** Granules are mixed with equal quantity of sand and broadcasted directly on the soil or in thin film of standing water. (eg.) Carbofuran 3G applied @ 1.45 kg/8 cent rice nursery in a thin film of water and impound water for 3 days.
b) **Infurrow application:** Granules are applied at the time of sowing in furrows in beds and covered with soil before irrigation. (eg.) Carbofuran 3G applied @ 3 g per meter row for the control of sorghum shootfly.
c) **Side dressing:** After the establishment of the plants, the granules are applied a little away from the plant (10-15 cm) in a furrow.
d) **Spot application:** Granules are applied @ 5 cm away and 5 cm deep on the sides of plant. This reduces the quantity of insecticide required.
e) **Ring application:** Granules are applied in a ring form around the trees.
f) **Root zone application:** Granules are encapsulated and placed in the root zone of the plant. (eg.) Carbofuran in rice.
g) **Leaf whorl application:** Granules are

applied by mixing it with equal quantity of sand in the central whorl of crops like sorghum, maize, sugarcane to control internal borers.

h) **Pralinage:** The surface of banana sucker intended for planting is trimmed. The sucker is dipped in wet clay slurry and carbofuran 3G is sprinkled (20-40 g/sucker) to control burrowing nematode.

4. **Seed pelleting/seed dressing:** The insecticide mixed with seed before sowing (eg.) sorghum seeds are treated with chlorphyriphos 4 ml/kg in 20 ml of water and shade dried to control shootfly. The carbofuran 50 SP is directly used as dry seed dressing insecticide against sorghum shootfly.
5. **Seedling root dip:** It is followed to control early stage pests (eg.) in rice to control sucking pests and stem borer in early transplanted crop, a shallow pit lined with polythene sheet is prepared in the field. To this 0.5 kg urea in 2.5 litre of water and 100 ml chlorpyriphos in 2.5 litre of water prepared separately are poured. The solution is made upto 50 ml with water and the roots of seedlings in bundles are dipped for 20 min before transplanting.
6. **Sett treatment:** Treat the sugarcane setts in 0.05% malathion for 15 minutes to protect them from scales. Treat the sugarcane setts in 0.05% Imidacloprid 70 WS @ 175 g/ha or 7 g/l dipped for 16 minutes to protect them from termites.
7. **Trunk/stem injection:** This method is used for the control of coconut pests like black headed caterpillar, mite etc. Drill a downward slanting hole of 1.25 cm diameter to a depth of 5 cm at a light of about 1.5 m above ground level and inject 5 ml of monocrotophos 36 WSC into the stem and plug the hole with cement (or) clay mixed with a fungicide. Pseudo stem injection of banana, an injecting gun or hypodermic syringe is used for the control of banana aphid, vector of bunchy top disease.
8. **Padding:** Stem borers of mango, silk cotton and cashew can be controlled by this method. Bark of infested tree (5 x 5 cm) is removed on three sides leaving bottom as a flap. Small quantity of absorbant cotton is placed in the exposed area and 5-10 ml of Monocrotophos 36 WSP is added using ink filler. Close the flap and cover with clay mixed with fungicide.
9. **Swabbing:** Coffee white borer is controlled by swabbing the trunk and branches with HCH (BHC) 1 per cent suspension.
10. **Root feeding:** Trunk injection in coconut results in wounding of trees and root feeding is an alternate and safe chemical method to control black headed caterpillar, eriophyid mite, red palm weevil. Monocrotophos 10 ml and equal quantity of water are taken in a polythene bag and cut the end (slant cut at 45) of a growing root tip (dull white root) is placed inside the insecticide solution and the bag is tied with root. The insecticide absorbed by root, enter the plant system and control the insect.
11. **Soil drenching:** Chemical is diluted with water and the solution is used to drench the soil to control certain subterranean pests. (eg.) BHC 50 WP is mixed with water @ 1 kg in 65 litres of water and drench the soil for the control of cotton/stem weevil and brinjal ash weevil grubs.
12. **Capsule placement:** The systemic poison could be applied in capsules to get toxic effect for a long period. (eg.) In banana to control bunchy top vector (aphid) the insecticide is filled in gelatin capsules and placed in the crown region.
13. **Baiting:** The toxicant is mixed with a bait material so as to attract the insects towards the toxicant.
    a) **Spodoptera:** A bait prepared with 0.5 kg molasses, 0.5 kg carbaryl 50 WP and 5 kg of rice bran with required water (3 litres) is made into small pellets and dropped in the field in the evening hours.
    b) **Rats:** Zinc phophide is mixed at 1:49 ratio with food like popped rice or maize or cholam or coconut pieces (or) warfarin can be mixed at 1:19 ratio with food. Ready to use cake formulation (Bromodiolone) is also available.
    c) **Coconut rhinoceros beetle:** Castor rotten cake 5 kg is mixed with insecticide.
14. **Fumigation:** Fumigants are available in solid and liquid forms. They can be applied in the following way.
    a) **Soil:** To control the nematode in soil, the liquid fumigants are injected by using injecting gun.
    b) **Storage**: Liquid fumigants like Ethylene dibromide (EDB), Methyl bromide (MB), carbon tetrachloride etc. and solid fumigant like Aluminium phosphide are recommended in godowns to control stored product pest.
    c) **Trunk**: Aluminium phosphide 7f to I tablet is inserted into the affected portion of coconut tree and plugged with cement or mud for the control of red palm weevil

23. AGRICULTURE CHEMISTRY 15786

Foliar Nutrition: A Promising Tool for Correcting Nutrient Deficiencies in Crop Plants

Vijaysingh Thakur[1] and Siddu Malakannavar[2]

[1]University of Agricultural Sciences, Raichur; [2]University of Agricultural Sciences, Dharwad

INTRODUCTION: Foliar feeding, a term referring to application of essential plant nutrients to above-ground plant parts, it has been documented as early as 1844, when an iron sulfate solution was sprayed as a possible remedy for "chlorosis sickness" (Pace, Gary M. 1982). Foliar application of nutrients has become an important practice in crop production while soil application of fertilizers is the basic method (Alam *et al.,* 2010). Foliar application can supply the nutrients for plants rapidly to obtain high performance guarantee. From an ecological perspective, foliar fertilization is more acceptable, because the small amounts of nutrients is used for rapid use by plants (Stampar *et al.,* 1998).

Foliar applied nutrients at the appropriate growth stages become important for their efficient use and better response of the crop (Krishnaveni *et al*., 2004). In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application (Jamal *et al.,* 2006). It has been well established that the fertilizer elements which are absorbed through roots can also be absorbed with equal efficiency through foliage (Garcia and Hanway, 1986). Foliar nutrition can help to maintain a nutrient balance within the plant, which may not occur strictly with soil uptake (Meena *et al.,* 2007).

Importance: The nutrients are known to alter the various physiological and biochemical functions which finally influences on the yield and quality of the crop produce. Sometimes, soil applied nutrients are insufficient for crop to meet out their nutrient requirement and it may be due to non-availability of nutrients because of abrupt soil conditions, exhausted soil condition or nutrient losses through leaching and many more things which can hinder the availability of nutrients to plants and cease the plant growth, which ultimately affect the yield and quality of the crop produce. So, foliar application of nutrients was found to be more advantageous than soil application with the elimination of losses through leaching and fixation. It thus increases photosynthetic rate, better nutrient translocation from the leaves to the developing seeds (Manomani and Srimathi, 2009). Furthermore, nutrient status is an important and deciding factor in judging the total dry matter accumulation in plants.

Finally, it is most economical way of fertilization to achieve quality production and yield, especially when sink competition for carbohydrates among plant organs take place, while nutrient uptake from the soil is restricted (Kannan, 1986) and it is most effective and economical way to improve plant nutrient deficiency (Pradeep and Elamathi, 2007) and it constitutes one of the important milestones in the progress of agricultural production.

Meteorological Condition for Successive Foliar Application

Time: Late evening or early morning, Temperature: Below 24°C (75°F), since heat causes the pores on some species leaves to close., Humidity: > 70 %, Wind speed: less than 5 mph.

Caution: Rainfall within 24 to 48 hours after a foliar application may reduce the application effectiveness, as not all nutrient materials are immediately absorbed into the plant tissue. Rates of absorption or entry into the leaf tissue for various nutrients varies.

Nutrient Time for 50% Absorption: Nitrogen (as urea) 1/2 - 2 hours, Phosphorus 5-10 days, Potassium 10-24 hours, Calcium 1-2 days, Magnesium 2-5 hours, Sulphur 8 days, Zinc 1-2 days, Manganese 1-2 days, Iron 10-20 days, Molybdenum 10-20 days.

Do's and Don'ts of Foliar Application

Do's:

- Obtain an accurate plant tissue analysis before foliar spraying.
- Use narrow tires and foliage deflectors on ground applicators and adjust wheels to accommodate row widths to avoid damage to plant foliage.
- Clean application equipment thoroughly before spraying.
- Use wide angle hollow cone spray nozzles in ground applicators.
- Select the proper nozzle spray tip that will operate within the desired pressure range of your pump capacity.
- Calibrate each spray nozzle for proper volume using pressure setting and ground speed desired.
- Adjust nozzles on boom to spray at a 90° angle straight down from spray boom.
- Adjust boom height above plant canopy for uniform spray pattern.

- Make sure all hoses, pumps or pipelines are thoroughly drained of any other plant food products and flushed with water before use.
- Flush residual amounts of fertilizer solution from aluminum equipment with water after use to avoid possible pitting of equipment from prolonged exposure.

Don'ts

- Foliar spray plants under drought conditions, or when plants are under other forms of stress, such as disease or insect damage.
- Foliar spray during hot, dry mid-day temperatures. The best time is late evening; however, early morning or overcast days are acceptable.
- Foliar spray under windy conditions if drift into adjacent fields is a factor.

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24. ORGANIC FARMING 15130

Need of Organic Farming

[1]Vivek Kumar Kurrey, Omesh Thakur[1] and [2]Aradhana Dhruw

[1]Ph.D. Scholar, Department of Vegetable Science, [2]Ph.D. Scholar, Department of Plant Physiology, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh, 492012, India.

**Corresponding Author E. Mail: vivekkumar.kurrey@gmail.com*

INTRODUCTION: India is the second most populous country in the world. With the increasing population, the cultivable land resource is shrinking day to day. To meet the food, fibre, fuel, fodder and other needs of the growing population, the productivity of agricultural land and soil health needs to be improved. Green Revolution in the post independence era has shown path to developing countries for self-sufficiency in food but sustaining agricultural production against the finite natural resource base demands has shifted from the "resource degrading" chemical agriculture to a "resource protective" biological or organic agriculture.

1. Imbalance in production
2. Dependency on synthetic chemical fertilizers
3. Increase in secondary & micronutrient deficiencies
4. Increase in pesticide use
5. Unscientific water management and distribution
6. Reduction in productivity
7. Reduction in quality of the produce
8. Extinction of gene pool
9. Environmental pollution
10. Imbalance in social and economic status

Organic vegetables fetch a premium price of 10%- 50% over conventional products. Market of organic products is growing at faster rate (20%) as compared to conventional ones (5%). This growth rate is highest in Japan, USA, Australia and EU. Export preference of organic vegetables offers a great scope to a country like India, which has inculcated the skill of growing organically since time immemorial.

The Basic Concepts behind Organic Farming are:

1. It concentrates on building up the biological fertility of the soil so that the crops take the nutrients they need from the steady turnover within the soil nutrients produced in this way are released in harmony with the needs of the plants.
2. Control of pests, diseases, and weeds is achieved largely by the development of an ecological balance within the system and by the use of bio-pesticides and various cultural techniques such as crop rotation, mixed

cropping, and cultivation.

3. Organic farmers recycle all wastes and manures within a farm but the export of the products from the farm results in a steady drain of nutrients.
4. In a situation, where conservation of energy and resources is considered to be important, community or country would make every effort to recycles to all urban and industrial wastes back to agriculture and thus the system would be only be a small inputs of new resources to "top up" soil fertility.

Definitions of Organic Farming

US Department of Agriculture, which defined Organic Farming as, "A system that is designed and mailed to produce to agricultural products by the use of methods, and substances that maintain the integrity of organic agricultural products until they reach the consumer". This is accomplished by using, where possible, cultural, biological and mechanical methods, as oppose to use substances to fulfill any specific fluctuations within the system so as to maintain long term biological activity, ensure effective management, recycle waste to return nutrients to the land, provides attentive cares for farm animals and handle the agricultural products without the use of extraneous synthetic additives or processing in accordance with the act and regulations in this part.

According to Funtilana (1990), "Organic Farming is giving back to the nature what is taken from it". It is not mere non-chemicalism in agriculture; it is a system of farming based on integral relationship. Therefore, one should know the relationship among soil, water, plant and micro flora and overall relationship between plants animal kingdom. It is the totality of these relationships, which is the backbone of the Organic Farming.

The Key Characteristics of Organic Farming include:

Organic farming approach involves;

1. Conversion of land from conventional management to organic management.
2. Management of the entire surrounding system to ensure biodiversity and sustainability of the system.
3. Crop production with use of alternative sources of nutrients such as crop rotation, residue management, organic manures are biological inputs.
4. Management of weeds and pests by better management practices, physical and cultural means and by biological control system.
5. Maintenance of livestock with organic concept and make them an integral part of the entire system.
6. Careful attention to the impact of the farming system on the wider environment and the conservation of wildlife and natural habitats.

The four principles of organic agriculture are as follows

The Principle of Health - Organic agriculture should sustain and enhance the health of soil, plant, animal and human as one and indivisible.

The Principle of Ecology - Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

The Principle of Fairness - Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

The Principle of Care - Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. These basic principles provide organic farming with a platform for ensuring the health of environment for sustainable development, even though the sustainable development of mankind is not directly specified in the principles.

Certification and Legislation of Organic Food in India

At present in India, the following six authorized accreditation agencies has been approved by the Ministry of Commerce, Government of India. They are

- APEDA (Agricultural & Processed Food Product Export Development Authority)
- Coffee Board
- Spices Board
- Tea Board
- Coconut Development Board
- Cocoa & Cashew nut Board

In addition there are four Certification Agencies accredited by APEDA such as

- IMO Control Pvt. Ltd., Bangalore (Institute fur Marketecologie, Switzerland)
- Skal International (The Netherlands), India, Bangalore
- SGS (Societe Generale de Surveillance, Switzerland) India Pvt. Ltd., Gurgaon
- ESCOCERT (Ecological Certification, France) International, Germany

APEDA ((Agricultural & Processed Food Product Export Development Authority) is an export promotion organization, involved in publicizing Indian Organic logo globally. Expo-Import Bank in association with APEDA is engaged in promotion of organic agriculture products by creating awareness through active participation in International Conferences. It has also engaged to identify exclusive Agri Export Zone (AEZ) for organic produce in some parts of country, such as organic pineapple in Tripura, where use of chemical fertilizers and pesticides is negligible. NSOP (National Standards for Organic

Production): It has been formulated by Dept. of Commerce, Govt. of India for National Program for Organic Production (NPOP). Any production certified as per NSOP may use the term, *"Organic"*. A product can be labelled as, *"For Export only"* when it has been produced in India to an Organic Standard other than NSOP for example EU Regulations, IFOAM etc. Truthful label claims are allowed for domestically produced organic products that meet the NSOP and an International Organic Standards. Organic Certificates remained valid for one year/until the next decision is made. Organic Certification Standards invalid incase where you voluntarily or your certification is suspended by the Certification Agencies. The frequency of inspection is generally done once in a year. Additional inspections are conducted wherever found necessary. NSOP also formulated rules for misuse of the term, *"Organic"*. Any operation that knowingly sells per labels a product as, *"Organic"* except in accordance with the National Standards may be subject to a civil penalty India's first ever local Organic Certification Body, INDOCERT (Indian Organic Certification Agency), was established in March, 2002 with an objective to offer a reliable and affordable organic inspection and certification services to farmers, processors, input suppliers and traders. It is an independent, nationally operating nonprofit trust whose primary aim is in conducting inspections and granting certification for organic production methods. It provides certifications both for domestic as well as export market. INDOCERT also functions as a platform for training, awareness creation, information dissemination, and networking in the field of organic farming. It has been set up by a group of Indian NGO's and corporate organizations with the technical collaboration of FiBL, bio.inspecta, and the Swiss State Secretariat of Economic Affairs (SECO). INDOCERT has strong technical collaborations with two well reputed organizations from Switzerland: FiBL (Research Institute of Organic Agriculture) and bio.inspecta (the leading Swiss certification agency). Bio.inspecta assists INDOCERT for certification according to USDA national organic program (NOP) and JAS (Japanese Agricultural Standard for Organic Agriculture) through a re-certification procedure. It evaluates inputs used in organic production and confirms their compliance with the Indian National Organic Standards and the European Regulation EC 2092/91. Presently INDOCERT restricts its input approval scheme to fertilizers and soil conditioners and to inputs related to plant protection (pesticides, repellents etc).

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Role of Vermicomposting in Sustainable Agriculture

Navya N. C.[1*], Archana Sanyal[2] and Kailash Chandra[3]

[1]*M.Sc. (Agri), Dept. of Soil Science & Agril. Chemistry, UAS, GKVK, Bengaluru.*
[2]*PhD Scholar, Dept. of Seed Science & Technology, IARI, New Delhi*
[3]*PhD Scholar, Dept. of Genetics & Plant Breeding, BHU, Varanasi*
**Corresponding Author E. Mail: navyanc69@gmail.com*

India has Agricultural based economy as 70% population subsists in rural areas and engaged in various agricultural operations. The much valuable fertile lands of the farmers got reduced due to rapid industrialization and urbanization that followed the overgrowth of population. With the aim of getting most out of the available fertile land to become self-sufficient in food supplies, 'Green Revolution came in for which a heavy price had to be paid in terms of declined soil productivity due to indiscriminate use of agrochemicals without associated timely amendments with organic fertilizers, and over exploitation of the technology. The availability of organic manures in bulk is a big problem nowadays which is a consequence of reduction in rearing of cattle at household level because of stumpy availability of grazing lands.

Apart from that in many communities garbage collection and disposal is a serious problem. In most areas the collected garbage is sent to landfills. By avoiding organic material from the waste stream, this amount can be greatly reduced. In India 80% of the waste stream is biodegradable, much of this material can easily be broken down in a vermicomposting system. Diverting this waste saves the community money that would otherwise be spent on its collection and disposal.

The technology of vermicomposting, that could retrieve nutrients from organic waste that was generated in large volumes through agricultural activities, came in as a boon to the farmers. The significant positive impact of vermicompost on the soil lead to lesser use of agrochemicals. Since the source material for vermicomposting comes from the ongoing farm activities this methodology becomes a sustainable one.

Agriculture is one such sector that influences and in turn is influenced mostly by environment. Sustainability of nature and its resources in the world depend on the eco-friendly nature of agriculture.

Nutrient uptake of crops was found to be better when supplied with inorganic fertilizers along with vermicompost than with inorganic fertilizer alone. Use of vermicompost with other manures or biofertilizers also gives good yields protecting the productivity levels of the soil. Maximum yields of Tomatoes, sunflowers, onions were comprehended with the application of 50% N through vermicompost and 50% through neem cakes. Overall performance of crops was found to be better when the inorganic fertilizer quantity was reduced to 50% of the recommended level and applied together with 5 tons/ha of vermicompost (2 - 4 tons per acre) for any crop.

Vermicompost treatment has been reported to control blister blight disease in crops, comparable to the effects of fungicide treatment. In solanaceous crops, it controlled the damaging effects of soil borne pathogens. 10% vermicompost extracts possesses anti-bacterial and anti-fungal properties. Wilt disease in tomato and brinjal was found to be controlled by soaking the seeds in vermicompost extract for one hour or by broadcasting 5 tons / ha of fresh (2 tons/acre) vermicompost. In addition to this, it is well documented that Vermicompost application enhances the activities of various beneficial soil organisms.

Advantages of Vermicomposting

- Vermicomposting, is an ecofriendly natural process of producing biofertilizer prepared from biodegradable organic wastes free from chemical inputs.
- Using earthworms for composting is very beneficial, as they only feed on materials organic in nature.
- Earthworm - composting does not need great investment or inputs, since red worms and the worm feed (including organic waste of diverse source mostly of plant origin, used papers, farm wastes such as animal manure, etc.) are easily available.
- Earthworm - composting, can eventually lead to a money-making venture. Both the earthworms and its castings, can be sold. Vermiwash and vermitea also have great benefits as foliar sprays used against various plant pests and diseases.
- Vermicomposting brings about a significant reduction in the C/N ratio in the organic waste fed, most congenial for plant growth. The 20 - 25: 1 C/N in waste is brought down to 12 - 15:1 in the vermicompost.
- Vermicomposting slows down the release of nutrients to the plants and also checks their leaching into groundwater.
- Vermicomposting can be planned to any capacity, from household production to huge commercial production of several tons.
- Vermicomposting is the best answer for organic waste management.

Vermicomposting must be done properly and following points should be considered during its preparation:

- Using the suitable species of earthworms
- Temperature conditions should be maintained carefully for activity of earthworms.
- Judiciously maintaining appropriate vermibin conditions, cautiously managing the 'bad odor' by taking care of the proportion of 'browns' to 'greens' through providing proper aeration
- Taking proper precautions to avoid the common pests like birds, rodents, ants& flies

Conclusion: Vermicomposting, is an ecofriendly natural process, mediated by earthworm activity that feed only on organic matter, producing a bio - fertilizer, from biodegradable organic wastes free from inorganic hazardous chemical inputs. Application of vermicompost not only improve the soil condition but also enhance the activity of various beneficial microorganisms which could help to increase the productivity per unit basis. It also provides the basis for judicial application of pesticides and inorganic fertilizers in the soil to reduce chemical load on environment, which is on the prime concern. A household that utilizes vermicomposting also receives the benefits of less waste disposal costs if the system is large enough, there is the possibility of selling the worm castings and tea as fertilizer, providing an additional income. On the basis of above it has no doubt that vermicomposting is the safest method of organic waste disposal with the objective of sustainable agriculture.

26. VERMICOMPOSTING 15633

Earthworms: Another Secret to Successful Farming

Dr. C. Malarvizhi

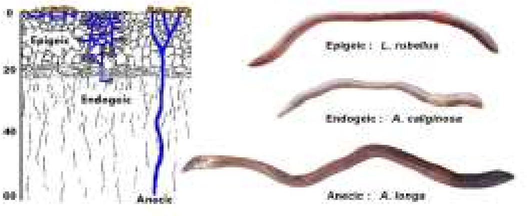
Imayam Institute of Agriculture and Technology, Thuraiyur, Tamil Nadu-621 206

Earthworms are known as farmers' best friends because of the multitude of services they provide that improve soil health and consequently plant health. The density of earthworms in the soil is considered to be a good indicator of a healthy soil because they improve many soil attributes like structure, water holding capacity, moisture content etc., and also increase nutrient availability and degrade pesticide residues. They produce plant growth stimulants and increase the mineralization of soil by mixing soil minerals with organic matter. Earthworm activity changes the microbial community structure of soil. It has been proposed that earthworms have a mutualistic relationship with microorganisms and may contribute to the maintenance of soil fertility and soil microbial diversity.

Types of Earthworms

Three ecological categories of earthworms – Anecics, Epigeics and Endogeics, have been described. Each of these creates earthworm spheres with differing characteristics.

Epigeic: Surface Dwellers: Epigeic earthworms live in areas containing high amounts of organic matter. They live at or near the soil surface and feed on leaf litter, decaying plant roots or dung. Epigeic species tend to have dark skin colour (pigmentation). The pigmentation acts as camouflage as they move through the leaf litter. Being close to the ground surface exposes the earthworms to predators so their muscles are strong and thick in proportion to their length, allowing for quick movement.



Endogeic: Topsoil Dwellers: Endogeic earthworms are the most common earthworm species. Their niche is the top 20 cm depth of soil. Endogeic earthworms eat large amounts of soil and the organic matter in it, although species sometimes come to the surface to search for food. They form shallow semi-permanent burrows. Endogeic earthworms have some pigmentation. Their muscle layers are not as thick nor do they move as quickly as epigeic earthworms. Endogeic species range in size from 2.5–30 cm.

Anecic: Subsoil Dwellers: Anecic earthworms live in permanent burrows as deep as 3 m below the soil surface. They collect food from the soil surface and ingest organic matter from the soil. Anecic earthworms form extensive burrows that extend laterally and vertically through the subsoil. Their burrows can be up to 2 cm in diameter.

How is the Earthworm Useful to the Farmer?

Improved Nutrient Availability: Worms feed on plant debris (dead roots, leaves, grasses, manure) and soil. Their digestive system concentrates the organic and mineral constituents in the food they eat, so their casts are richer in available nutrients than the soil around them. Nitrogen in the casts is readily available to plants. Worm bodies decompose rapidly, further contributing to the nitrogen content of soil. Worms often leave their nutrient-rich casts in their tunnels, providing a favourable environment for plant root growth. The tunnels also allow roots to penetrate deeper into the soil, where they can reach extra moisture and nutrients. Earthworm tunneling can help incorporate surface applied lime and fertilizer into the soil.

Improved Drainage: The extensive channeling and burrowing by earthworms loosens and aerates the soil and improves soil drainage. Soils with earthworms drain up to 10 times faster than soils without earthworms. In zero-till soils, where worm populations are high, water infiltration can be up to 6 times greater than in cultivated soils. Earthworm tunnels also act, under the influence of rain, irrigation and gravity, as passageways for lime and other material.

Improved Soil Structure: Earthworm casts cement soil particles together in water-stable aggregates. These are able to store moisture without dispersing. Research has shown that earthworms which leave their casts on the soil surface rebuild topsoil. In favourable conditions they can bring up about 50 t/ha annually, enough to form a layer 5 mm deep. One trial found worms built 18-cm thick topsoil in 30 years.

Improved Productivity: Research into earthworms found earthworms introduced to worm-free perennial pastures produced an initial increase of 70–80% in pasture growth, with a long-term 25% increase: this raised stock carrying capacity. Researchers also found that the most productive pastures in the worm trials had up to 7 million worms per hectare, weighing 2.4 tonnes.

Increase Organic Matter: Earthworms feed on soil and dead or decaying plant remains, including straw, leaf litter and dead roots. They are the principal agents in mixing dead surface litter with the soil, making the litter more accessible to decomposition by soil microorganisms. Animal dung is also an attractive food for many species of earthworms.

Overall, earthworm effects on soil fertility and plant growth are positive. They improve soil structure and stabilize SOM fractions within their casts. In the short term, they increase mineralization, which make mineral nutrients available for plants. Earthworm triggers the release of molecules analogous to phytohormone that tends to improve plant growth. Tillage is generally detrimental to earthworms whereas practices increasing SOM content positively impact earthworm communities

27. WATER MANAGEMENT 13425

C_4 Rice

CH. Durga Raju[1], L. Ramchander[2], G. Anil kumar[3]
[1]College of Agriculture, Professor Jayashankar Telangana State Agriculture University, Hyderabad
[2]Bidhan Chandra Agricultural University, West Bengal, India.
[3]University of Agricultural Sciences, Dharwad, Karnataka.
*Corresponding Author E. Mail: chelpurid345@gmail.com

Rice is the staple food of over half of the world's population and this rice consuming population is increasing at the rate of 1.098% per annum and natural resource base for agriculture is being degraded because large areas of farmland are being diverted from food production to industrialization and bio-fuel production. An unpredictable climate change is threatening to further reduce agriculturally viable land due to more instances of drought and flood. Despite the use of improved varieties and advanced technologies, the yield potential of present day rice cultivars has improved just a little indicating that these varieties have hit a yield ceiling (Akita 1994). One of the avenues being recently explored is the improvement of photosynthetic capacity by installing the C_4photosynthetic pathway into C_3 crops like rice to drastically increase their yield.

In C_3 plants CO_2 is assimilated into a 3-carboncompound by the photosynthetic enzyme ribulose-1, 5-bisphosphate carboxylase oxygenase (Rubisco). As the name indicates, Rubisco also catalyzes oxidation of ribulose-1, 5-bisphosphate (RuBP) in a wasteful process known as photorespiration which can incur a loss of up to 25% of previously fixed carbon (Sage 2004). At temperature above30°C which is typical of tropical rice growing areas of the world, rate of oxygenation increases substantially and this considerably reduces the photosynthetic efficiency of C_3plants by up to40%. Thus, photosynthesis of rice in the tropics and warm temperate regions becomes inefficient. The C_4 plants which haveCO_2 concentrating mechanism within their leaves have very much reduced levels of photorespiration and thushave evolved to thrive in hot, arid environments and offer valuable insights for crop improvement strategies. Ricewith a C_4 photosynthesis mechanism would have increased photosynthetic efficiency while using scarce resources such as land, water, and fertilizer specifically nitrogen more effectively (Hibberd et al. 2008).

This highly specialized form of photosynthesis essentially has developed a CO_2 concentrating mechanism around the Rubisco enzyme thus eliminating the oxygenase function of Rubisco thereby reducing the wastage of energy due to photorespiration. Rubisco from C_4 species is more efficient than from C_3 species in terms of carboxylation (Kubien et al. 2008). The other associated benefits of the C_4 system include higher water use efficiency because steeper concentration gradient for CO_2 diffusion can be maintained through partly closed stomata, higher radiation use efficiency as C_4 photosynthesis efficiency does not get saturated at high light intensity (Rizal et al. 2012) and higher nitrogen use efficiencies because it will require less Rubisco and hence less nitrogen.

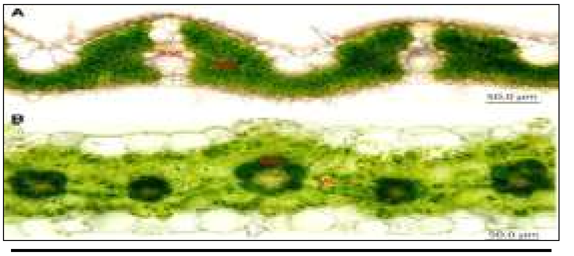


FIG: Anatomical differences between C_3 and C_4 leaves. (A) C_3 (Oryza sativa L., rice variety IR64) and (B) C_4 (Setaria viridis) leaf.

This novel approach to modify the photosynthesis systemof rice is a challenging and long term endeavour becausethe C_4 pathway is very complex and many factors controllingthe mechanism are still unknown. Therefore, itrequires ingenuity and expertise of scientists involved indiverse disciplines such as genetic engineering, biochemistry, bioinformatics, molecular biology, photosynthesis, systemsbiology, physiology, plant breeding, metabolomicsetc. For the same, the C_4 rice consortium was conceptualizedand established which began the practical work of C_4rice engineering since 2009. Based on the study of theevolution of C_4 from C_3 species and the associatedchanges, the following modifications are essential to establisha functional C_4 photosynthetic pathway in rice.

1. Increase the number and size of chloroplasts in bundlesheath cells of rice.
2. Reduce the vein spacing thereby increasing the veindensity in the leaf.

3. The activity of the Calvin cycle should be significantlyreduced in MC and greatly enhanced in the BSC of rice.
4. The photorespiration in mesophyll cells has to be greatly reduced.

Conclusion: The C4 photosynthetic pathway has evolved more than 66times in different species, suggesting that C3 plants maybe in some way preconditioned to C4 photosynthesis. Developing crop plants with enhanced photosynthesis willimprove crop yield and make efficient use of resources ina sustainable manner. The C4 rice consortium is strivingto install a Maize-like photosynthetic mechanism in riceto break its yield barrier and to breed a new generation of"climate-ready" rice which will yield more even under thesituations of increasing temperature and decreasing wateravailability.

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28. PLANT BREEDING AND GENETICS 15267

Synthetic Seeds: A Novel Concept in Seed Biotechnology

M. R. Paneliya[1*] and B. B. Golakiya[2]

Department of Genetics and Plant Breeding[1], Department of Plant Pathology[2]
College of Agriculture, JAU, Junagadh-365002, Gujarat
**Corresponding Author E. Mail: paneliyamehul.mp@gmail.com*

INTRODUCTION: Synthetic seeds are defined as artificially encapsulated somatic embryos, shoot buds, cell aggregates, or any other tissue that can be used for sowing as a seed and that possess the ability to convert into a plant under *in vitro* or *ex vitro* conditions and that retain this potential also after storage (Capuano *et al.*, 1998). Synthetic seeds technology involves the production of tissue culture derived somatic embryos encased in a protective coating. Synthetic seed; However, the term "synthetic seeds'' should not be confused with commercial seeds of a synthetic cultivars which is defined as an advanced generation of an open pollinated population composed of a group of selected inbred clones or hybrids.

Concept: The concept of somatic embryo encapsulation to produce an analogue to true seeds is based on the similarity of somatic embryo (SE) with zygotic embryo in term of morphology, physiology and biochemistry. An important difference between somatic and zygotic embryos is that the latter typically ceases growth, becoming quiescent or dormant as water is lost, storage tissue matures and the seed coat hardens. This arrested growth phase is a major factor accounting for efficient storage and handling qualities of natural seed. The term artificial seed was coined by Murashige in 1977. The technology was patented in 1988 by Redenbaugh and co workers. In India, the techniques of encapsulation of somatic embryos is used in many modern research laboratories.

Why Synthetic Seeds?

In some of the horticultural crops seeds propagation is not successful due to heterozygosity of seeds particularly in cross pollinated crops, minute seed size *e.g*.; orchids, presence of reduced endosperm, some seeds require mycorrhizal fungi association for germination *e.g*.: orchids, no seeds are formed

Characteristics of Synthetic Seeds

(1) High volume - Large scale propagation method, (2) Maintains genetic uniformity of plants, (3) Direct delivery of propagules to the field, thus eliminating transplants, (4) Lower cost per plant let and (5) Rapid multiplication of plants

Procedure for Production of Synthetic Seed

The somatic embryos for synthetic seeds are produced in the lab through culturing of somatic cells and treating with different hormones to produce root and shoot. Procedure are (1) Establish somatic embryogenesis (2) Synchronize and singulate somatic embryos (3) Mass production of somatic embryos (4) Standardization of encapsulation (5) Standardization of artificial seeds (6) Mass production of synthetic seed and (7) Green house And Field planting

Synthetic Seed Production Methods

1. **Desiccated system:** Prior to encapslatation, somatic embryos are first hardened to withstand desiccation. Then, hardened are

encapsulated artificial with the use of appropriate growth medium. In this method, the artificial seeds are produced by coating a mixture of somatic embryos or shoot with polyethylene glycol (PEG). The coated mixture is then allowed to dry for several hours on Teflon surface under sterile conditions. The dried mixture in the form of wafers is then placed in-vitro in the cultural medium, allowed to rehydrated and stored for embryo survival and conservation.

2. **Hydrated system:** The gel used to enclosed somatic embryo remains hydrated. The system consists of somatic propagules (embryo or shoot buds) encapsulated in a hydro gel like sodium alginate, gel rite, agar, carregenan etc. The most common gelling agent is sodium alginate with complexing agent as calcium salts. Somatic embryos are sieved from the suspensions cultures; mixed with sodium alginate and dropped in calcium chloride solution. When sodium alginate drops come in contact with calcium chloride solution, surface complexion begins and firm round beads are formed, each containing 1 – 2 propagules. These beads are allowed to stand for 60 – 90 minutes and washed with water. Air dried and stored at 4ºC, Auxiliary, apical, adventitious buds can also be encapsulated in this method. The buds are trimmed to the smallest possible size and mixed with sodium alginate

Method for Synthetic Seed Encapsulation

Dropping method: Somatic embryos are dipped in hydro gel, this step encapsulate SEs. Hydro gel used may be any of the following: **a)** Alginate-sodium alginate, agar from see weeds. **b)** Seed gum like guar gum, locust bean gum. Sodium alginate solution (1-5%) is prepared in MS basal medium solution. SEs. are dipped in this solution. These are coated beds are added are one with the help of pipette (5mm) in to a complexation solution flask kept such for around 20-30 minutes complexation solution is calcium nitrate solution (100 mM). Embryos get covered by calcium, alginate which is a stable complex due to ionic bond formation become harder. Seeds become harder then gelled embryos are washed with water or MS basal medium. The synthetic seeds are ready. Alternatively, a burette is filled with sodium alginate solution (1-5%), dripped in to a calcium nitrate solution (100mM) drop by drop somatic embryo is inserted in to the drop formed at the burette tip. Sodium alginate drop along with SE falls into the solution of calcium nitrate. Useful adjutants like growth regulators, herbicides, insecticides, fungicides and mycorrhizae can be supplied to the SE while encapsulation along with the matrix. This method is applicable for embryo / auxiliary / apical / adventitious bud.

Molding method: This method follows simple procedure of mixing of embryos with temperature dependent gel (*e.g.*, gel rite, agar). Cells get coated with the gel at lowering of the temperature.

Type of Gelling Agents used for Encapsulation

Several gels like agar, alginate, polyco 2133, carboxy methyl cellulose, carrageenam, gelrite, guar gum, sodium pectate, tragacanth gum, etc. were tested for synthetic seed production. Out of which, alginate encapsulation was found to be more suitable and practicable for synthetic seed production. Alginate hydro gel is frequently selected as a matrix for synthetic seed because of its moderate viscosity and low spin ability of solution, low toxicity for somatic embryos and quick gellation, low cost and biocompatibility characteristics. The use of agar as gel matrix was deliberately avoided as it is considered inferior to alginate with respect to long term storage. Alginate was chosen because it enhances capsule formation and also the rigidity of alginate beads provides better protection (than agar) to the encased somatic embryos against mechanical injury.

Application of Synthetic Seeds

By combining the benefits of a vegetative propagation system with the capability of long-term storage and with the clonal multiplication, synthetic seeds have many diverse applications in the field. Multiplication of non-seed producing plants, ornamental hybrids or polyploidy plants like Propagation of male or female sterile plants for hybrid seed production, Germplasm conservation of recalcitrant species, Multiplication of transgenic

Advantages and Limitations of Synthetic Seeds

List of advantages for synthetic seeds *i.e.,* (1) Ease handling during storage, transport and planting as these are of the small size (2) Inexpensive transport due to small size (3) Has potential for long term storage without losing viability (4) Product uniformity as somatic embryos used are genetically identical. (5) Large scale propagation (6) Mixed genotype plantation suitable for monoculture (7) Germplasm conservation (8) Artificially seed technology preserves / protect and permits economical mass propagation of elite plant genotype (9) Not a season dependent technology (10) Propagation of plant unable to produce viable seeds (11) Maintains the clonal nature of the resulting plants (12) Serves as a channel for new plant lines produced through biotechnological advances to be delivered directly to the green house or field (Gray and Purohit, 1991). But some limitations *i.e.*, (1) Limited production of viable micropropagules that are useful in synthetic seed production (2) Asynchrous development of somatic embryos (3) Improper maturation of somatic embryos that makes them inefficient for germination and conversion in to normal plants (4) Lack of dormancy and stress tolerance in somatic embryos that limit the storage of synthetic seeds (5) Somaclonal variations which may alter the genetic constituent of the embryos

Conclusion: Synthetic seeds have wide spread applicability in large scale plant propagation. For some ornamental and extinct plant species, it is the only means of propagation. They have been used in commercial productions of self-pollinated crop species. In general, synthetic seeds technology has influenced almost every aspect of plant biotechnology and has the potential to become the most promising and viable technology for large scale production of plants.

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29. PLANT BREEDING AND GENETICS 15309

Breeding for Heat Stress Tolerance in Plants

A. U. Ingle and Suvarna Gare

Ph.D. Scholar, Genetics and Plant Breeding, Department of Agricultural Botany PGI, MPKV, Rahuri
**Corresponding Author E. Mail: anan.ingle10@gmail.com*

Introduction: Plant breeding is a process of development of new cultivars. Plant breeding involves development of varieties for different environmental conditions – some of them are not favorable. Among them, heat stress is one of such factor that reduces the production and quality significantly. So breeding against heat is a very important criterion for breeding for current as well as future environments produced by global climate change (*e.g.* global warming).

Heat stress due to increased temperature is a very important problem globally. Occasional or prolonged high temperatures cause different morpho-anatomical, physiological and biochemical changes in plants. The ultimate effect is on plant growth as well as development and reduced yield and quality. Breeding for heat stress tolerance can be mitigated by breeding plant varieties that have improved levels of thermo-tolerance using different conventional or advanced genetic tools.

What is Heat Stress Tolerance?

Heat stress is defined as increased temperature level sufficient to cause irreversible damage to plant growth and development. Generally a temperature rise, above usually 10 to 15 °C above ambient, can be considered heat shock or heat stress. Heat tolerance is broadly defined as the ability of the plant tolerate heat– means that grow and produce economic yield under high temperatures.

Significance: Current and Future: Global Warming

Heat stress is a serious threat to crop production globally (Hall, 2001, 1992). Global warming is particularly consequence of increased level of green house gases such as CO_2, methane, chlorofluorocarbons and nitrous oxides. The Intergovernmental Panel on Climatic Change (IPCC) has predicted a rise of 0.3 °C per decade (Jones et al., 1999) reaching to approximately 1 and 3 °C above the present value by 2025 and 2100 AD, respectively.

Physiological Consequence of Heat Stress

At very high temperatures cause severe cellular injury and cell death may occur within short time, thus leading to a catastrophic collapse of cellular organization (Schoffl et al., 1999). However, under moderately high temperatures, the injury can only occur after longer exposure to such a temperature however the plant efficiency can be severely affected. High temperature directly affect injuries such as protein denaturation and aggregation, and increased fluidity of membrane lipids. Other indirect or slower heat injuries involve inactivation of enzymes in chloroplast and mitochondria, protein degradation, inhibition of protein synthesis, and loss of membrane integrity. Heat stress associated injuries ultimately lead to starvation, inhibition of growth, reduced ion flux, production of toxic compounds and production of reactive oxygen species (ROS). Immediately after exposure to high temperature stress-related proteins are expressed as stress defense strategy of the cell. Expression of heat shock proteins (HSPs), protein with 10 to 200 kDa, is supposed to be involved in signal transduction during heat stress. In many species it has been demonstrated that HSPs results in improved physiological phenomena such as photosynthesis, assimilate partitioning, water and nutrient use efficiency, and membrane stability.

Traits Associated with Heat Stress Tolerance

Different physiological mechanisms may contribute to heat tolerance in the field—for example, heat tolerant metabolism as indicated by higher photosynthetic rates, stay-green, and membrane thermo-stability, or heat avoidance as indicated by canopy temperature depression. Several physiological and morphological traits have been evaluated for heat tolerance - Canopy temperature, leaf chlorophyll, stay green, leaf conductance, spike number, biomass, and flowering date.

(a) Canopy Temperature Depression (CTD): CTD has shown clear association with yield in warm environments shows it association with heat stress tolerance. CTD shows high genetic correlation with yield and high values of proportion of direct response to selection (Reynolds et al., 1998) indicating that the trait is heritable and therefore amenable to early generation selection. Since an integrated CTD value can be measured almost instantaneously on scores of plants in a small breeding plot (thus reducing error normally associated with traits measured on individual plants), work has been conducted to evaluate its potential as an indirect selection criterion for genetic gains in yield. CTD is affected by many physiological factors, which makes it a powerful.

(b) Stomatal Conductance: Canopy temperature depression is highly suitable for selecting physiologically superior lines in warm, low relative humidity environments where high evaporative demand leads to leaf cooling of up to 10 °C below ambient temperatures. This permits differences among genotypes to be detected relatively easily using infrared thermometry. However, such differences cannot be detected in high relative humidity environments because the effect of evaporative cooling of leaves is negligible. Nonetheless, leaves maintain their stomata open to permit the uptake of CO2, and differences in the rate of CO_2 fixation may lead to differences in leaf conductance that can be measured using a porometer. Porometry can be used to screen individual plants. The heritability of stomatal conductance is reasonably high, with reported values typically in the range of 0.5 to 0.8. Plants can be assessed for leaf conductance using a viscous flow porometer that is available on the market (Thermoline and CSIRO, Australia). This instrument can give a relative measure of stomatal conductance in a few seconds, making it possible to identify physiologically superior genotypes from within bulks.

(C) Membrane Thermostability: Although resistance to high temperatures involves several complex tolerance and avoidance mechanisms, the membrane is thought to be a site of primary physiological injury by heat, and measurement of solute leakage from tissue can be used to estimate damage to membranes. Since membrane thermostability is reasonably heritable (Fokar et al., 1998) and shows high genetic correlation with yield.

(D) Chlorophyll Fluorescence: Chlorophyll fluorescence, an indication of the fate of excitation energy in the photosynthetic apparatus, has been used indicator for heat stress tolerance

(E) Chlorophyll Content and Stay Green: Chlorophyll content and stay green traits have been found to be associated with heat stress tolerance. Xu *et al.* (2000) identified three QTLs for chlorophyll content (Chl1, Chl2, and Chl3) (coincided with three stay-green QTL regions (Stg1, Stg2, and Stg3) were identified in Sorghum. The Stg1 and Stg2 regions also contain the genes for key photosynthetic enzymes, heat shock proteins, and an abscisic acid (ABA) responsive gene.

(F) Photosynthesis: Declined photosynthesis is suggested as measure of heat stress sensitivity in plants.

(G) Stem Reserve Remobilization: During any stress condition the photosynthesis carried out by the plants get arrested due to membrane integrity of cell and cell organells alongwith inactivation of various enzymes participating in photosynthesis process at that time stem reserve becomes the main source of grain filling so this trait is very important regarding breeding for stress tolerance.

Combination Breeding and Physiological Breeding

The physiological-trait-based breeding approach has merit over breeding for yield *per se* because it increases the probability of crosses resulting in additive gene action. The concept of combination phenomics comes from the idea that two or more stress have common physiological effect or common traits - which is an indicator of overall plant health. Similar analogy in human medical terms is high blood pressure or high body temperature or high white blood cells in body is an indicator of health problems and thus we can select healthy people from unhealthy using such a measure. As both abiotic and abiotic stresses can result in similar physiological consequence, tolerant plant can be separated from sensitive plants. Some imaging or infrared measuring techniques can help to speed the process for breeding process. For example, spot blotch intensity and canopy temperature depression can be monitored with canopy temperature depression.

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Germplasm Conservation Strategies

D. S. Sutar[1], Dr. S. B. Ghuge[2] and A. D. Autade[3]

[1]SRA, [2]Safflower Breeder, AICRP on Safflower, [3]Ph.D. Scholar, Department of Agricultural Botany (Seed Technology), Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani – 431402 (M.S.)

*Corresponding Author E. Mail: dhanshilasutar21@gmail.com

Germplasm

"The sum total of genes in a crops species is referred to as genetic resources or gene pool or genetic stocks or germplasm".

- In other words, gene pool refers to a whole library of different alleles of a species. Germplasm or gene pool is the basic material with which a plant breeder has to initiate the breeding programme.
- Germplasm contains the information for a species' genetic makeup, a valuable natural resource of plant diversity.

Conservation of Plant Genetic Resources

- Conservation of plant genetic resources is necessary for food security and agro-biodiversity.
- Biodiversity provides a valuable source of compounds to the medical, food and crop protection industries.
- Genetic diversity provides options to develop through selection and breeding of new and more productive crops, resistant to biological and environmental stresses (Rao, 2004).
- Maintainace of Ecosystem.

Need for Conservation of Plant Germplasm

- 07Loss of genetic diversity among crop plant species.
- Human dependence on plant species for food and many different uses.
  E.g.: Basic food crops, building materials, oils, lubricants, rubber and other latexes, resins, waxes, perfumes, dyes fibres and medicines.
- Species extinction and many others are threatened and endangered – deforestation.
- Great diversity of plants is needed to keep the various natural ecosystems functioning stably – interactions between species.
- Aesthetic value of natural ecosystems and the diversity of plant species.

Germplasm Conservation

- The Germplasm has to be maintained in such a state that there is minimum risk for its loss and that either it can be planted directly in the field or it can be prepared for planted for planting with relative ease.
  - **Ex-situ Conservation-** Germplasm conservation is attempted outside or away from its natural habitat.
  - **In-situ Conservation-** Conservation of germplasm in its natural habitat or in area where it grows naturally.
  - **On-farm Conservation-** One of new approach to in situ conservation of genetic resources, focusing on conserving cultivated plant species in farmers' fields. It's nothing but "The sustainable management of genetic diversity of locally developed traditional crop varieties, with associated wild and weedy species or forms, by farmers within traditional agricultural, horticultural or agri-silvicultural cultivation systems" (Maxted *et al.* 1997).

Types of Conservation

- Short term (Working Collections): (>3-5 years) at 10-15 ^{o}c at 10% moisture.
- Medium Term (Active Collections): 10-15year at temperature 15^{o}c with 5% moisture.
- Long Term (Base Collections): 50 years more stored about -20 C with 5% moisture content.

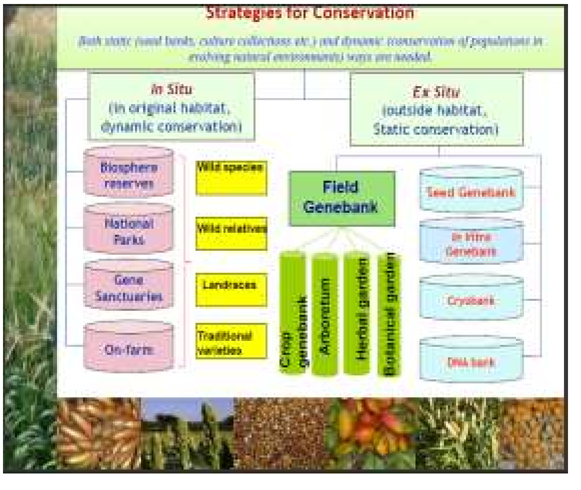

TABLE: Gene Banks for Various Crops:

SN	Crops	Centres
1	Wheat	IIWBR, Karnal
2	Rice	CRRI, Cuttack, IGKV, Raipur
3	Potato	CPRI, Shimla
4	Cotton	CICR, Nagpur
5	Sugarcane	SBI, Coimbatore
6	Tobacco	CTRI, Rajahmundry
7	Pulses	IIPR, Kanpur

SN	Crops	Centres
8	Forage crops	IGFRI, Jhansi
9	Tuber crops (except potato)	CTCRI, Trivendaram, Kerala
10	Plantation crops	CPCRI, Kasargod
11	Oilseeds crop	DOR, Hyderabad
12	Horticultural crops	IIHR, Bangalore
13	Sorghum	NRC Sorghum, Hyderabad
14	Soybean	NRC Soybean, indore
15	Ground nut	NRC Groundnut, Junagarh
16	Maize	IARI, New Delhi

Application of Germplasm Conservation

- Plant material from endangered species can be conserved.
- Recalcitrant seeds can be maintained for long.
- Plant materials (cell/tissue) of several species can be cryopreserved and maintained for several years and used as and when needed.
- Cryopreservation is an ideal method for long term conservation of cell culture which produces secondary metabolites *e.g.* medicines.
- Disease (pathogen) free plant material can be frozen and propagated whenever required.
- Conservation of somaclonal and gametoclonal variation in culture.
- Cryopreservation is a good method for the selection of cold resistant mutant cell lines which could develop into frost resistant plant.

Limitation of Germplasm

- The expensive equipment needed to provide controlled and variable rates of cooling/warming temperatures can however be a limitation in the application of in vitro technology for large scale germplasm conservation.
- Formation of ice crystal inside the cell should be prevented as they cause injury to the cell.
- Sometimes certain solutes from the cell leak out during freezing.
- Cryoprotectant also affects the viability of cells.

31. PLANT BREEDING AND GENETICS 15514

Molecular Cytogenetics: A Recent Tool for High Precision Crop Improvement

*Parul Sharma

[1]Ph.D. Scholar, Department of Crop Improvement, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176062, India

*Corresponding Author E. Mail: sharma.parul023@gmail.com

INTRODUCTION: Traditionally, the term cytogenetics has referred to studies of the cellular aspects of heredity, especially the description of chromosome structure and the identification of genomic aberrations that cause disease. Cytogenetics has been used for many years for various applications, from clinical diagnostics to basic genomic research. **Cytogenetics is the combination of genetics and cytology.**

Genetics - The branch of science which deals with the study of heredity and the variation is called as genetics.

Cytology - The branch of science which deals with the study of structure and function of cell and cell organelles is celled as cytology.

Cytogenetics - The branch of genetics which deals with the study of cell and structure and function of the chromosomes is called as cytogenetic.

Cytogenetics is a branch of genetics that is concerned with the study of the structure and function of the cell, especially the chromosomes. The introduction of chromosome banding in 1969–70 has been one of the most important innovations in cytogenetics. The discovery was first made in *Vicia faba* by the group of Caspersson and Zech with quinacrine that intercalated into DNA producing dark and light Q- bands visible by UV microscopy along each chromosome (Caspersson et al. 1968). However, over the past 25 years molecular cytogenetic techniques of increasingly higher resolution have been developed.

Classical Cytogenetics era to Modern Molecular Cytogenetics era

The development of *In situ* hybridization technique (Gall and Pardue 1969) marked the transition from Classical Cytogenetics era to Modern Molecular Cytogenetics era. This technique involves the annealing of radioactively labelled nucleic acid sequences to cytological (chromosomal) preparations *in situ* (on slides) and subsequent detection of the hybrid regions by autoradiography. Subsequently, Rayburn and Gill (1985) improved ISH with the development of a technique involving the use of a nonradioactive probe (such as biotin) for indirect labeling through nick translation. The hybridization (DNA probe and target sequence) could be visualized through avidin or streptavidin fluorescent labeling. The development of fluorescent molecules led to direct (combined with a fluorochrome) or indirect (through an intermediate molecule incorporated into a probe) binding to DNA bases, which eventually evolved into fluorescent *in situ* hybridization (FISH). Schwarzacher et al. (1989) successfully modified the fluorescent *in situ* hybridization (FISH) protocol as a new cytogenetic technique called genomic *in situ* hybridization (GISH) in which whole genome is used as a probe.

FISH (Fluorescent *In Situ* Hybridization): FISH is a flexible technique that has driven the further development of other cytogenetic techniques. The cytogenetic methods and their advancement have been developed to increase the resolution at which various rearrangements of chromosome can be clearly identified. Fibre FISH is one of the advancement in FISH to improve the resolution of target that involves the analysis of interphase nuclei to the level of chromatin strands by the preparation of released chromatin fibres. This method consists of chromatin from which proteins such as histones are removed, allowing it to unfold and extend. This method, known as fibre FISH, provides a resolution of 1–500 kb. M-FISH and SKY are the most advanced FISH-based approaches, and these approaches facilitate the simultaneous visualization and detection of all human and non-human chromosomes through color karyotyping. The use of DNA microarrays now provides high resolution down to the single-nucleotide level. Indeed, the process involves comparative genomic hybridization using an array rather than a metaphase spread as the substrate.

Principle of FISH

FISH is a method for localizing and detecting specific nucleotide sequences by hybridizing the complementary strand of a nucleotide sequence (the probe) with the DNA of interest (also called target). All this hybridization work is done within the cell, so called as *in situ*.

- The principle of fluorescent *in situ* hybridization includes the hybridization between a labeled DNA probe and a target sequence. The labeling is done by various means such as nick translation, random primed labeling and PCR method. Labeling can be performed in two ways either by indirect or direct labeling method. In direct labeling, fluorescent molecule is directly bind to the probe whereas in case of indirect method, the fluorescent molecule is firstly attach to a reporter molecule that recognizes a primary molecule and bind to it.
- Then denaturation of the labeled probe and the target DNA is done to yield ssDNA.
- After denaturation, there is hybridization step that involves the complementary DNA sequences of probe and target.
- Finally, the signals are detected by fluorescence microscopy.

GISH (Genomic *In Situ* Hybridization)

One of the important modifications of the FISH technique is GISH, wherein the total DNA from the genome of one parent of a polyploid species or a hybrid is labeled as a probe. GISH is used to estimate the amount of alien chromatin within chromosomes in interspecific hybrids. GISH was first used for plants at Plant Breeding Institute, Cambridge (1987) by Schwarzacher et al., using the biotinylated probe of total genomic DNA from *Secale africanum*. Their paper was published in 1989 and this paper coined the term GISH and here the technique got its name.

Applications in Crop Improvement

These techniques of molecular cytogenetics has been used with great success in the study of plants, in different approaches. GISH was first used by Schwarzacher et al. (1989) to identify the genomes of the intergeneric hybrid between *Hordeum chilense* (2n = 2x = 14) and *Secale africanum* (2n = 2x = 14). Detection of chromosomal aberrations, FISH based karyotyping, study of phylogenetic relationships, analysis of somaclonal variations, detection of alien chromatin, analysis of copy number changes are the foremost applications of these techniques showing that molecular cytogenetics is an important tool in high precision crop improvement.

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Genotyping by Sequencing in Genomics Assisted Breeding

Dr. A. V. S. Durga Prasad

Asst. Professor, Dept. of Genetics & Plant Breeding, Agricultural College, Mahanandi-518502, A.P.

INTRODUCTION: Genotyping-by-sequencing (GBS) is an approach that identifies and genotypes the SNPs simultaneously. GBS is a robust, cost-effective, highly multiplexed sequencing approach considered a powerful approach for association studies and also to facilitate the refinement (anchoring and ordering) of the reference genome sequence while providing tools for genomics-assisted breeding (GAB). With the continuous increase in NGS machine output, thereby continuous reduction in cost/sample, GBS will clearly become the marker genotyping platform of choice in coming years. Unlike other SNP discovery and genotyping platforms, GBS overcomes the issue of ascertainment bias of SNPs in a new germplasm. Keeping the cost/sample in view, it is also believed that GBS will provide an attractive option for genomic selection applications in breeding programs where cost per sample is considered a critical factor.

Methodology

GBS approach involves the use of restriction enzymes (REs) for reducing the complexity of genomes followed by targeted sequencing of reduced proportions, so that each marker can be sequenced at high coverage across many individuals at low cost and high accuracy. Overall, the process of GBS involves the following sequential steps: (i) isolation of high quality DNA, (ii) selection of a suitable RE and adaptor, (iii) preparation of libraries for NGS, (iv) single-end sequencing of either 48-plex or 96-plex library on NGS platforms like Genome Analyzer II or HiSeq 2000 of Illumina Inc. (v) sequence quality assessment/filtering, (vi) sequence reads alignment, (vii) calling of SNPs.

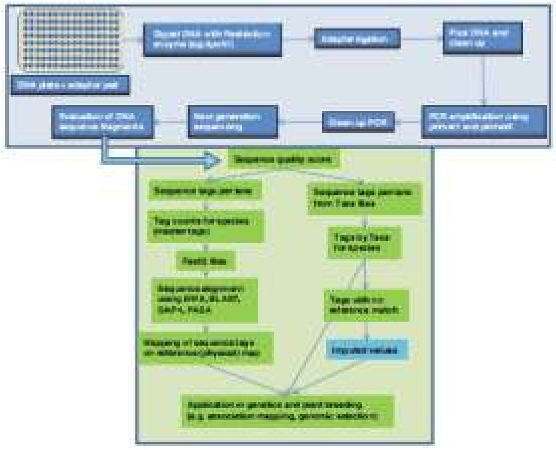

FIG. workflow for genotyping-by-sequencing (GBS) approach

Applications

GBS is a highly multiplexed approach that can typically lead to the discovery of thousands of SNPs in one experiment and may be suitable for population studies, germplasm characterization, high-density genetic mapping, genomic selection and other breeding applications in diverse organisms. The GBS approach can be used even in those plant species that do not have the reference genome available. In such cases, the sequence tags can be treated as dominant markers for kinship analysis. Moreover, availability of the genome sequence in a given species helps in increasing the number of marker loci analyzed through imputation.

33. PLANT BREEDING AND GENETICS 15801

Genetic Architecture and Development of Quality Protein Maize

Dan Singh Jakhar

Research Scholar, Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, BHU, Varanasi – 221005

**Corresponding Author E. Mail: dansingh410@gmail.com*

INTRODUCTION: Maize or corn (*Zea mays* L.) is one of the worlds' most important cereal crops for both human nutrition and livestock feed, in a number of developed and developing countries, worldwide. It is most probably originated in Central America, specifically Mexico and spread Northward to Canada and Southward to Argentina. In view of the changing farming scenario in the country, maize has been promising as one of the potential crops that address numerous concerns like food and nutritional security, climate change, water scarcity, bio-fuel etc. As per the USDA report of May, 2016, the world maize production has been estimated about 96.88 crore tonnes in 2015-16 which is 4.6 per cent lower than last year (101.35 crore tonnes).

Conventional maize has two drawbacks; it lacks two amino acids *viz,* lysine and tryptophan, which results in poor net protein utilization and its low biological value causing wet malnutrition that leads to 'Kwashiorkor' caused by a lack of protein in the diet. Globally, an estimated 805.3 million people were chronically undernourished in 2012-14, with insufficient food for a healthy and active life. India remains home to the largest numbers of undernourished people in the world; 217 million as of 2012. The challenge is to deliver nutritious, safe and affordable food to an ever increasing population in the coming decades to eliminate food and nutritional insecurity. QPM, by virtue of 30% more lysine, 55% more tryptophan, 38% less leucine and enhanced protein quality over normal maize, holds immense promise for alleviating protein malnutrition.

The biological value of QPM is 80% as compared to 45% of conventional maize. In *opaque2* maize proteins, nitrogen balance index is close to those of skimmed milk (0.72 and 0.80, respectively). The *opaque2* maize offers 90% of the nutritional value of skim milk, the standard for adequate nutrition value which has been demonstrated for young children (FAO 1992). In order to meet the nutritional requirement among resource poor people globally. It is important to develop and deploy improved, low-cost, affordable QPM hybrids, with higher grain yield and quality to provide a better food and nutrition security of maize-based population.

Quality Protein Maize

It is an improved variety of maize which contains higher amount of lysine and tryptophan with lower amount of leucine and isoleucine in the endosperm than those contained in normal maize. Lysine levels in conventional and QPM maize average 2.0% and 4.0% of total protein in whole grain flour, respectively. These levels can vary across genetic backgrounds with ranges of 1.6-2.6% in Conventional Maize (CM) and 2.7-4.5% in Quality Protein Maize (QPM) counterparts (Table 1).

TABLE 1. Lysine and tryptophan levels as percentages of total protein in whole grain flour of conventional and QPM (*o2o2*) genotypes.

Traits	CM	QPM
Protein (%)	> 8	> 8
Lysine in endosperm protein (%)	1.6-2.6 (mean 2.0)	2.7-4.5 (mean 4.0)
Tryptophan in endosperm protein (%)	0.2-0.6 (mean 0.4)	0.5-1.1 (mean 0.8)

Source: Vivek *et al.* (2008)

Needs of Quality Protein Maize

- Maize is a major cereal crop and plays very important role in human and animal nutrition in a number of developed and developing countries worldwide derive their protein and calorie requirements from maize
- With its high content of carbohydrates, fats, proteins, some of the important vitamins and minerals, maize acquired a well-deserved reputation as a "poor man's nutria-cereal"
- Normal maize varieties are deficient to two essential amino acids, lysine and tryptophan

Genetic Architecture of Quality Protein Maize

Genetic architecture of QPM is important for QPM breeding, seed maintenance, and production of grain with acceptable lysine and tryptophan content. QPM owes its origin primarily to a naturally occurring mutant, called *opaque2* (*o2*). In QPM, this recessive allele has to be present in a homozygous state (*o2o2*), unlike conventional maize, which has a dominant allele at the same locus, usually in a homozygous (*O2O2*) state. The *o2* gene also enhances the levels of the two essential amino acids in the endosperm. Varieties derived from this original variant/mutant have been used throughout the course of QPM development. Scientists employed conventional breeding approaches to incorporate the *opaque2* gene into a CM background.

Development of Quality Protein Maize

It involves manipulating three distinct genetic systems

- Recessive homozygous allele of the *o2* gene
- Modifiers for kernel hardness
- Amino acid modifiers

Conclusion

Quality protein maize (QPM) is improved over normal or non-QPM maize in grain concentrations of the two essential amino acids, lysine and tryptophan. It has been produced by the introduction of *opaque-2* modifier genes. Normal maize is a poor-quality food staple; unless consumed as part of a varied diet, which is beyond the means of most people in the developing world. QPM contains almost double the amount of lysine and tryptophan as compared to the non-QPM maize. These amino acids allow the body to manufacture complete proteins, thereby eliminating wet-malnutrition. In addition tryptophan can be converted in the body to Niacin, which theoretically reduces the incidence of Pellagra disease.

34. PLANT BREEDING AND GENETICS 15806

Crop Diversification for Sustainability and Livelihood Security

Ritesh Kumar Parihar

Research Scholar, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi- 221005 (U.P.)
**Corresponding Author E. Mail: r.parihar1991@gmail.com*

INTRODUCTION: The term 'diversification' has been derived from the word 'diverge' which means to move or extend in the direction different from a common point (Jha, Kumar and Mohanty, 2009). Agricultural diversification can be described in terms of the shift from the regional dominance of one crop towards the production of a large number of crops to meet the increasing demand of those crops. It can also be described as the economic development of non-agricultural activities (Start, 2001). Crop diversification means different strategies of shifting from less profitable to more profitable crops, changing of varieties, cropping systems, increasing export and competitiveness in domestic as well as international market, protecting the environment and making conditions favorable for combining agriculture-fishery-foresty-livestock.(Van Luat, N. 2001).

Agricultural diversification towards high-value crops can potentially increase farm incomes, especially in a country like India where demand for high-value food products has been increasing more quickly than that for staple crops. Indian agriculture is overwhelmingly dominated by smallholders, and researchers have long debated the ability of a smallholder-dominated subsistence far economy to diversify into riskier high-value crops. A diversified agricultural economy opens up many opportunities. Soil fertility can be increased by way of crop rotation. It adds value in the agriculture by increasing the total crop productivity and at the same time stabilizes the farm income by minimizing the risk associated with only one crop. Since majority of the farmers in India have small landholdings and their income from crop cultivation as well as non-farm income is not enough to meet their subsistence level and also, the country that produces only a few specialized crops is more prone to risk due to fluctuations in domestic and international prices, hence, both the horizontal and vertical diversification become the need of the hour. Further, a sustained economic growth, rising per capita income and growing urbanization are apparently causing a shift in the consumption patterns in favor of high value food commodities like fruits, vegetables, dairy, poultry, meat and fish products from staple food such as rice, wheat and coarse cereals. Such a shift in consumption patterns in favor of high-value food commodities depicts an on-going process of agricultural diversification. This study basically aims at analyzing the trends and patterns of agricultural diversification and related development in the regions of eastern India.

Major Driving Forces for Crop Diversification: (Nishan, 2014)

The major driving forces for crop diversification are:

1. Increasing income on small farm holdings.
2. Withstanding price fluctuation.
3. Mitigating ill-effects of aberrant weather.
4. Balancing food demand.
5. Improving fodder for livestock animals.
6. Conservation of natural resources (soil, water, etc.).
7. Minimizing environmental pollution.
8. Reducing dependence on off-farm inputs.
9. Decreasing insect pests, diseases and weed problems.
10. Increasing community Food security

Determinants of Crop Diversification

Number of factors governs nature and speed of crop diversification.

- Resource endowments: 1. Agro climatic conditions 2. Soil 3. Labour 4. Facility of irrigation
- Technological factors
- House hold factors
- Institutional and infrastructural factors
- Price factors

Suggested Alternate Crops in Place of Rice and Wheat in Major growing States

Sr. no	State	Main crop	Kharif alternate crop	Main crop	Rabi alternate crop
1	Punjab	Rice	Maize, Moong/Urd	Wheat	Mustard, Chick pea, Lentil, Field pea
2	Uttar Pradesh	Rice	Arhar (short duration) Moong/Urd	Wheat	Mustard, Chick pea, Lentil, Field pea

Sr. no	State	Main crop	Kharif alternate crop	Main crop	Rabi alternate crop
3	Bihar	Rice	Not suggested as most of the rice area is waterlogged	Wheat	Maize, Mustard, Lentil.

Approaches of Crop Diversification

A. Horizontal diversification (a) Crop substitution (b) Crop intensification
B. Vertical diversification:
C. Other approaches: 1. Land based approach 2. Water based approach. 3 Varietal diversification

Over all strategies for Crop Diversification

- Diversion of high water requiring crops to less water intensive crops.
- Diversion of Cotton to Pulses, Oilseeds and Maize in light textured and shallow soils.
- Replacement of low yielding low value coarse cereals to high yielding high value crops like Pulses.
- Inter cropping or mixed cropping be promoted in dry areas.
- Shifting high risk crops with short duration Pulses and drought resistant Oilseeds crops.

Conclusion: Diversification in agriculture is possible and essential to save the crumbling agriculture economy and environment. However the process and strategies of making it happen are not as easy as said. People who are actual players in the field have a definite mindset and conditioned behavior. Conducive conditions are another aspect. Suggestion alone is not the solution to the problem. We need to think of practical and workable strategies. First of all, it must be understood that diversification is a dynamic phenomenon and can be multidimensional. In the present context, there may be two-pronged diversification: 1) crop-wise diversification and 2) area-wise

Diversification. Increase in crop diversification leads rural economic developments. The most feasible way of improving the diversification is to reduce the sown area of rice cultivation through altering it towards other crop production. Orchard framing mainly in the urban areas may be the most valuable alternatives to enhance the diversification rate.

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35. PLANT BREEDING AND GENETICS 15824

Apomixis in Plants: Genetic Gold of Plant Breeding

Boraiah K. M.

ICAR-Indian Institute of Seed Science, Kushmaur, Mau 275 101 (UP)
**Corresponding Author E. Mail: bors_km@yahoo.co.in*

Apomixis is a peculiar biological and reproductive phenomena in which could revolutionize agriculture and seed industry in particular. The harnessing of apomixis is expected to launch a new era for plant breeding and seed production. Apomixis has suddenly become the center of attention for plant reproductive biologists and the seed industry. Apomixis, derived from two Greek word “Apo” (away from) and “mixis” (act of mixing or mingling). Winkler (1908) defined apomixis as “the substitution for sexual reproduction or another asexual reproductive process that does not involve nuclear or cellular fusion (*i.e.* fertilization)”. In other words apomixes is a type of reproduction in which sexual organs of related structures take part but seeds are formed without union of gametes. Apomixis is widely distributed among higher plants. More than 300 species belonging to 35 families are apomictic. It is most common in *Gramineae, Compositae, Rosaceae* and *Rutaceae*. Among the major cereals maize, wheat and pearl millet have apomictic relatives.

Types of Apomixis

The three basic types of apomixis are diplospory, apospory and adventitious embryony. Both diplospory and apospory involve apomeiosis, where meiosis is not initiated or not completed, resulting in an unreduced (2*n*) embryo sac (ES). In adventitious embryony a normal sexual embryo sac (*n*) is produced while the asexual embryo grows not from an egg but from a sporophytic cell outside the embryo sac. This somatic embryo is nourished by the endosperm produced within the sexual embryo sac, and the sexual embryo may abort. Diplosporous embryo sacs arise from the megaspore mother cell (MMC) while aposporous embryo sacs develop from an aposporous initial cell elsewhere in the nucellus. Diplospory can be further divided into the meiotic type, where the MMC initiates meiosis but there is restitution of the products, and the mitotic type, where meiosis is bypassed. There are further variations on the development of embryo sacs arising from apomeiosis, such as the formation of four nuclei rather than eight, which may be linked to maintaining parental genome balance in the endosperm. Apomeiotic apomixis often requires a sexual endosperm to support the parthenogenetic embryo, but in autonomous apomixis the endosperm develops without fertilization.

Endosperm Development in Apomicts: The sexual embryo may arrest but the sexual endosperm is required to nourish the asexual embryo. Therefore, the seed contains an endosperm with the normal 2m (matenal): 1p (paternal) genomic ratio, which poses no imprinting-related problems. Various modifications that may be interpreted as strategies to restore the normal balance are employed in nature. One involves changes to the structure of the female gametophyte: the 'Panicum' type of embryo sac contains four nuclei instead of the eight typical of sexual embryo sacs, so that there is only a single unreduced polar nucleus, and therefore fertilization produces a 2m: 1p ratio. Other species modify fertilization behaviour in addition to gametophyte structure. In *Dichanthium annulatum* the unreduced polar nuclei remain separate and either one degenerate or both are fertilized by one sperm each, resulting in two primary endosperm nuclei with a 2m: 1p constitution. In *Ranunculus auricomus* both sperm fertilize the unreduced central cell, resulting again in a 2m: 1p ratio. Pseudogamous apomicts do not appear to modify male gametophytic development to produce unreduced sperm, although this would be an alternative means of restoring the balance. There are also apomictic species in which the endosperm develops with a ratio other than 2m: 1p, raising the question of whether the imprinting system is also modified in these plants.

Polyploidy and Apomixis: The complexity of the regulatory pathways that need to be altered if we are to develop apomictic seeds. Apomixis might require the coordinated deregulation of several genes involved in reproduction. Polyploidy is a possible route to such deregulation. Several researchers have proposed that apomixis might eventually be expressed in diploids, but that apomixis alleles are not transmitted through haploid gametes, or are lethal in diploid progenies, suggesting that the relationship between apomixis and polyploidy might be structural rather than functional. Other evidence, however, suggests a functional role for partial or complete genome duplications. In *Paspalum notatum*, for example, simple chromosome doubling of diploid plants produces apomictic autotetraploids, indicating that the alleles for apomixis are present in the diploids, and that their expression is ploidy dependent.

Genetic Control of Apomixis: Evidence from several taxa indicates that apomeiosis is transmitted as a dominant mendelian factor, though penetrance is limited, explaining the occurrence of facultative apomicts. In some species, such as *R. auricomus*, *Pennisetum maximum* and *Hieracium piloselloides*, apomeiosis along with the other elements of apomictic reproduction are inherited as a single trait. However, in *Taraxacum officinale*, *Poa pratensis* and *Erigeron annuus*, apomeiosis does not always co-segregate with other features of apomixis. In all species tested there is strong suppression of recombination around the apomeiosis locus, suggesting that apomixis may be controlled by many genes that are inseparably linked in one or two co-adapted complexes (Grimanelli *et al.,* 2001).

Mutation studies give significant clues about the genetic mechanism of apomixis. Deletion studies in a *Hieracium* species of the family *Asteraceae* showed that apospory is constituted by two dominant genes named *LOA* and *LOP* (Koltunow *et al.*, 2011). *LOA* conditions aposporous cell differentiation and suppression of sexually developing megaspores, while *LOP* mediates autonomous development of the embryo and endosperm. Mutations in *LOA* and *LOP* result in sexual reproduction. Accordingly, apomixis is conditioned via the breaking down of the default sexual pathway by two different loci.

The ecological and evolutionary studies in *Taraxacum* (dandelion) and *Chondrilla* (skeleton weed) revealed that the apomicts have a wider geographical distribution than sexuals, illustrating the short-term ecological success of apomixis. The close phylogenetic relationship between *Taraxacum* and *Chondrilla* and the similarity of their apomixis mechanisms suggest that apomixis in these two genera could be of common ancestry.

Why Apomixis is Genetic Gold?

Apomixis is an attractive trait for the enhancement of crop species because it mediates the formation of large genetically uniform populations and perpetuates hybrid vigor through successive seed generations. Many agronomic advantages of apomixis can be envisioned: the rapid generation and multiplication of superior forms through seed from novel, currently underused germplasms; the reduction in cost and time of breeding; the avoidance of complications associated with sexual reproduction, such as pollinators and cross-compatibility; and the avoidance of viral transfer in plants that are typically propagated vegetatively, such as potatoes.

Apomictic hybrids will not need cytoplasmic male sterility and fertility restorer systems, which means much shorter and easier hybrid development procedures. Besides increasing the time needed to develop hybrid varieties, these systems also cause problems by making hybrid varieties dependent on a limited number of sterility sources and increasing their genetic vulnerability due to the cytoplasmic uniformity of all hybrids (Spillane *et al.*, 2004). Apomixis technology will eliminate the need for male sterility systems and falling seed prices will allow production of hybrid varieties in all crops. Yield increases of 20%–50% can be expected from hybrids in self-pollinating major crops such as rice and wheat (Tester and Langridge, 2010) as a result of apomixis technology.

Another advantage of apomixis in self-pollinating crops is that it will allow the development of new varieties with one cross. Thus, the whole variety development process, including seed multiplication and performance tests, will be completed within 3 or 4 years rather than 8 to 10 years. Autonomous apomictic crops will not need pollination and hence do not require male system development. Therefore, elimination of male flowers or flower parts will save some precious assimilates in some plants (*e.g.*, maize). Lack of need for pollination in autonomous apomictic crops will also prevent losses due to pollination failure, which has been gaining importance in recent years due to "pollinator decline" in cross-pollinating species (Kluser and Peduzzi, 2007) and threats to sexual reproduction caused by global warming (Hedhly *et al.*, 2008). A major advantage of apomixis for plant breeding is that it will increase the survival of interspecific crosses since chromosomal irregularities in meiosis, and consequently hybrid sterility, is not a problem in apomictic plants. This could enormously increase the genetic diversity to be used in plant breeding.

The complex, multiple mechanisms of apomixis have been difficult to elucidate so far. However, due to its potential advantages in plant breeding, apomixis has been the focus of an enormous amount of investigation. The final steps towards understanding the genetic system controlling apomixis are now underway and from which apomixis begins to be successfully introduced or mimed in sexual species. Use of apomixis could change the face of plant breeding in the near future.

36. PLANT BREEDING AND GENETICS 15831

Haploidy and Double Haploids in Plant Breeding

Dr. Megha R. Puttawar

Asstt. Professor, College of Agriculture Konghara, Botany Section, Ta. Kelapur, Dist- Yavatmal
**Corresponding Author E. Mail: puttawarmegha@yahoo.com*

The usefulness of haploid plants in basis research in cytogenetics, genetics, evolution and practical plant breeding is well known. Haploid plants provide an efficient research tools for studies on induced mutagenesis and genetic transformation. They also help elucidate the genetic control of chromosome pairing inherently present in allopolyploids such as bread wheat, durum wheat and oats. Genetic control of chromosome pairing in haploid nuclei has helped in assessing intergenomic relationships.

Haploid plants are sporophytes with half the normal chromosome number. Various aspects of their usefulness in basic breeding has been amply documented. Haploids provide an efficient research tool for studies on induced mutagenesis and genetic transformation. They have helped elucidate the genetic control of chromosome pairing inherently present in allopolyploids. The genetic control of chromosome pairing has, in turn, helped assess intergenomic relationships. Haploids offer a unique opportunity for studying chromosome pairing relationships because the intergenomic homologies, that generally remain masked due to homologous chromosome pairs in the parental species, are the best revealed in the chromosome complemented in the haploid state.

In addition to its numerous applications in biological research, the haploid approach is an integral component of the several plant genetics and breeding programs. It provides an efficient and rapid means of producing truly homozygous (equivalent of pure or inbred) lines, thereby accelerating the breeding process. The double haploid (DH) populations, which are genetically similar to recombinant inbred lines (RILS), developed by single seed decent, have been used for mapping quantitative trait loci (QTLs) for several important traits. Furthermore, wheat cultivars developed from DHs have been released for cultivation and are dominant cultivars in some countries especially Canada. The importance of haploid-induced instant homozygosity after chromosome doubling cannot be overemphasized. The haploidy technique has been truthfully employed for elucidating their cytogenetic architecture and for their genetic improvement.

Definitions and Terminology: A "haploid" is a general term used for all sporophytes (whether diploid or polyploidy) with the gametic chromosome number. Strictly speaking, a haploid plant derived from a diploid species is more appropriately called a "monoploid" because it has only one set of chromosomes *i.e.*, only one genome. Because monoploids are sporophytes, their somatic chromosome number is denoted by 2n, as in the case of diploids and polyploids. Whereas 2n refers to somatic chromosome number, x would show the basic chromosome number in one genome of a monoploid. Thus, a haploid (a monohaploid or simply a monoploid) derived from diploid Einkorn wheat (Triticum monococcoccum L.) is indicated to have 2n = x =7 chromosomes. However, a haploid derived from a polyploidy species such as bread wheat (T. aestivum L., 2n =6x=42; AABBDD) or durum wheat (T. turgidum L., 2n =4x=28;AABB) is preferably termed a polyhaploid. Thus a polyhaploid of bread wheat has 2n = 3x = 21 chromosome with the genomic constitution ABD, whereas a polyhaploid of durum wheat has 2n = 2x = 14 chromosomes with the genomic constitution AB.

Polyploids derived from polyploidy species are further classified according to the nature of polyploidy of the parental species from which they are extracted. A Polyhaploid from an autopolyploid, such as the potato (solanum tuberosum L., 2n =4x=48), is termed as autopolyhaploid. However, the term “haploid” is widely used as general term in both diploid and polyploidy species, and the terms “haploid” and “polyploidy” are often used interchangeably for haploids derived from polyploidy species. Because allopolyploids wheat can also be called amphidiploides (or amphiploides), their haploides can be termed amphihaploides. Thus, a haploid (or allopoly haploid) extracted from durum wheat (AABB =28) can also be called amphihaploides (AB =14). On basis of their chromosomal constitution, haploides are further classified into various categories as described below.

Classification of Haploids

As stated above a “haploid” is a general term for all plants whether derived from a diploid in a polyploidy with half the chromosome number of the euploid form of the species. Systems of classification of haploides have been proposed various workers. The following classification is based largely on the one proposed by

Spontaneous Occurrence of Wheat Haploids: Allopolyploidy, resulting from interspecific or intergeneric hybridization in conjuction with sexual (meiotic) doubling of the chromosomes in the interspecific (

Induction of Haploids: Haploids (and double haploids) are useful in biology or for application in plant breeding. Efficient and reliable methods of producing haploids / doubled haploids must be developed and standardized so they can be fruitfully employed. Several such methods have been tried with varying degrees but only the two most common will be discussed here:

Anther Culture: The beginning of the tissue cultures was made as early as 1080, when a german botanist, G. Haberlandt successfully completed differentiated individual plant cells, isolated from different tissues in several plant species.

Maize – Induced Haploids: Maize induced haploids: the method of choice

Despite several problems inherent in microspore embryogenesis in some crops (such as rice), anther culture is still perhaps the most widely used technique for producing haploids in many crop plants (Sriatpanahi et al., 2006b). However, in cultivated wheats, particularly durum wheat, wide hybridization offers an effective tool for extracting haploids. Although Hordeum bulbosum-mediated haploid production has been accomplished n bread wheat (Barclay, 1975), and has widespread use in doubled haploidy programs in barley, this method has not been effective in durum wheat. Cross-compatibility genes in wheat are a major problem for the effective use of H. bulbosum-mediated haploid production system.

Characterization of Haploid Plants

Although certain diagnostic morphological features *i.e.*, slower growth, smaller size. And narrower leaves, can help identify haploid plantlets, the most reliable method of detecting haploids is by chromosomal count. It is of course important to confirm their haploid status before inducing chromosome doubling to produce DHs. Details of root-tip chromosome counting – pretreatments to condense chromosomes, fixation of root tips, suitable stains and staining techniques and chromosome squashing and spreading procedures- are routine and easy to apply.

In well spread preparations, 14 chromosomes of the haploid complement in durum wheat can be easily counted, with one dose each of the satellite chromosomes 1B and 6B; 1B has smaller satellite. In conventionally stained somatic cells, however, the chromosomes of the A and B genomes cannot be identified.

Production of Double Haploids

Production of homozygous lines by doubling the chromosomes number of haploids is an important goal of haploid research. Doubling can be done spontaneously or through the use of chemicals such as colchicines that affect spindle tubule formation.

In case of spontaneous doubling, production of unrelated gametes in haploids leads to seed set in both durum and bread wheat haploids. Reports of seed set in both durum and bread wheat haploids. Reports of seed set on haploid plants are rare. This creates a need for induced chromosome doubling for efficient doubled-haploid production. For DHs to be useful, an efficient method of their production must be available. Androgenetic DHs have been produced in wheat, rice, mustard etc. by numerous workers. Colchicines treatment provides an effective means of producing DHs. Treatment of cytologically confirmed haploid plantlets with 0.2 % aqueous solution of colchicines at 25 º C gives good results. The seedlings are immersed upto the the crown level in colchicines solution in an adequately aerated beaker presumably to avoid the roots dying due to the flooding response. Alternative chromosomes doubling strategies have been explored. Addition of colchicines to wheat anther culture media increased DH plant production. In vitro colchicines treatment, in which haploid embryos were rescued on medium containing 0.5 % colchicines and later moved to colchicines- free medium, had 92 % of their regenerated plants showing chromosomes doubling.

37. CROP PHYSIOLOGY 15871

Biosensor: A New Age Technology to Detect Fruit Ripening

[1]S. Behera, [2]A. K. Padhiary and [3]R K Rout

[1]Krishi Vigyan Kendra, Kalahandi; [2]Krishi Vigyan Kendra, Sambalpur; [3]College of Agriculture, OUAT, Bhawanipatna

*Corresponding Author E. Mail: srikrushnabehera.ouat@gmail.com

INTRODUCTION: Fruit quality monitoring is one of the major concerns within the food industry (Kriz et al., 2002). In particular, there is a growing need to develop analytical instruments which can provide quality monitoring for the entire food processing operation, including starting materials and final products (Whitaker, 1994). Biosensors are highly selective analytical instruments, due to the high selectivity of the biological recognition element employed which have been applied in an array of disciplines including medicine, industry, environmental analysis, food technology, and military (Wang, 2001).

A biosensor is a compact analytical device incorporating a biological or biologically derived sensing element either associated or integrated within a physicochemical transducer (Fig.1). The usual aim of such a device is to produce either a discrete or continuous digital electronic signal that is proportional to a single analyte or a related group of analytes present in a sample (Compagnone et al., 1995).

Description

The application of biosensors in the medical diagnostics market has been highly successful. However, their potential success in the food, agriculture, veterinary diagnosis and environmental market is still to be established. Biosensor systems which are relatively small, portable instruments, have an on-site application and relatively inexpensive are desirable in the agro/food analysis. A vast amount of research is being undertaken in diagnostics companies and research institutions to develop biosensor technologies for the agricultural diagnosis sector. However, moving the technology to the market place faces many challenges. For a developed biosensor to be successful it must compete with the fairly well established chemical, DNA and immunoassays techniques. The future holds much promise, but lies in addressing niche markets and changing requirements in complex systems.

Fruit maturity at harvest is the most important factor that determines shelf life and final fruit quality. If harvested immature then fruits are more subject to shrivelling and mechanical damage, and are of inferior quality when ripe, whereas overripe fruits are liable to become soft and mealy with bland flavor soon after harvest (Kader, 1999; 1992). Therefore, fruits harvested either too early or too late in their season are more susceptible to post harvest physiological disorders than fruits harvested at proper maturity. Fruits can be divided into two groups:

1. Fruit that are incapable of enduring their ripening process once picked from the plant like berries, cheery, citrus fruits, grapes, lychee, pineapple, pomegranate, and tamarillo.
2. Fruits that can be harvested mature and ripped off the plant like apple, apricot, avocado, banana, cherimoya, guava, kiwifruit, mango, nectarine, papaya, passion fruit, pear, peach, persimmon, plum, quince, sapodilla, sapote (Kader, 1999;1992).

Volatile compounds are responsible for the characteristic aroma of fruits and are present in extremely small quantities (<100< g/g fresh wt.). The major volatile formed is ethylene. Scientists are trying to develop portable instruments with sensors that detect volatile production by fruits and hence detecting maturity and quality. Other strategies include the removal of a very small amount of fruit tissue and measurement of total sugar or organic acid content (Seymour et al., 1993).

Fruit	Carbohydrate (g)	Fats (g)	Proteins (g)	Glucose (g)	Ascorbic Acid (mg)	Malic Acid (mEq)	Citric Acid (mEq)	Other Acids (mEq)
Apple	6.6	0.17	0.26	1	7.8	3-19	-	Quinic acid (in unripe fruits)
Pear	15.46	-	1	2	5.3	1-2	30	-
Apricot	63	0.5	3.4	2.8	9.4	12	12	Quinic 2-3
Cherry	16	0.2	1.1	2.8	7	5-9	-	Quinic and shikimic
Peach	9.5	0.3	0.9	1.2	6.6	4	4	-
Plum/prune	11.4	0.3	0.7	2.9	9.5	4-6	-	Quinic (Specially in unripe fruits)
Strawberry	43	0.53	0.88	3.1	82	1-3	10-18	Quinic 0.1, Succinic 0.1
Raspberry	5.4	0.8	1	1.6	32.2	1	24	–
Currant, red	7.5	0.4	1.4	2.9	30	2-4	21-28	Succinic, Oxalic
Current / black	7.8	0.4	1.1	2.8	120	6	43	-
Gooseberry	5.4	0.4	0.9	2.8	30	10-13	11-14	Shikimic 1-2
Grapes	18.1	0.16	0.72	12.48	51	1.5-2	–	Tartaric 1.5-2
Orange	8.9	0.3	0.6	2.6	36.7	3	15	Quinic acid
Lemon	1.4	0.7	0.4	0.6	33.2	4	73	Quinic acid
Pineapple	2.9	0.2	0.3	1.2	16.2	1.5-7	6-20	–
Banana	12.3	0.3	0.7	2.9	6.7	4	–	–
Fig	42.5	0.8	3.4	14.7	4.8	0.2-1	6	Acetic acid
Guava	10	0.5	1	–	400	-	10-20	–

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38. CROP PHYSIOLOGY 13638

Plant Nutrients Uptake and its Importance

Pallavi N.[1], Nandini K. S.[2] Archana R.[2]

[1]AICRP on Groundnut, ZAHRS, Hiriyur-577 598, Karnataka

[2]Department of Vegetable Science. College of Horticulture, Mudigere – 577132, Karnataka

Nutriophysiology deals with metabolic and biochemical functions of the chemical elements and their interaction with other aspects of plant physiology and plant biochemistry. It deals with initial acquisition of chemical elements, their distribution within the plant and interactions of the plant with its chemical media.

The supply and absorption of chemical compounds needed for growth and metabolism of plants may be defined as Plant Nutrition and the chemical compounds required by the plants are termed as Nutrients. Plants require some nutrients, such as carbon and nitrogen, in large quantities to survive. Such nutrients are termed macronutrients, where the prefix *macro-* (large) refers to the quantity needed, not the size of the nutrient particles themselves. Other nutrients, called micronutrients, are required only in trace amounts for plants to remain healthy. Such micronutrients are usually absorbed as ions dissolved in water taken from the soil, though carnivorous plants acquire some of their micronutrients from captured prey.

The following table gives list of element nutrients essential to plants and their importance within plants are generalized.

Micronutrients – Necessary in Small Quantities

Sl. No	Element	Form of uptake	Importance
1	Chlorine	Cl^-	Photosystem II and stomata function
2	Iron	Fe^{2+}, Fe^{3+}	Chlorophyll formation
3	Boron	HBO_3	Crosslinking pectin
4	Manganese	Mn^{2+}	Activity of some enzymes
5	Zinc	Zn^{2+}	Involved in the synthesis of enzymes and chlorophyll
6	Copper	Cu^+	Enzymes for lignin synthesis
7	Molybdenum	MoO_4^{2-}	Nitrogen fixation, reduction of nitrates
8	Nickel	Ni^{2+}	Enzymatic cofactor in the metabolism of nitrogen compounds

Macronutrients – Necessary in Large Quantities

Sl. No.	Element	Form of uptake	Importance
1	Nitrogen	NO_3^-, NH_4^+	Nucleic acids, proteins, hormones, etc.
2	Oxygen	O_2 H_2O	Cellulose, starch, other organic compounds
3	Carbon	CO_2	Cellulose, starch, other organic compounds
4	Hydrogen	H_2O	Cellulose, starch, other organic compounds
5	Potassium	K^+	Cofactor in protein synthesis, water balance, etc.
6	Calcium	Ca^{2+}	Membrane synthesis and stabilization
7	Magnesium	Mg^{2+}	Element essential for chlorophyll
8	Phosphorus	$H_2PO_4^-$	Nucleic acids, phospholipids, ATP
9	Sulfur	SO_4^{2-}	Constituent of proteins

39. CROP PHYSIOLOGY 15307

Cadmium Toxicity in Higher Plants

Suvarna Gare and Anant Ingle

Ph.D. Scholar, Department of Agricultural Botany, PGI, MPKV, Rahuri.
**Corresponding Author E. Mail: gare.suvarna111@gmail.com*

Heavy metal toxicity is one of the main current environmental health problems, and potentially harmful because of bioaccumulation through the food chain and plant products for human consumption. Therefore, heavy metal contaminations of soils and plants have become an increasing problem especially by industrial effluents and agricultural improvement. Of the total 90 naturally occurring elements, 53 are considered heavy metals (Weast,1984) and few are of biological importance.

Cadmium (Latin word- Calamine) is a chemical element with symbol Cd and atomic number 48 and Atomic mass is 112.414 and placed in trasition metals in periodic table ("D" block element). This soft, bluish-white metal is chemically similar to the two other stable metals in group 12, zinc and mercury. Oxidation state of cadmium is +2, Melting point- 321.07°C, Boiling point- 767°C, Density- 8.65 g cm^{-3}. The average concentration of cadmium in Earth's crust is between 0.1 and 0.5 ppm. It was discovered in 1817 by Friedrich Stromeyer and K.S.L. Hermann, both in Germany, as an impurity in zinc carbonate.

Cadmium is non-essential element that negatively affects plant growth and development. It is released into the environment by power stations, heating systems, metal working industries or urban traffic. Cadmium is recognized as an extremely significant pollutant due to its high toxicity and large solubility in water (Pinto *et al.*, 2004)). Important sources of cadmium input to the marine environment include atmospheric deposition, domestic waste water and industrial discharges (Benavides *et al.*, 2005). Wagner (1993) estimated that non-polluted soil solutions contain cadmium concentrations range from 0.04 to 0.32 mM. Soil solutions which have a cadmium concentration varying from 0.32 to about 1 mM can be regarded as polluted to a moderate level (Benavides et al., 2005).

Sources of Cadmium/Heavy Metals in Soil

1. Muncipal and industrial waste
2. Sediment from waste water treatment plants
3. Leachate from soild waste treatment plant
4. Mining waste

Increasing industrialization, anthropological activities and wide spread use if metals in various products, their continuous discharge from foundries, smelters, coal-fired plants and various other types of waste disposal practices have led to even more introduction of heavy metals like Cd, Pb, Hg, Ni, etc into the soil environment. Metal based pesticides and industrial activities pollute the soil with high levels of Mn, In, Cu, As, Pb, Fe and Hg. Power plants contribute metals like Se, B, Cs, Ni, Cd and Cu to the environment (Verkleij and Schatt, 1990).

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Effects of Heavy Metal Stress on Plants

1. Excessive transpiration or water loss
2. Limited photosynthesis and respiration
3. Altered membrane integrity
4. Protein denaturation
5. Enzyme activation or inactivation
6. Other biochemical alterations

A. Plant's Responses to Cd Stress

1. Morpho-Anatomical Responses

1. Chlorosis, growth inhibition and alteration in normal plant metabolism
2. Enters food chain
3. Inhibits lateral root formation
4. Inhibits cell growth and intercellular spaces- stronger cross linking between pectin molecules and Cd

2. Effects on Nutrient Transport and Accumulation

1. Cadmium being a divalent cation may compete with Ca, Mg or iron (Fe) in their transport across membranes. It is taken up by plants via cation transport systems normally involved in the uptake of essential elements,
2. competition between nutrients and toxic metal in the plant for binding sites
3. Cadmium entry through the Ca channel in the leaves dis-turbs the plant-water relationship, causing stomatal closure in many plants, leading to lower transpiration rate, and inhibition of photosynthesis through an adverse effect on chlorophyll metabolism.
4. The decrease of Mn, Fe, Mg, S and P concentrations in leaves of Cd-sensitive cultivars under Cd stress has been shown to be the key reason for the restraint of leaf photosynthesis
5. Cd-induced inhibition of photosynthesis has also been attributed to an inhibition of the activity of key enzymes of the Calvin cycle and the photosynthetic electron transport chain in rice, and inhibition occurred at the up-take level or in translocation of nutrients. Cadmium may interfere with the nutrient uptake by altering the plasma membrane permeability, leakage of nutrients through plasma membrane and affect the element transport processes across the membrane

3. Physiological Responses

1. Inhibition of seed germination
2. Reduction in root growth- corresponding loss of plasma membrane integrity of root cells
3. Disturbance in mineral nutrition and sugar metabolism
4. Cd competes for Ca binding sites- inactivates Ca binding proteins
5. Interacts with Sulphydryl group of various biomolecules- general mechanism of Cd toxicity
6. Influences biomass production
7. Invades sulfur metabolism- influences activity of many enzymes eg.- ATP sulfurylase, APR, nitrate reductase, nitrite reductase, ferredoxin glutamate synthase, NADH glutamate synthase and glutamine synthase etc.
8. Alters activity of ribonuclease (Shah and Dubay, 1995)
9. Production of phytochelatins
10. Protein denaturation (Jungmann et al., 1993)
11. Produces oxidative stress by generating Reactive Oxygen Species

4. Molecular Responses of Plants to Cadmium

1. Cadmium damages DNA and Zn probably modulates the protection of DNA from Cd-induced damage
2. Cadmium negatively influences the structural integrity of DNA which was identified utilizing the principle of the formation of a fluorescent complex between double-stranded DNA and ethidium bromide.

Conclusions

1. Cadmium is a non-essential heavy metal which is phytotoxic and has negative impact on plants.
2. It retards various physiological, morphological, biochemical and molecular activities of plant species.
3. It is easily taken up by the roots of plants and causes severe damage to plant system.
4. Increase in activity of antioxidant enzymes could be attributed to the increased tolerance to cadmium
5. At higher concentration it may even cause death of the plant species. At low concentrations it can induce production of stress proteins and other secondary metabolites which indirectly help plants to resist against the oxidative damage caused by cadmium.

40. CROP PHYSIOLOGY 15798

Physiology of Flowering in Perennial Fruit Crops

Rakesh Sil Sarma

Department of Plant Physiology, Institute of Agricultural Sciences, BHU, Varanasi.

INTRODUCTION: Flowering is an physiological and biochemical developmental process in perennial fruit trees, crucial to reproductive success and continuity of the species through time. Some perennial fruit crops complete their life cycle within 5 year, and others have a longer reproductive life, which is characterized by the generation of new flowering and vegetative shoots every year (perennial plants). Despite the differences in their lifespan, the underlying genetics of flower induction and floral organ formation appears to be similar among these plants. In many perennial woody plants growing in the temperate and cold regions, regulation of seasonal growth cessation and floral initiation are closely integrated, both taking place in photoperiods shorter than a critical length. linkage between flowering and dormancy responses is the well-known dual effects of chilling temperature on vernalization and its relation to dormancy. Elucidation and disentangling of these networks of integrated processes are now awaiting joint research efforts in the areas of molecular genetics and experimental plant physiology.

Hormonal Influence of Flowering

Flowering is regulated by a complex moleculer network of genes that integrate multiple environmental cues and endogenous signals so that flowering occurs; hormone regulation, molecular signaling and homeostasis are very important in floral physiology of perennial fruit crops. Working alone or in combination, hormones are able to promote flowering by epigenetic regulation. Some plant hormones, such as gibberellins, jasmonic acid, abscisic acid and auxins, have important effects on chromatin compaction mediated by DNA methylation and histone posttranslational modifications, which hints at the role that epigenetic regulation may play in flowering through hormone action. miRNAs have been viewed as acting independently from DNA methylation and histone modification, ignoring their potential to interact with hormone signaling – including the signaling of auxins, gibberellins, ethylene, jasmonic acid, salicylic acid and others – to regulate flowering. Therefore, in this review we examine new findings about interactions between epigenetic mechanisms and key players in hormone signaling to coordinate flowering. Different studies indicate the importance of the interactions among different plant hormones, such as ethylene (ET), indole-3-acetic acid (IAA), cytokinins (Cks) and abscisic acid (ABA) for flower induction in A. thaliana. Among the different hormonal pathways, the phytohormone gibberellic acid (GA) plays a dominant role. GA is connected with the other floral pathways through the GA-regulated DELLA proteins, acting as versatile interacting modules for different signaling proteins.

Photoperiodism and Vernalization in Flowering

Photoperiod is sensed in the leaves, with long-day (LD) and short-day (SD) plants flowering in response to the change in the dark period, requiring short and long dark periods, respectively. In Arabidopsis, CONSTANS (CO) mRNA expression is regulated by the circadian clock and peaks toward the end of the day. Under LD conditions the photoreceptors cryptochrome 1 and 2 and phytochrome A act antagonistically to phytochrome B to stabilize the CO protein, allowing it then to up-regulate FT. Both CO and FT proteins are expressed specifically in the vascular tissues of the leaf. Once expressed, the FT protein is then transported via the phloem to the meristem, so that in Arabidopsis at least, the FT protein acts as a 'florigen'. Plants have evolved many systems to sense their environment and to modify their growth and development accordingly. One example is vernalization, the process by which flowering is promoted as plants sense exposure to the cold temperatures of winter. A requirement for vernalization is an adaptive trait that helps prevent flowering before winter and permits flowering in the favorable conditions of spring. In Arabidopsis and cereals, vernalization results in the suppression of genes that repress flowering.

Floral Physiology of Fruit Crops Case Studies

Fruit production and quality depend on adequate source-sink relationships. Carbohydrates (CH) translocated from leaves or reserve organs are the most important for the growth and development of sink organs (mainly fruits). The rate of translocation of photosynthates from the sources (mainly leaves) to the sinks (mainly fruits) influences photosynthesis. The photosynthesis is instantly dependent on leaf export function and disturbance of sink-source relationships is usually created by removing a part of sources or sinks. The fruiting has strong effects on individual tree growth and architecture: (1) fruit load modifies the partitioning of available carbohydrates and water economy in a short term, (*i.e.*, during annual cycle), and (2) heavy yields affect tree vigor in a longer term by reducing cumulated growth over years. Reaching equilibrium between both growth and fruiting is thus one of the main objectives of the fruit grower. Some cultural practices, by manipulating either source size or sink size, influence source–sink relationships involved in fruit growth. Thinning, which controls crop load by removing the smallest fruits, usually increases the size of the remaining fruit.

Conclusion: Flowering of fruit crops is an important physiological and biochemical event that sets the start of blooming and fruit production. Initiation is the first event that takes place for fruits to flower. Flowering is decisive factor in the productivity of perennial fruit crops. Floral bud differentiation and flower initiation in mango denotes distinct changes in phytohormones and mobilization of carbohydrates from source to sink, which depend by climatic conditions, shoot age and size, besides genetic characters. Very high and very low temperature during flowering is harmful to pollen and tree fails to flower. As climate change accelerates, its effects on flowering induction will become increasingly significant. Now evidence suggests that proper epigenetic regulation of plant hormone signaling is necessary for the correct transition from the vegetative to the reproductive stage.

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41. HORTICULTURE 13543

Canopy Management Practices in Horticultural Crops

P. L. Deshmukh[1] and V. A. Bodkhe[2]

[1]*Ph.D. Scholar, Department of Horticulture, Dr. P.D.K.V., Akola, Maharashtra.*
[2]*Ph.D. Scholar, Department of Horticulture, M.P.K.V., Rahuri, Maharashtra.*
**Corresponding Author E. Mail: pravindeshmukh1991@gmail.com*

Canopy management is the manipulation of tree canopies to optimize the production of quality fruit. It involves more than just pruning and tree training. It also includes the regulation of flowering and fruit growth. In many fruit crops, improved production and fruit quality has come from producing more fruit from smaller trees. This is because small trees are better at capturing and converting sunlight into fruit than large trees. Smaller trees also mean safer and more efficient harvests. If we are going to have small tree orchard systems then we must develop the canopy management techniques needed to achieve this and we need to know how these modified canopies will affect fruit quality.

Training and Pruning

Training: Training and Pruning is important orchard an operation directly helps in growth, bearing and quality of fruits. A properly trained and pruned fruit plant sustain better crop load. Training is important initial orchard operation (1-3 year age) refers to judicious removal of plant parts with the objectives to make a strong frame work, so that plant can bear good crop in the future. Training also includes providing supports, bending tying and pinching to encourage the side shoots.

Principles of Training

- Training should be started from very beginning age of the plant.
- Most of the trees are trained in single stem system. While, in some fruit crops like Pomegranate, Fig, Custard apple and bushy plants are trained through multi stemmed training system.
- Through training can control apical dominancy with balance retain desirable branches on tree.
- The shoots having narrow crotch angle (<40-45^0) should be discarded.
- Water sprouts should be removed time to time.

Pruning: Pruning is an art and science of cutting away a portion of the plant to improve the shape, to influence its growth, flowering and fruitfulness, to improve the quantity and quality of the product. It is nothing but renewal of plant part so as to influence of physiological functions in promoting more crop with better fruit quality

Principles of Pruning

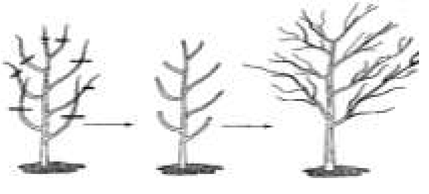
1. Removal of water sprouts in later part of plant life.
2. Alteration of growth and development
3. Pruning Seasons
4. Avoid bark injury while pruning
5. Pruning should be completed well in advance of flowering season.
6. In deciduous plants, pruning should be done in advance of winter so that low temperature injury may be minimized.
7. Apply Bordeaux mixture or paste or COC just after pruning to avoid incidence of diseases spread.
8. Over crowded, diseased, damaged and insect infested shoots should be removed.

Parts of Trees

1. Trunk: The main stem of the plant
2. Head: The point on the trunk from which first branches arise.
3. Scaffold: The main branches arising from the head branches
4. Crotch: The angle made by scaffold limbs to the trunks or secondary branch of scaffold limb.
5. Leader: Main stem growing from ground level up to the tip dominating all other branches.
6. Water shoot: Vigorous growing unbranched shoot arising on any branch.
7. Water sucker: Growth appearing on rootslc5bk portion.

Methods of Pruning

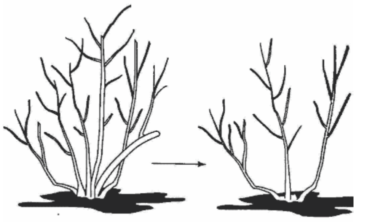
1. Heading Back



- Only 1/3 to 1/2 terminal portion is removed.
- Encourages development of secondary branches, lateral bud growth destroys apical dominance of twig shoot and branches.

2. Thinning Out

- Undesirable shoots and branches are removed from the base or point of attachment of main truck.
- Encourages longer growth of the remaining terminals



- Used for rejuvenation of old trees.

3. Dehorning

- Removal of all wood after leaving 7-1O m. thick stub all over the tree.

4. Renewal Pruning

The first two types, thinning and heading back, are the basic method of pruning. Renewal pruning is employed to rejuvenate old plants by removing old, unproductive branches, which allows for fresh and vigorous replacement growth.

- **Ringing or girdling**: in this process a circular ring of bark measuring about 5 mm to 3 cm in length is moved for hastening bearing by allowing greater accumulation of photosynthesis in upward of the plant.
- **Notching**: making a notch above a bud by removing a wedge shaped piece of bark is termed as notching. It checks the influence of hormone and encourages growth.
- **Nicking**: making a notch below a bud by removing a wedge shaped piece of bark is termed as nicking. This ensuring accumulation of carbohydrates from the leaves to the bud and may result in the formulation of fruit bud.
- **Root pruning**: a portion of coiled, fibrous, old roots are removed from citrus, temperate fruit crops for regulating the flowering.
- **Leaf pruning**: a portion of leaves are pruned to regulate flowering in guava, bonsai for size control and maintain fruit: leaf ratio.

Time of Pruning: Pruning can be done during dormant season because during this period the sieve-plates of the phloem remain blocked with a thick layer of callus, thus restricting the movement of carbohydrates. It should be started just after leaf fall but must be completed before start of growth.

42. HORTICULTURE 14299

Special Production Practices of Banana

Sanvar Mal Choudhary, Pravin L. Deshmukh and Aadik N. Alekar

Ph.D. Scholar, Department of Horticulture, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722 Maharashtra

Banana is one of the oldest cultivated tropical fruits in India. It is a monocotyledonous, perennial, herbaceous succulent plant, propagated through rhizomes which are sympodial in nature. The portion above the ground made of sheaths of the leaves is known as pseudostem. It is one of the important energy producing fruits and is a good source of mineral and vitamins. The plants are considered as the symbol of prosperity and fertility. Owing to its greater socio-economic significance and multifaceted uses banana is popularly known as *kalpataru* (A plant with virtues). Ripe fruits are delicious and are used for table purpose. Immature fruits are used for vegetable. The leaf of banana is used as a plate for serving meals, especially in south India. Many products from banana are made *viz.,* banana chips, soft drink, flour, jam, vinegar, puree, powder etc. Banana crop need special cultural care in order to get proper production. Intercultural operations may be classified as pre-flowering and post0 flowering cultures, as these are quite different. The first is practiced to improve the vegetative growth of the plants while the second is meant for improving the quality of fruits. The detail accounts of such practices are furnished here under:-

Desuckering: A single clump of banana produces many suckers. The sucker starts emerging after about three months of planting. The number of sucker depend upon cultivar, soil fertility, growing environment, etc. if too many suckers are allowed to grow, they compete with the mother plants for nutrients and consequently the production suffer badly. The surplus and unwanted plants are removed which is known as Desuckering. It may be done simply by cutting off the young sucker at ground level without damaging the meristem. The sucker thus regrows many times and needs cutting several times. Hence, it is common practice to cut the sucker down, make a small cavity in the centre of cut surface and pour in 2 ml of kerosene oil. The oil moves downward, kills the meristem and prevents suckers growth. Application of 3-5 drops of 2, 4-D (1:16) solution on cut surface helps in killing undesirable suckers.

Earthing Up: It is important particularly during rainy season, this will prevent plants from waterlogged and also it will provide support to the base of the plant, due to this there are fair chances of formation of good root system.

Propping: Providing support to banana bunch is known as propping. This is done to prevent falling of banana pseudostem which support banana bunch. The lodging of banana bunch is caused by poor anchorage, rhizomes above ground level, selecting weak and shallow suckers, exceptionally large bunches, thin pseudostem, strong winds, use of tall cultivars, damage due to *Erwinia* rhizome rot or the burrowing nematode. Both tall as well as dwarf varieties require propping. Former requires due to more height and later requires due to its heavy bunch load. However, tall varieties are easily liable to wind damage compared to dwarf ones.

Leaf Removal: Removal of old leaves in banana serves three basic purposes:

- Leaves showing leaf spots for more than 50 % area are excised to check further spread of disease.
- Leaf pruning can change light and temperature factors of microclimate.
- Healthy leaves which are rubbing and scaring fingers on the bunch may be removed to improve fruit quality.

Preferably there should be minimum 12 healthy leaves at flowering and 9 at a harvest to have maximum bunch filling.

Bunch Covering: Bagging (bunch covering) is a cultural technique used by planters where export quality bananas are grown. This practice protects bunches against cold, sun scorching, against attack of thirps and scarring beetle. It also improves certain visual qualities of the fruits. Bunch covering with dry leaves is a common practice in India.

Removal of Male Flower Bud: Removal of male bud after completion of female phase is necessary. Once the process of fruit setting is over, the inflorescence rachis should be cut beyond the last hand otherwise it grows at the cost of fruit development. This helps in early maturity of the bunch.

Mattocking: The height at which pseudostem should be cut after bunch harvest is termed as mattocking. It has been found that cutting of pseudostem at 2 m height has been found beneficial. It has been observed to increase bunch mass on the follower by 12 % and decrease time to the next harvest by 5 % compared with cutting at 10 cm. such type of result is noted owing to diversion of food reserve of pseudostem towards follower crop.

Mulching: Banana crop responds to mulching.

Mulching reduces cost of cultivation by reducing number of irrigation. Sugarcane trash and banana trash are abundantly available which can be used.

Bunch Trimming: Removal of withered styles and perianths which persist at the distal end of the fruit is termed as bunch trimming. This is usually done in Dwarf Cavendish variety of banana. The withered styles and perianths are removed by hand when dry, some 8-12 days after bunch emergence. The practice prevents fruit scaring and the incidence of cigar end rot. However, the practice is difficult to follow in case of tall cultivars.

43. HORTICULTURE 14856

Present Status and Strategies of Off-Season Vegetable Production

K. N. Panchal[1], P. L. Deshmukh[2] and V. A. Bodkhe[1]

[1]Ph.D. Scholar, Department of Horticulture, M.P.K.V., Rahuri, Maharashtra-413722.
[2]Ph.D. Scholar, Department of Horticulture, P.D.K.V., Akola, Maharashtra-444104
*Corresponding Author E. Mail: panchal.kishor24@gmail.com

The value of vegetables as an important article of daily diet is well known since time immemorial as they supply all major component of human diet. They play a significant role in human diet by making it balance and supply most important natural elements viz. vitamins, minerals, fibres, carbohydrates and supplementary amount of protein and colour. Vegetables are commonly called "protective food' because of their protective effects against degenerative diseases and reducing the risk of many chronic diseases. About 300 g vegetables per capita per day are required. But the availability of vegetables in India is only 200 g per capita per day which is very low compared to the recommended dose. The low availability of vegetables is India is due to the high population pressure and heavy post harvest losses.

Vegetable production in India before independence was 15 million and since independence for decades the growth rate was stabilized around 0.5%. The impetus on vegetable research and policy intervention to promote vegetable crops witnessed a sudden spurt in growth. Now, India is the second largest producer of vegetables in the world, next to China with cultivation of vegetables in about 9.25 million hectares. The vegetable output hit 162.2 million tonnes during 2012-2013 compared to 156.3 million tonnes in the previous year. The potential technological interventions with improved gene pool and precise management take growth rate to higher levels. Vegetable industry being labour intensive, offers better employment opportunities to the woman and young rural youths. The vegetables produces higher tonnage per unit area at a time as compared to the conventional cereals and fruit crops, besides better food values and comparatively more income. The food habits of people are changing and therefore, the food baskets of the people is also changing. Moreover, the awareness about balanced diet is also increasing among people and they have started understanding the concept of nutritional security. In India, a big portion of farmers falls in marginal categories and vegetable growing is suitable for small and marginal farmers. It is a source of intensive employment because of the involvement of labour. In addition, vegetables have great export potential and are a good source of foreign exchange.

Current Status of Vegetable Production in India

Vegetable are the most sustainable and affordable source of micronutrient including vitamins and minerals. In the new millennium vegetable production and consumption have to meet the national demand of increasing populations. Our demand of vegetables will be 225 million tonnes by 2020 and 350 million tonnes by 2030. We have gifted with diverse climatic conditions which make it possible to grow an array of vegetables in a year:

- India is the second largest producer of the vegetables (15% of the world production), however average production is low.
- Current area=9.25 million ha.
- Production= 162.18 million tones.
- Percent area under vegetables 3%.
- Only 12 commercial vegetables occupy 65% production.
- Post harvest losses=20-25%.
- Less than 2% vegetables are commercially processed as compared to 70% in Brazil and 65% in USA.
- India export onion, potato, tomato, brinjal, green beans, carrot, pea, gherkin, chillies and capsicum as processed vegetables.
- Major export markets-gulf countries, UK, Srilanka, Malaysia and Singapore.

Vegetable Production in Hilly Regions

The hilly region constitutes high proportion of area under forest, pasture, grazing and waste lands, only 18 per cent area is put under cultivation. Small and marginal holdings below 2 hectares, constitute more than 85 per cent of total holdings in the Western Himalayan Region. Crop pattern in the region is dominated by traditional and low productivity crops which occupy about 99 percent of the cropped area (cereals 92%), providing basic livelihood for vast majority of the population.

Due to the domination of traditional crops and their stagnating and low productivity coupled with low availability of per capita net sown area, the income and employment at small farms are not adequate. The situation is worsening over time due to increase in population and due to non-availability of other sources of employment and income.

Today hybrids are gaining more popularity due to their high productivity, improved quality, built in resistance, environmental adaptation and earliness, which results into better monetary returns to vegetable growers. Large scale hybrid seed production sometimes remains handicapped because of high labour cost, unavailability of trained labour at crucial times. Tremendous progress has been made by public and private sectors in the development of hybrid varieties in seasonal crops including tomato, brinjal, chilli, capsicum, cabbage cucumber, muskmelon etc. and various vegetable hybrid varieties have been recommended for cultivation in various parts of the country.

Significantly higher vegetable production has been achieved since 30 years because of hybrid technology. But hybrids should not be mistaken as a panacea for all problems of low productivity. It should be adopted in only economical select groups of high value crops (tomato, cabbage, cauliflower, capsicum, chilli, okra). Incorporation of technologies like specific disease resistance, hot and cold tolerance for off-season production is required.

Concept of Off-Season Vegetable Production

Off-season vegetable cultivation refers to the production of vegetables after or before their normal season of production by -

- Availing and using different agro climatic conditions.
- Adjusting the planting time.
- Selecting and improving the varieties.
- Creating the controlled environment by making plastic tunnels, polythene house.

Impact of Climate Change

During the last decade unfavourable environment is becoming a serious issue in hampering successful vegetable production. The changes in climate on global scale reflect a significant impact on agriculture especially the vegetable production and consequently affecting the world's food supply. Climate change is not necessarily harmful; the problems arise from extreme events that are difficult to predict. More erratic rainfall patterns and unpredictable high temperature with long dry spells are adversely affecting the vegetable productivity. Extreme climate conditions are also lowering the soil fertility and increasing the soil erosion. Thus, additional fertilizer application or improved nutrient use efficiency of crops is be needed to maintain productivity or harness the potential for enhanced crop growth due to increased atmospheric CO2. Developing countries like India in the tropics are particularly vulnerable to the effect of climate change on crop productivity.

Success in mitigating climate change depends on how the vegetable crops and growing system will adapt to the effect of various abiotic and biotic stresses. Therefore, farmers in developing countries like India need tools to adapt and mitigate the adverse effects of climate change on productivity of vegetables. In addition to agronomic practices, there is a need to identify the germplasm of the major vegetable crops which are tolerant to high temperature, flooding and drought. Vegetable production can considerably be enhanced by the methods which include modifying fertilizer application to enhance nutrient availability to plants, direct delivery of water to roots (drip irrigation), grafting to increase flood and disease tolerance and use of soil amendments to improve soil fertility and enhance nutrient uptake by plants.

44. HORTICULTURE 14911

Role of (Iron and Zinc) Micronutrients for Horticultural Fruit Crops

V. A. Bodkhe[1*], P. L. Deshmukh[2] and K. N. Panchal[1]

[1]Ph.D. Scholar, Department of Horticulture, M.P.K.V., Rahuri, Maharashtra-413722.
[2]Ph.D. Scholar, Department of Horticulture, P.D.K.V., Akola, Maharashtra-444104.
*Corresponding Author E. Mail: Vab380@gmail.com

INTRODUCTION: The nutrient elements which are required comparatively in small quantities are called as micro or minor nutrients or trace elements. Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants. The requirement of micronutrients (boron, iron, copper, zinc, manganese, chloride and molybdenum) is only in traces, which is partly met from the soil or through chemical fertilizer or through other sources. The major causes for micronutrient deficiencies are intensified agricultural practices, unbalanced fertilizer application including NPK, depletion of nutrients and no replenishment. Horticultural crops suffer widely by zinc deficiency followed by boron, manganese, copper, iron (mostly induced) and Mo deficiencies. Cl, Cu, Fe and Mn are involved in various processes related to photosynthesis and Zn, Cu, Fe, and Mn are associated with various enzyme systems; Mo is specific for nitrate reductase only. B is the only micronutrient not specifically associated with either photosynthesis or enzyme function, but it is associated with the carbohydrate chemistry and reproductive system of the plant. The significance of micronutrients in growth as well as physiological functions of horticultural crops fruits are briefed here nutrient wise.

1. Iron

Plants need iron to produce chlorophyll and to activate several enzymes including those involved in the oxidation /reduction processes of photosynthesis and respiration. Iron concentrations of 50-100 ppm are often quoted as satisfactory leaf analysis values for most crops. But leaf analysis is not a reliable guide as there is poor mobility between tissues. Custard apples are relatively sensitive suffering from iron deficiency while other crops such as bananas are usually not affected much. This sensitivity appears to be related to crop's poor ability to absorb or utilise iron.

The common deficiency symptoms include development of light green chlorosis of all the tissues between the veins. A distinctive pattern results from the network formed by the midrib and veins, which remain green for example, custard apples. If the chlorosis is severe and persistent, yellowing increases to the point of bleaching and burns can develop within this chlorotic area. Because iron does not move easily within the plant, older leaves can remain green while flushes of new growth are chlorotic. In pine apples, chlorosis is strongest towards the margins of young inner leaves. The fruits are small, reddish in colour, hard and prone to cracking. The effects of iron deficiency in different fruit crops are discussed below.

Banana: Banana requires more nutrients than any other commercially cultivated crop and various nutritional disorders affecting the yield and quality of banana have been reported. Iron deficiency is comparatively very rare in banana plantations. However, foliar spray of 0.2 –0.5 % ferrous sulphate checks the disorder effectively. Fe deficiency decrease the ratio of variable fluorescence to maximum fluorescence as observed from fluorescence induction curves indicating the involvement of Fe in both chlorophyll biosynthesis as well as in components of phosphorylation.

Citrus: The element acts as a catalyst in chlorophyll synthesis. The deficiency of iron causes network of green veins against a light green or yellow background in leaves followed by bronzing of leaves.

Grapes: The leaves turn yellow (chlorosis) during iron deficiency and the entire shoot become yellow to yellowish green under extreme conditions. The corrective measure is two sprays of 0.2% ferrous sulphate, one before bloom and the second after fruit set.

Papaya: Iron deficiency is comparatively very less in papaya. However, it is reported that foliar application of ferrous sulphate 0.15% at monthly intervals from fifteen days after planting improved the total sugars and TSS of papaya.

Pomegranate: Pomegranate responds well to foliar application of iron. Ferrous sulphate 0.4 % prior to flowering, at full bloom and at fruit set increases the yield of fruits. Combined foliar application of 0.25 % each of sulphates of zinc, ferrous and manganese with 0.15% boric acid increased the yield and juice content.

2. Zinc

Zinc deficiency is the most widespread and limiting growth and yield in fruit crops. It commonly affects banana, custard apple and mangoes. Problems often appear in spring when crops are growing quickly but have difficulty in absorbing nutrients from cold soil.

Zinc is important for the formation and activity of chlorophyll and in the functioning of several enzymes and the growth hormone, auxin. The severe stunting of leaves and shoots, which is so typical of zinc deficient crops is a consequence of low auxin levels in tissue. Young leaves are usually the most affected and are small, narrow, chlorotic and often rosetted due to failure of the shoot to elongate. Bloom spikes are small, deformed and drooping. In young pine apple plants, zinc deficiency is indicated by the young heart leaves bunching together and then tilting horizontally. This condition is commonly called crook neck. Older plants may develop yellow spots and dashes near the margins of older leaves that eventually coalesce into brown blisterlike blemishes giving the leaf surface n uneven feel. The symptoms and corrective measures for zinc deficiency in different tropical fruit crops are mentioned below.

Banana: Compared to other micronutrients, Zn is the most commonly reported deficiency in banana plantations. A fruit yield of 50t/ha removes 500g of Zn/ha/year. In bananas, each successive leaf of the flush is smaller than the previous one and emerges with a reddish pink coloration on its underside. The opened leaf usually loses this pinkish colour but chlorotic bands develop parallel with lateral veins and alternate with green strips producing a rain bow leaf pattern.

Due to imbalanced fertiliser application and high density planting, incidence of Zn deficiency has become yield limiting. Disproportionate and high application of DAP as basal and top dressing create P induced Zn deficiency in banana. The leaf width is reduced more than the length and the leaf becomes lanceolate in shape. Spraying of Zinc sulphate 0.3% + 0.5% urea at 45 and 60 days after planting of main crop and 45 days after cutting of mother plant for ratoon crop corrects the disorder well. In Zn deficient soils, application of Zinc sulphate @ 30-50g/plant at the time of planting is recommended.

Mango: The major nutritional disorder in mango is little leaf caused by the deficiency of zinc. This leads to stunted growth of roots, shoots and leaves. The lamina of leaves turn pale yellow while midrib remain green. Yellowing, necrotic patches develop on old leaves with drying of leaves. In severe deficiency, flushing may stop and twigs or even whole branches die back. Subsequently necrotic patches turn grey and cover the entire surface. Two sprays of 1-2% Zinc sulphate, one at the time of flowering and the other at one month after the first spray correct the disorder.

Citrus: The deficiency is very common in sweet oranges, pummelos, lemons and mandarins in South India and some parts of North India. Zinc deficiency is also known as mottle leaf and indicates yellow blotches between veins or terminal shoot leaves, reduced leaf size, narrow pointed and chlorotic leaves and appearance of small green spots in yellowed areas, but veins remaining green followed by small sized and misshapen fruits. Internodes are short giving the shoot a rosette look and the fruits become small and hard with reduced yield. Spraying of zinc sulphate 0.3% with calcium chloride 0.5g/litre, sucrose 0.5g/ litre and urea 5g/litre once for a young tree and twice for old trees at fortnightly intervals in spring flush (Feb-March) corrects Zn deficiency very effectively.

It is also reported that foliar application of Mg (2%), Cu (0.4%) and Zn (0.5%) increase fruit yield (48kg/plant) and juice content in sweet orange.

Jackfruit: The deficiency symptom is characterized by small leaves with shorter stalks producing a rosette appearance. Interveinal chlorosis will be noticed. The fruits will be smaller in size and the yield will get affected because of higher proportion of fruit drops. Foliar application of nutrient solutions contains zinc sulphate (500 gm) and lime (250 gm) mixed with 100 gm of urea and 100 ml soap solution dissolved in 100 litres of water is given thrice at 20 days intervals. When the tree putforths new growth, basal soil application of 250 g zinc sulphate along with compost FYM during March and September in equal doses is most beneficial.

Grapes: Small leaves (little leaf) or rosette, widened petioles and small sized fruits are the major symptoms. In some varieties, clusters become stagger and the size of berries range from very small with one or two seeds to normal sized ones with normal seed development. Smearing 10 % zinc sulphate on the pruned stem or spraying of 0.5 – 1% zinc sulphate 10 days before flower formation is the control measure.

Guava: Small leaf and leaf chlorosis are the major symptoms of deficiency. Interveinal chlorosis was also observed with reduction in leaf size. Die back, scant flowering, drying and cracking of the fruits are other symptoms. The disorder can be corrected with spraying of 0.5% zinc sulphate 15 days before flowering.

Papaya: Micronutrient disorders are comparatively rare in papaya but zinc and boron deficiencies are commonly observed in the orchards where papaya is grown continuously. Zn 0.5% + B 0.1% foliar sprays at 4th and 8th month after planting increased the fruit yield (330.68 kg/tree) and latex yield (21.65 g/fruit at stage I), apart from improving the quality traits. Quality of fruits was improved in terms of TSS (12.94 %), total sugars (6.575%), reducing sugars (5.566%), non-reducing sugars (1.004%). Titrable acidity and ascorbic acid content was also found to be influenced significantly.

45. HORTICULTURE 15011

Techniques of Vegetable Growing Under High and Low Temperature Conditions

J. Srinivas[1*], Pratibha Thombare[2]

[1]Ph.D. Scholar, Dept. of Horticulture, Vegetable Science, SKLTSHU, Hyderabad-500030
[2]M.Sc. Scholar, Dept. of Foods and Nutrition, Home Science, VNMKV, Parbhani-431402
*Corresponding Author E. Mail: srinivasjogdande@gmail.com

Techniques

1. The cbf genes represent one of the most significant discoveries in the field of low temperature adaptation and signal transduction.

2. All-important crops and few vegetables and tree species have contained this gene.
3. The transgenic contain this gene are able to survive freezing temperature as much as 4-5˚C lower than the non-transgenic controls.
4. Tomato plants have also been successfully engineered using the CBF genes to achieve chilling tolerance.
5. Thus the CBF technology has a great potential for improving the cold and freezing tolerance in plants.
6. OSISAP1 gene and CBF1 gene.
7. The expression of these genes changes in the membrane lipid composition, accumulation of compatible osmolytes or cessation of plant growth.
8. Cloning and expression of these genes has led to the development of strong tolerance to freezing through transgenic approaches.
9. Dehydration responsive element binding factor (DREB/CRB3).
10. The gene is responsible for the expression of many cold tolerant genes during cold stress in plants.
11. Glyceraldehydes phosphate Acetyl Transferase (GPAT) gene.
12. The gene is responsible for the unsaturation of the fatty acids present in the plant cell wall, which give the cold tolerance to the plants during cold stress.
13. Cold regulated (COR15A) gene.
14. This gene encodes for polypeptides that decreases the incidence of freeze induced lamellar to hexagonal II phase transitions, which increases freezing tolerance to the plants.
15. Desaturase (desC) gene.
16. The expression of this gene increases the fatty acid unsaturation of the cell wall lipids giving strength to the cell wall of the plant during cold stress.

Stress due to Extreme Temperature.

According to IPCC (Intergovernmental panel on climate change).

- Global air temperature – increase by 1.1-6.4°c (2100).
- Ambient temperature- expected to rise by 0.2° c.
- Rise in temperature greatly influences the agriculture production. High temperature decrease crop yield by shortening the life cycle and accelerated senescence.

Heat Stress

- Heat stress is often defines has the rise in temperature beyond a threshold level for a period of time sufficient to cause irreversible damage to plant growth and development. Heat stress affects plant growth throughout its ontogeny; heat threshold level varies considerably at different developmental stages. (Kim *et al.* 2007).

  HSP are molecular chaperones, which either prevent complete denaturation (small HSP: sHSP) or are supporting proper folding (other HSP) of enzymes under or after protein denaturing conditions. (Hall., 2007).

  Examples: HSP 90, HSP 70, HSP 60.
- Avoid denaturation of many proteins at high temperatures.
- Temporarily bind and stabilize an enzyme at a particular stage.

Management of Heat Stress

- Exploitation of genetic variability.
- Conventional breeding and molecular strategies.
- Selection
- MAS
- Genetic transformation.
- Seed treatment-with H2O2, Proline
- Spray growth regulator.

Cold Stress

Chilling Injury

- Occurs at Low temperature but non freezing temperatures.
- Tropical and subtropical plants at10^{0}C to 25^{0}C.
- Temperate plants at 0 to 15^{0}C.
- Chilling Effect is manifested by physiological and cytological changes.
- Cytological changes may be reversible or irreversible depending upon time of exposure to low temperature.

Freezing Injury

- Freezing of soil water, and freezing of the fluids within the plant.
- Freezing damage occurs primarily due to the formation of ice crystals, which damage cell structure when the temperature falls below 0^{0}C.
- Ice usually forms first in the cell walls and intercellular spaces. Damage occurs when ice crystals grow and puncture into the cytoplasm.

46. HORTICULTURE 15112

Innovative Farming: Hydroponic (Soil-Less Farming)

Aradhana Dhruw, Omesh Thakur and Vivek Kurrey

Ph.D. Scholar, Department of Plant Physiology, Indira Gandhi Agricultural University, Raipur (C.G.)
**Corresponding Author E. Mail: aradhana.dhruw200@gmail.com*

What is Hydroponics?

The science of soil-less gardening is called hydroponics. It basically involves growing healthy plants without the use of a traditional soil medium by using a nutrient like a mineral rich water solution instead. A plant just needs select nutrients, some water, and sunlight to grow. Not only do plants grow without soil, they often grow a lot better with their roots in water instead.

Advantages of Hydroponic: Hydroponic gardening is fast becoming a popular choice for many growers around the world due to its more sustainable approach to resource usage than the usual growing methods. Here are a few of its many benefits:

1. By providing constant and readily available nutrition, hydroponics allows plants to grow up to 50% faster than they would in soil. Also, fresh produce can be harvested from a hydroponic garden throughout the year.
2. Great for both the environment and the grown product, hydroponic gardening virtually eliminates the need for herbicides and pesticides compared to traditional soil gardening.
3. Any water that is used in hydroponic gardening stays in the system and can be reused, reducing the constant need for a fresh water supply!
4. Arable land is often in short supply and gardening space continues to decrease. A great option when you lack yard space or have a tiny balcony, hydroponics also lends itself really well to indoor gardening.

The Nutrient Solution: Ready-to-use store bought solutions can be used for hydroponics nutrient systems or one can make one's own special solutions for different types of crops based on the chemical elements the plants need most.

The right nutrient mix combines primary nutrients (nitrogen, potassium, magnesium), secondary nutrients (calcium, sulphur, phosphorus) and micronutrients (iron, copper, manganese, zinc, molybdenum, boron). Here is a recipe for a basic nutrient solution that you can make yourself by diluting the nutrients in 20 litres of filtered water.

- 25 ml of $CaNO_3$ (calcium nitrate)
- 1.7 ml of K_2SO_4 (potassium sulfate)
- 8.3 ml of KNO_3 (potassium nitrate)
- 6.25 ml of KH_2PO_4 (mono-potassium phosphate)
- 17.5 ml of $MgSO_4$ (magnesium sulfate)
- 2 ml of trace elements

Store your solution in a food-grade container at room temperature and away from light. Make sure to shake it well before using. Also, your plants will inform you if they are receiving too few or too many nutrients – not enough and the leaves will turn yellow; too much and they will look brown, burnt or curled.

Considerations of Hydroponic

While you can grow almost anything hydroponically, some vegetables thrive more in hydroponic systems than others. Choose plants that don't mind moisture and that don't get too big for their set up, such as cucumber, tomato, capsicum, strawberry, lettuce and leafy greens.

Also, when setting up a hydroponic garden, depending on the size, sturdiness and root development of the plants to be grown and the structure of the system, one needs to decide whether to use only a solution culture or some sort of a growth medium.

Plants with shallow roots, like leafy greens, do fine in solution cultures. On the other hand, plants with deep roots, such as beets, and heavy vegetables, such as cucumbers, do better with growth mediums such as foam, coconut husk, sponges, and peat moss.

Also, flowering and fruiting plants need exposure to sunlight while leafy greens grow well even under inexpensive fluorescent lights that are placed above them.

Three Ways to Build a Homemade Hydroponics System

1. Hydroponic Raft: For beginners, a simple raft system is ideal. It's easy to make, doesn't cost much to get going and will give you vegetables much more quickly than conventional gardening methods.

2. Vertical Hydroponics: Vertical hydroponic systems provide an excellent option for gardeners lacking space. Try and remember to use recycled materials to put the system together and make your hydroponic system as green as they can be.

3. Aquaponics: A small yard, a corner in a community garden or an unused space in your home can easily be turned into a thriving aquaponic farm for vegetables and fish. An aquaponic system combines elements of aquaculture and hydroponics in a symbiotic environment by putting fish waste to work as fertiliser for crops. The system is mostly enclosed, with little to no waste and no need for fertiliser or pesticides.

A typical household-sized vertical aquaponic system can fit into a 3ft by 5ft (1m x 2m) area. A small pump draws nutrient-rich water from the fish tank to the tops of the vertical columns. The water trickles down through the roots of the plants, gathering oxygen from the air as it falls back into the tank.

Simply put, hydroponics can grow the healthiest food possible, in large quantities, in the smallest space and in a sustainable way. Not only does hydroponics accomplish all the goals set by organic farming, but it takes a step further by offering people the ability to grow food in places where traditional agriculture simply isn't possible.

47. HORTICULTURE 15127

King of Bitter (Kalmegh): Antidiabetes Herb

*1Omesh Thakur, 1Vivek Kumar Kurrey, 2Aradhana Dhruv

*1Department of Vegetable Science, 2Department of Plant Physiology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India 492012

Andrographis Paniculata is also known as 'Green Chiretta' or 'Creat' in English; 'Kalmegh' in Hindi and Bhunimba in Sanskrit. It has been used as a household relieve for intermittent fevers and jaundice. More than half of all herbal preparations used to relieve liver ailments contain this herb.

Botany: *A. paniculata* is an erect annual herb that grows 30 to 110 cm in height and is native to India, China, and Southeast Asia. And belongs to the family Acanthaceae, It grows erect to a height of 30–110 cm (12–43 in) in moist, shady places. The slender stem is dark green. The square stem has wings on the angles of new growth and is enlarged at the nodes, while small white flowers with rose-purple spots are borne on a spreading panicle. The plant produces yellowish-brown seeds, and all parts have an extremely bitter taste. The portion of the plant appearing above ground are harvested in the fall. The fruit is a capsule around 2 cm (0.79 in) long and a few millimeters wide. It contains many yellow brown seeds.

Distribution: It is indigenous to India. In India, it is distributed in the States of Madhya Pradesh, Andhra Pradesh, Assam, Bihar, Karnataka, West Bengal, Utter Pradesh, Tamil Nadu and Kerala It is widely distributed in Madhya Pradesh and also in Bangladesh, Pakistan and all South East Asian countries. It is cultivated as an ornamental garden plant. All part of plant are extremely bitter due to which plant is known as king of bitter. This plant is called Hempedu Bumi (meaning bile of earth) in Malaysia.

Agrotechnology: In India, it is cultivated as rainy season (Kharif) crop. Kalmegh is a hard plant it can be grown in all the type of normal soil. It shows good growth specially in light black soil, sandy loam soil with rich organic content. For the good production point of view water loging should not be in the farm. The pH of soil must be in the range of 6.5 -8.5. Kalmegh can be cultivated by the genetic method (seeds) as well as vegetative method (layering/ Cutting). About 400 gms. seed are sufficient for one hectare. The spacing is maintained 30 × 15 cm. To prepare the nursery first of all clean the farm. Mix the 100 Kg organic manure in the soil. After the manuring do a light irrigation of the bed. Now take the 500 gm seeds of the Kalmegh mix them in 3 Kg sandy soil and broadcast it in the bed. After the broadcasting, put a thin layer of the organic manure and soil mixture. Cover it with a mulching of the crop residual. To protect the seedling from direct sunlight a shed can be constructed on the nursery. Give light irrigation after every 3-4 days with the help of sprinkler. For the best germination percentage keep in the mind that the seed should not be older than 8 months. The seeds start to germinate after 7-8 days meanwhile the weeding can be done as per requirement. The time of transplanting from nursery to the field is 50 days old plant. At that time the height of the plant will be 7-8 cm. At the time of nursery raising the field preparation should also be started. First of all the weeds must be removed by 2-3 deep ploughing. After the ploughing mix the 5 Ton Organic Manure/Acre. The manure should be mixed properly. After the mixing of the manure level the filed with the help of leveller. Before levelling please do a light ploughing by the cultivator. There is possibility of the huge weeds infection as the planting is done during Mansoon. If the weeds are not controlled properly it can affect the growth of the plant. The pre emergence weedicides can be used. The manual weeding can be done after the interval of the 20-25 days. After the two manual weeding the field will free from weed infection. There is no need of extra irrigation as the crop is transplanted in the season of Monsoon. If it is not raining on the time the field can be irrigated at the interval of 20-20 days as per the requirement of the soil. No major insect and disease infestation has been reported. The plants at flowering stage (90–120 days after sowing) are cut at the base leaving 10–15 cm stem for plant regeneration. About 50–60 days after first harvest, final harvest is performed. In Indian condition, the yield varies between 2000–2500 Kg dry herb per hectare.

Medicinal properties of *Andrographis paniculata*

- Antibacterial, antifungal
- Antiviral, antipyretic, adaptogenic, anti-inflammatory
- Improves immunity, Liver protecting
- Carminative, diuretic, gastric and liver tonic
- Choleretic, hypoglycemic, hypocholesterolemic
- Bitter tonic, Blood purifying

Chemical constituents: Andrographolide is the major constituent extracted from the leaves of the plant. This bitter principle was isolated in pure form by Gorter (1911). It is colourless, crystalline, bitter in taste and known as diterpenoid lactone other reported compound include 14- deoxy-11-oxoandrographolide, non bitter compound neoandrographalide, Andrographine, Root Andrographolide, Plant Neoandrographolide, Plant Panicoline, Root Paniculide-A, Plant

Who should not use Andrographis paniculata

- Kalmegh is contraindicated in following conditions:
- Bleeding disorders, hypotension, male and female sterility.
- It has shown anti-fertility effect in laboratory animals.
- Duodenal ulcers, hyperacidity, and oesophageal reflux, Pregnancy.

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48. HORTICULTURE 15147

Diseases of Banana and their Management

B. Kumaraswamy[1]* and J. Srinivas[2]

[1]M.Sc Scholar, Department of Plant Pathology, Dr. PDKV, Akola, Maharashtra,

[2]Ph.D. Scholar, Dept. of Horticulture, Vegetable Science, SKLTSHU, Hyderabad-500030

*Corresponding Author E. Mail: swamy.agrico@gmail.com

Banana is staple food that represents major dietary sources of carbohydrates, fiber, vitamins A, B_6, C and also potassium, phosphorus and calcium. It is a very important agricultural product viewed as breakfast cereal in most developed countries. After rice, wheat and milk products, it is considered to be the fourth most important food crop in world, based on gross value.

I. Bunchy Top: Viral Disease

1. Symptoms appear at stage of growth associated with occurrence of prominent dark green streaks on petioles and along leaf veins, **2.** In badly diseased plants leaves, bunch together, margins of lamina become wavy and slightly roll upwards, **3.** In case of secondary infections, irregular, dark green streaks occur along the secondary veins from series of dark green dots to a continuous dark green line, **3.** Severe stunting, non-elongation of leaf stalks, more erect leaves, non-production of bunches are other external symptoms.

Management: 1. Raising barrier crops like sunhemp in three to four rows on the field boundaries to check aphids from entering the fields from neighbouring infected fields**, 2.** Vector control with systemic insecticides, *viz*., Phosphomidon @ 1ml/l or Methyl demetonor Dimethoate @ 2 ml/l **3.** Discouraging intercropping with *Colocasiai* in disease endemic areasAdoption of strict quarantine measures, **4.** Use of only certified banana suckers or tissue culture plants for planting

II. Panama Wilt: Fusarium oxysporum f.sp. cubense

1. Symptoms initially seen in older plants in a mat, 2. The earliest symptoms are faint yellow streaks on the petiole of oldest, lower most leaves, 3. Affected leaves show progressive yellowing, break at the petiole and hang down along the pseudostem, Longitudinal splitting of pseudostem is very common, Light yellow to dark brown discolouration of vascular strands in pseudostem, 4. Usually the discolouration appears first in the outer or oldest leaf sheath and extends in to the inner sheaths.

Management: 1. Use of disease free suckers for planting, 2. Avoid ill drained soils,3. Flood fallowing for 6 to 24 months or crop rotation with puddle rice, 4. Dipping of suckers in carbendazim (0.1%) solution before planting, 5. Neem cake + *Trichoderma viride* should be applied in planting pits, 6. Soil drench with 0.2% carbendazim or rhizome injection with 0.2% carbendazim, 7. Growing resistant Cavendish varieties, *viz*., Basrai (Vamanakeli or Dwarf cavendish), Poovan (Karpura chakkarakeli) etc.

III. Moko Disease: Ralstonia solanacearum

1. Symptoms start on rapidly growing young plants, 2. vascular discoloration (pale yellow to dark brown or bluish black) is concentrated near the centre of the pseudostem, becoming less apparent on the periphery, 3. Greyish brown bacterial ooze is seen when the pseudostem of affected plant is cut transversely, 4. A firm brown dry rot is found within fruits of infected plants (characteristic symptom)

Management: 1. Grow relatively resistant varieties like poovan and montha, 2. Disinfestation of tools with formaldehyde diluted with water in 1:3 ratio, 3. Drenching soil in infected pockets with bleaching powder solution (1.5%) and Bordeauxmixture 1% + streptocycline (0.02%) 4. Biocontrol with Pseudomonas fluorescens.

IV. Banana Mosaic / Infectious Chlorosis / Heart Rot: Cucumber Mosaic Virus

1. Typical mosaic-like or discontinuous linear streaking in bands extending from margin to midrib running parallel to veins (Mosaic),2. Leaf size is reduced and leaves show thickened veins chlorosis of newly emerged leaves (Infectious chlorosis), 3. Occasionally rotting of central youngest leaf and leaf sheaths in severe cases (Heart rot) which progress into the pseudostem leading to death of plants.

Management: 1. Adoption of strict quarantine measures, 2. Use of disease free suckers for planting, 3. Dry heat treatment of suckers at 400 C for 1 day, 3. Avoid growing cucurbits as intercrop, 4. Vector control with Methyl demeton or Dimethoate @ 2 ml/l at 3 – 4 weeks interval.

V. Yellow Sigatoka – Mycosphaerella musicola

Black sigatoka – Mycosphaerella fijiensis

1. Early symptoms appear on the lower leaves, 2. Initially small reddish brown specks develop on leaves near the tip or margin of lamina and specks may also be produced near the midrib 3. Specks increase in size and turn in to spindle shaped spots with reddish brown margin and gray centre surrounded by a yellow halo,4. Spots formed near the midrib enlarge and extend towards the margin of lamina,5. Fruits in bunches of infected plants are under developed and may ripen prematurely

Management: 1. Planting banana in well drained soils, **2.** Growing moderately resistant cultivars like Karpura Chakkerakeli, **3.** Removal and destruction of affected leaves followed by spraying with BM 1% + linseedoil 2%, **4.** Applying recommended dose of potassium fertilizer Spraying chlorothalonil 0.2% with non ionic adhesive in pre-monsoon period and propiconazole 0.1% interspersed with tridemorph 0.1% at 20 days interval in rainy period.

49. HORTICULTURE 15766

Vegetables: Best Natural Source of Prebiotics for Human Health Benefits

Ankit Panchbhaiya

Ph.D. Scholar, Department of Vegetable Science, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar- 263 145, Uttarakhand, India

**Corresponding Author E. Mail: anki38423@gmail.com*

What is Prebiotics?

Prebiotics are non-digestable carbohydrates (fiber) that are used by bacteria in the colon to produce measurable health benefits. They occur naturally in carbohydrate-rich foods; a prebiotic is not broken down or absorbed by the gastrointestinal tract. Beneficial bacteria use this fiber as a food source in a process called fermentation. By definition not all dietary fibers are considered as prebiotics. Only those dietary fibers which are soluble in water and digested by gut bacteria and those which are insoluble in water but fermentative in the large intestine like resistant starches fall in this category. Prebiotics mostly consist of oligosaccharides but sometimes they also contain polysaccharides (*e.g.* inulin). Commonly used prebiotics are fructo-oligosaccharides/oligofructose (FOS), galacto-oligosaccharides (GOS), inulin, isomalto-oligosaccharide (IMO), beta-glucan and psyllium husk.

Difference between Prebiotics and Probiotics

Both prebiotics and probiotics nurture the good bacteria required by the digestive tract for proper health beginning at the mouth. Probiotics are live, active cultures capable of multiplying in numbers whereas prebiotics serve as the food source for probiotics and do not grow or reproduce.

Health Benefits of Prebiotics

It has been suggested that prebiotic intake may reduce the prevalence and duration of diarrhea, symptoms associated with inflammatory bowel disease, blood triglyceride levels, intestinal infections, anxiety, abnormal bacterial leakage through the gut wall and some risk factors for cardiovascular disease. It enhances the bioavailability and uptake of minerals, including calcium, magnesium, and possibly iron and also enhanced and strengthened immune system. It exerts protective effects to prevent colon cancer and obesity. Most important of all is it increased "good" bacteria in the gut and concomitant decrease in the "bad," unwanted bacteria in the gut.

Sources of Prebiotics among Vegetables

In vegetables, prebiotics typically occur in the form of FOS, as inulin. This prebiotic is found in vegetables which are below:

Asparagus: Asparagus (*Asparagus officinalis*) is cultivated both commercially and in home gardens and it is a rich source of prebiotics. In addition to their prebiotic benefits, asparagus shoots are also a good source of protein and fiber, and they contain calcium, potassium, phosphorous, vitamin A and C, riboflavin, and niacin.

Chicory Root: Chicory root is also a great source of prebiotics. Approximately 47% of chicory root fiber comes from the prebiotic fiber inulin. The inulin in chicory root nourishes the gut bacteria, improves digestion and helps relieve constipation. Additionally, chicory root is high in antioxidant compounds that protect the liver from oxidative damage.

Dandelion Greens: Dandelion greens can be used in salads and are a great source of fiber. A high portion of this fiber comes from inulin. The inulin fiber in dandelion greens reduces constipation, increases friendly bacteria in the gut and boosts the immune system. Dandelion greens are also known for their diuretic, anti-inflammatory, antioxidant, anti-cancer and cholesterol-lowering effects.

Greens (Kale, Spinach and Chard): Greens include vegetables such as kale (*Brassica oleracea acephala*), spinach (*Spinacia oleracea*), and chard (*Beta vulgaris*). These vegetables are a good source of prebiotics and they also contain valuable nutrients such as vitamin A, vitamin C, fiber and potassium.

Garlic, Leeks and Onion: Garlic (*Allium sativum*), leeks (*Allium porrum*) and onion (*Allium cepa*) are excellent prebiotic sources that are also rich in antioxidants. Garlic and onion in particular can be eaten raw or cooked, and they also contain beneficial nutrients such as protein, fiber, calcium, phosphorous, potassium, and niacin. While leeks share the same nutritional properties as onions and garlic, these are in a less effective form.

Jerusalem Artichoke: Jerusalem artichoke tubers (*Helianthus tuberosus*) are a good source of prebiotics. Jerusalem artichokes are similar to potato tubers, except that 75 to 80 percent of the carbohydrates in Jerusalem artichoke tubers are in the form of inulin instead of starch. Jerusalem artichokes have been shown to increase the friendly bacteria in the colon even better than chicory root. Additionally, they help strengthen the immune system and prevent certain metabolic disorders.

Conclusion: Many people today are receiving their daily dose of probiotic supplementation. Less likely are people aware that they should also be receiving a regular supplement of prebiotics. Prebiotics have numerous health benefits such as improving gut health, inhibiting cancer, enhancing the immune system, and preventing obesity and have shown effective improvements in 91% of all human trials. They have also been shown to reduce symptoms of bowel related issues such as ulcerative colitis, Crohn's disease, irritable bowel syndrome and celiac disease. The combination of prebiotics when taken daily with probiotics has a synergistic health advantage. Some foods that act as synbiotics include kimchii, sauerkraut and pickles. These are all fermented foods that utilize great prebiotic fibers with carrots, cabbage and cucumbers. Radishes are also often used. Herbs like ginger that have prebiotic qualities are often used as well.

50. HORTICULTURE 15769

Phytochemistry and Medicinal Uses of the Bael Fruit (*Aegle marmelos* Correa)

Ankit Kumar*

Ph.D. Scholar, Department of Horticulture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (India) - 263145

**Corresponding Author E. Mail: aktamta1993@gmail.com*

Aegle marmelos commonly known as bael is a plant indigenous to India. In colloquial terms they are known as Bengal quince, Indian quince, holy fruit, golden apple in English and bael or bilva in Hindi. Bael is a slow growing, tough subtropical tree and is the only plant belonging to the genus Aegle. The tree grows wild in well drained soil and attains a size of about 12 to 15 m in height even in the harsh and dry climates. The branches contain spines that are narrow and are up to an inch in size. The leaves are alternate borne singly or in twos or threes and are made up of three to five oval, pointed, shallowly toothed leaflets. The fruit which are of dietary use is either round, pyriform, oval, or oblong in shape. It is about two to eight inches in diameter and its size and yield depend on the variety of bael and geoclimatic conditions. The tree bears fruit only when there is a long dry season and the peak fruiting season in India is normally during the month of May and June (Sharma *et al.*, 2007). The leaves, bark, roots, fruits and seeds are used extensively in the Indian traditional system of medicine the Ayurveda and in various folk medicine to treat myriad ailments. Bael fruits are of dietary use and the fruit pulp is used to prepare delicacies like murabba, puddings and juice. Bael fruits are also used in the treatment of chronic diarrhea, dysentery and peptic ulcers as a laxative and to recuperate from respiratory affections in various folk medicines. Scientific studies have validated many of the ethnomedicinal uses and reports indicate that the fruit possesses broad range of therapeutic effects that includes free radical scavenging, antioxidant, inhibition of lipid peroxidation, antibacterial, antiviral, anti-diarrheal, gastroprotective, anti-ulcerative colitis, hepatoprotective, anti-diabetic, cardioprotective and radioprotective effects.

Phytochemicals Present in Bael

Studies have shown that the bael fruit pulp contains important bioactive compounds such as carotenoids, phenolics, alkaloids, pectins, tannins, coumarins, flavonoids and terpenoids (Maity *et al.*, 2009). Bael fruit contains volatile compounds like hexanal, isoamyl acetate, limonene, β-phellandrene, p-cymene, acetoin, (E)-2-octenal, (E,E)-2,4-heptadienal, dehydro-p-cymene, linalool; 3,5-octadiene-2-one, -cubebene, trans-p-mentha-2,8-dienol, citronellal, cineole, p-cymene, citronella, citral, cuminaldehyde, β-cubebene, β-caryophyllene, hexadecane, pulegone, -humulene, verbenone, carvone, carvyl acetate, dihydro-β-ionone, (E)-6,10-dimethyl-5,9-undecadien-2-one, β-ionone, caryophyllene oxide, humulene oxide and hexadecanoic acid. They also contain coumarins like aegeline, aegelenine, marmelin, o-mtheyl halfordinol, alloimperatorin, furocoumarins, psoralen, o-isopentenyl halfordinol and marmelosin. They also contain tartaric acid, linoleic acid, tannins, phlobatannins, flavon-3-ols, leucoanthocyanins, anthocyanins, and flavonoid glycosides.

Bael Leaf in Medicine: Bael has an important place in the traditional systems of medicine the Ayurveda. The leaves, roots, bark, fruits and the seeds are reported to possess diverse medicinal properties and to cure various human ailments and diseases. The leaves are supposed to be the most useful in the treatment of fever, to stop abdominal pain, intermittent fever, allay urinary troubles, palpitation of the heart, dysentery, dyspepsia, stomachalgia, seminal weakness, vomiting, fever and swellings.

Bael Fruit as a Dietary Agent: Since antiquity, the ripe fruits of bael have been used as a dietary source in the Indian subcontinent. The pulp which is yellow or orange in color is very fragrant (characteristic floral aroma), pleasantly flavoured and sweet to taste. In India, a popular drink colloquially called as "bael sherbet" is prepared from the ripe fruit. The soft pulp is scooped, deseeded and blended with milk, sugar and cardamom and is consumed as a cooling drink. The semi ripe fruits are used in making jam by adding sugar, citric acid and preservatives.

Bael Fruit in Traditional Medicine: In the Ayurvedic system of medicine bael fruits are considered as an excellent remedy for diarrhea. The unripe fruits are bitter, acrid, sour, and astringent, and aids digestion and stomach irritation. The half-ripe fruit is astringent, digestive and anti-diarrheal. The ripe fruits are supposed to be more useful than the raw and are used to prevent sub-acute and chronic dysentery. The fruit pulp acts as a mild stimulant to the intestinal mucus membrane and stops diarrhea. The ripe fruit are aromatic, cooling and acts as a laxative.

Conclusion: Based on its value in traditional medicine and promise from preclinical studies bael fruit which is also of dietary use has emerged as fruit worth to be subjected to detail investigations for its myriad beneficial effects. The observed diverse pharmacological properties may be attributed to the presence of various compounds. Most of the pharmacological effects can be explained by the presence of alkaloids, flavonoids and volatile oils present in the fruit. However, future efforts should concentrate more on studies aimed at understanding the mechanism of action at the molecular level on the validated pharmacological activities. While all studies have been with mice and validated bael clinical applicability to humans, clinical studies with humans are required. In this regard the non-toxic nature of bael gives immense advantage as it can be easily recommended for human trials and at lesser costs. Additionally studies have also shown that the new activated carbon prepared from non-usable bael fruit shell is an efficient low cost adsorbent to remove the toxic metal chromium from aqueous phase, thereby preventing environmental pollution (Anandkumar and Mandal, 2009).

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51. HORTICULTURE 15770

Urban and Peri-Urban Horticulture: An Efficient Approach to Mitigate Food and Environmental Problems

Vishal Nirgude

Ph.D. Scholar, Department of Horticulture, College of Horticulture, G.B. Pant University of Horticulture and Technology, Pantnagar- 263145 (Uttarakhand)

**Corresponding Author E. Mail: nirgude.v7hort@gmail.com*

The world urban population is expected to double in thirty years leading to a growing number of urban poor. The urban population expansion is more pronounced in developing countries as result of the immigration from rural areas, as people flock to the cities in search of food, employment and security. The trend is accelerating and by the year 2030, it is expected that about sixty percent of the world's population will be living in cities. Such rapid urbanization and the harsh reality of urban poverty require innovative strategies to ensure adequate food supply and distribution systems to address escalating levels of urban food insecurity. Besides the growing demand for food, there is a rapid increase of poverty, unemployment, hunger and malnutrition in the urban and peri-urban environment around the world issues that are of great concern to central and municipal authorities. Within this reality, urban and peri-urban horticulture (UPH) has become a key component of the survival strategies of poorer sections of the population while also providing a significant contribution to the urban fresh food supply chain. UPH is also a source of employment and income and has the potential to improve the nutrition of disadvantaged urban residents. A key challenge is developing policy, strategies and technical support mechanisms ad hoc for the sustainable management of urban and peri-urban agricultural systems, addressing production issues and marketing needs within a broader framework of environmental planning and management, water supply and utilization schemes and food safety assurance.

Understanding urban and peri-urban horticulture: Urban area as a topic for research and education by horticultural scientists in India and industrialized countries on other continents has traditionally focused on the development and maintenance of public parks and ornamental gardens and on the plants and practices *i.e.*, the nursery and landscape trades needed for beautifying the homes and gardens of gentrified urban dwellers. However, peri-urban areas are the dynamic interface between our cities and rural areas. These regions usually comprise a mix of urban and rural uses, such as residential dwellings, small-to-medium scale horticulture such as post-harvest industries as well as the occasional town centre, often concentrated around a transport hub. Peri-urban regions tend to share many characteristics with urban regions, however they serve distinct functions that support the urban area to which they are adjacent. Due to their close proximity to markets and populations, peri-urban areas play an important role in providing food for urban populations especially in supplying food that is perishable such as fruits and vegetables which otherwise cannot travel long distances to market.

Importance of urban and peri-urban horticulture: Urban and peri-urban horticulture also contributes to improving the environment and mitigates climate change, for example by reducing organic waste, increasing the amount of open spaces and related storm water infiltration. It also creates a positive impact on health through improving nutrition as well as social and mental well-being. The concept of green cities in developing countries with urban and peri-urban horticulture contributes to feeding the planet with resilient and sustainable horticulture systems, contributes to the circular economy by recycling the organic waste, creates jobs and contributes to livelihoods and growth by creating local markets and supply chains. It is also socially, environmentally and economically sustainable. The horticulture commodity chain generates employment in production, input supply, marketing and in added-value products. Moreover, to increase productivity in limited resource areas, closed or semi closed systems (*i.e.* greenhouses) are considered more advantageous than open systems *i.e.*, fields. The production and daily delivery to market of perishable horticultural crops from smallholder farmers close to large urban centres (peri-urban horticulture; market gardening) have been important for millennia. Unsorted vegetables, fruits, flowers and also medicinal and aromatic plants is delivered directly to urban consumers with little or no official oversight for quality or safety.

Governmental and public issues: Although urban and peri urban horticulture is a gaining popularity in most developing cities, it often goes unrecognized in horticultural policies and urban planning. The essential first step towards sustainable management of urban and peri-urban horticulture is the official recognition of its positive role in urban development, particularly in the nutrition and livelihoods of the urban poor. Political and institutional support facilitates the legal measures needed to secure land for such activities, especially market gardening. Often, the process begins by registering informal groups of growers as associations and once the land and its users have been identified, city authorities process their requests for temporary permits or long term leases. Integrated production and protection management and to improved cultivars and cropping practices adapted to local conditions. Adoption of good horticultural practices, in peri urban areas help to build sustainable production systems that are environmentally friendly and ensure the safety and quality of produce. This encourage the use of organic compost in urban environments and train fruit and vegetable growers in the safe recycling of wastewater for irrigation. Commercial UPH development are low-income, small-scale fruit, vegetable and flower growers, who have very limited access to the services and inputs needed to increase the quantity and quality of production. Low output and low incomes perpetuate their poverty. This fosters the professionalization of small-scale growers by securing access to training, tools and inputs especially quality seed and planting materials and to micro-credit. Its projects encourage growers to form producer associations and facilitate linkages with extension, research, city administrators, private supply services and development of non-government organizations. In developing countries like India, fruit and vegetable intake is far below the recommended need. Crop diversification, improvements in storage and processing, public information campaigns, labelling of produce and the creation of neighbourhood collection points and markets need to implement. It encourages growers associations to explore new channels to consumers, such as farmers markets and supply contracts with restaurants and supermarkets. Niche markets for herbs, spices and organic produce are another profitable alternative.

Constraints in adopting the concept: There are many constraints that can be either directly or indirectly addressed by modern horticultural science and industry. Consider the following opportunities for targeted research or service provision. 1). Breeding and selection; The varieties well suited to direct marketing; attractive, nutritious, good shelf life and specialty cultivars not found on the supermarket shelves, etc., improving indigenous fruits and vegetables valued by ethnic minorities in towns and cities, varieties and cultivars with pest and disease resistance, opening the door to reduced input production systems. 2). Production and protection; Provision of affordable and good quality seeds and scions by the world's seed and nursery trades, better land

and crop management practices for highly intensive farming, development of safe and effective pest and disease management practices, options for and optimization of protected cultivation structures and practices and maximizing water use efficiency and 3). Harvesting and handling; Appropriate technologies for harvesting and handling, grading to improve quality and packaging to add value and developing cool stores and refrigerated transport.

Conclusion: Ensuring adequate food supply, environmental pollution reduction, employment and income generation are some of the important facets of urban and peri-urban horticulture. In the current scenario of changing dietary habits with increasing income, there is a growing demand for horticultural produce. At the same time population pressure in urban and peri-urban area is increasing at accelerated rate. This is a great challenge and needs attention for optimal management of urban and peri-urban resources require land use which views horticulture as an integral component of the urban natural resources system and balances the competitive and synergistic interactions among the users of the natural resources. Benefits of appropriate management include improved hydrological functioning through soil and water conservation, micro-climate improvements, avoided costs of disposal of the recycled urban wastes, improved biodiversity and greater recreational and aesthetic values of green space. When we look back, it is evident that urban and peri-urban activities for gardening interior and exterior landscaping, terrace garden by amateurs, parks, landscapes in water body and growing of fruit, vegetable and flowers adjacent to cities have been practiced but need scientific approaches. Interest in UPH is increasing not only to utilise the space but also for social and economic reason and there is international consultation for the promotion of UPH. With awareness for UPH it could be a reality to address the challenges which is posed by accelerated urbanisation which is taking place globally especially in developing nations.

Way forward: Urban and peri-urban horticulture opportunities are emerging in urban area for horticulture as demand for fresh fruits, vegetables are increasing resulting in various activities. Roof and terrace gardening is finding now place to get fresh horticultural produce and also for environmental services. Vegetable production, has expanded in and around cities in many developing countries as an informal activity practiced by poor and landless city dwellers. The broad diversity of horticultural crop species allows year round production, improved employment and income. Growers have realised that intensive horticulture can be practiced on small plots, making efficient use of limited water and land resources. Horticultural crops, as opposed to other food crops, have a considerable yield potential and can provide high amount of fresh produce per m^2 per year depending upon the technology applied. In addition, due to their short cycle they provide a quick to emergency needs for food. Some of the horticultural crops are perishable and post-harvest losses can be reduced significantly when production is located close to consumers. Mushroom centres, which do not need land can be a most promising activities in cities and peri-urban area. Therefore, urban and peri urban horticulture approach can be used as efficient tool for increasing and supply of horticulture produce from unutilized limited land resources and in less time.

52. HORTICULTURE 15777

Bio-Fortification in Fruit and Vegetable Crops

Sayan Sau[1] and Sukamal Sarkar[2]

[1]Department of Fruit Science, [2]Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal (741252), India

Bio-fortification, precisely defined as "fortification in the field rather than in the factory". In other word, bio-fortification is a process of increasing the density of vitamins and minerals in a crop through plant breeding, transgenic techniques, or agronomic practices.

Feasibility of "Bio-Fortification" as a Nutrient Enriching Technique

- Bio-fortification essentially improves the already grown and/or consumed and accepted crops and therefore does not require any significant change in eating behaviour, food habits, educating masses or food processing. After fulfilling the household's food needs, surplus biofortified crops make their way into rural and urban retail outlets.
- Some of the important micronutrients whose deficiency is common in Indian population include vitamin A, iron, zinc, calcium, folic acid, vitamin D and iodine that can normally be taken in adequate quantity through a well-planned diet.
- There are good numbers of food crops with high content of iron, beta carotene (precursor of vitamin A) and other necessary flavonoids present in all agro-climatic condition. So, we can easily be taken those crops as a model

crop for improvement.

Forms of Bio-Fortification

The nutritional value of crops can be enhanced by different bio-fortification techniques *i.e.* agronomic bio-fortification, improvement of plant varieties through conventional breeding, and through nutritional genetic modification.

Worldwide Recognized Successful Bio-Fortification Attempts in Fruit and Vegetable Crops

Pro-Vitamin 'A' and Iron Biofortification in Banana: The banana project, Banana21, has the key mission of "Alleviating micronutrient deficiencies in Uganda through biofortification of the staple food of Uganda, bananas". The initial targets for the project were a four fold increase in pro-vitamin A and a three fold increase in iron. The concept is that the micronutrient enhanced bananas for Uganda will be generated in Uganda by Ugandans.

β-Carotene Biofortification in Sweet Potato: Orange fleshed sweet potato (OFSP) is orange coloured, β-carotene enriched variety of sweet potato, staple crop in Africa. OFSP cultivars *i.e.* Ejumula and Kakamega, were officially released in April 2004 in Uganda and proved to be one of the most successful example of biofortified crop till date.

β-Carotene, Iron, and Protein Biofortification in Cassava: BioCassava Plus (BC+) is a cassava-biofortification project funded by the Bill and Melinda Gates Foundation for engineering increased accumulation of β-carotene, iron, and protein in cassava. β- carotene enrichment of storage roots in cassava is conferred by two transgenes: the *Erwinia crtB* phytoene-synthase gene, and the Arabidopsis 1-deoxyxylulose-5-phosphate synthase (DXS) gene. Increased iron content was achieved by the expression of the *FEA1* gene, from *Chlamydomonas reinhardtii*, in cassava storage roots. In the transformed lines, the relative amounts of all-trans-β-carotene, the most nutritionally efficacious form of carotenoid provitamin A, were 85 to 90% of the total carotenoids content. Iron content in the GM events ranged from 30 to 40 μg/g dry weight in storage roots compared to 10 μg/g dry weight in the wild type (Sharma et al., 2017).

Iron and Zinc Biofortification in Beans: The high seed mineral, red-mottled common beans (*Phaseolus vulgaris* L.) *i.e.* NUA35 and NUA56 have been developed by the International Center for Tropical Agriculture (CIAT). The seed iron content was 18 and 23 mg/kg higher for NUA35 and NUA56, respectively while zinc content was 8 and 7 mg/kg higher, respectively, than CAL96, which is a commercial cultivar in Colombia and Uganda.

Iodine Biofortification in Pepper: Li et al., 2016 in their experiment with iodine biofortification with pepper (*Capsicum annuum* L.) revealed that the iodine content of the pepper fruits grown in 0.25–5.0 mg/L KI solutions can amount to 350–1330 g/kg FW, matching the 150 g d^{-1}dietary iodine allowance recommended by WHO. Thus, the pepper can be used as a candidate crop for iodine biofortification. In addition, low-moderate levels (0.25–1.0 mg/L) of iodine application improved the fruit quality by enhancing the ascorbic acid and soluble sugar contents, and by reducing the total acidity of pepper fruits as well.

Zn Biofortification in Brassica oleracea cv. Bronco: Results of the experiment conducted by Barrameda-Medinaa et al, 2017 indicate that supplementation of 80–100 M Zn is optimal for maintaining the normal growth of plants and to promote the major Zn concentration in the edible part of *B. oleracea*. Any further increase of Zn supply induced an accumulation of total amino acids, and increased the enzymatic activities involved insulfur assimilation and synthesis of phenols, finally resulting in a foliar accumulation of glucosinolates and phenolic compounds. Thus, it could be proposed that the growth of *B. oleracea* under 80–100 M Zn may increase the intake of this micronutrient and other beneficial compunds for the human health.

Conclusion: Biofortification is a reasonable alternative to reach malnourished populations in relatively remote rural areas, for delivering naturally fortified foods to people with limited access to commercially-marketed fortified foods, which are more readily available in urban areas. To achieve more biofortified food items in daily diet of common people, it is very essential to combat the obstacle in the biofortification process with collaborating effort of scientist from all three essential sector *i.e.* agriculture, nutrition science and molecular breeding.

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53. HORTICULTURE 15791

Mangrove in Landscape

Khiromani Nag and Akhilesh Jagre

Assistant Professor, AKS University, Satna M.P.

A **mangrove** is a shrub or small tree that grows in coastal saline or brackish water. The term is also used for tropical coastal vegetation consisting of such species. Mangroves occur worldwide in the tropics and subtropics, mainly between latitudes 25° N and 25° S. The total mangrove forest area of the world in 2000 was 137,800 square kilometres (53,200 sq mi), spanning 118 countries and territories.

Mangroves are salt tolerant trees, also called halophytes, and are adapted to life in harsh coastal conditions. They contain a complex salt filtration system and complex root system to cope with salt water immersion and wave action. They are adapted to the low oxygen (anoxic) conditions of waterlogged mud.

The word is used in at least three senses: (1) most broadly to refer to the habitat and entire plant assemblage or *mangal*, for which the terms *mangrove forest biome*, and *mangrove swamp* are also used,(2) to refer to all trees and large shrubs in the mangrove swamp, and (3) narrowly to refer to the mangrove family of plants, the Rhizophoraceae, or even more specifically just to mangrove trees of the genus *Rhizophora*.

The mangrove biome, or mangal, is a distinct saline woodland or shrubland habitat characterized by depositional coastal environments, where fine sediments (often with high organic content) collect in areas protected from high-energy wave action. The saline conditions tolerated by various mangrove species range from brackish water, through pure seawater (3 to 4%), to water concentrated by evaporation to over twice the salinity of ocean seawater (up to 9%).

Etymology: The term "mangrove" comes to English from Spanish (perhaps by way of Portuguese), and is likely to originate from Guarani. It was earlier "mangrow" (from Portuguese *mangue* or Spanish *mangle*), but this word was corrupted via folk etymology influence of the word "grove".

Ecology: Mangrove swamps are found in tropical and subtropical tidal areas. Areas where mangal occurs include estuaries and marine shorelines.

The intertidal existence to which these trees are adapted represents the major limitation to the number of species able to thrive in their habitat. High tide brings in salt water, and when the tide recedes, solar evaporation of the seawater in the soil leads to further increases in salinity. The return of tide can flush out these soils, bringing them back to salinity levels comparable to that of seawater.

At low tide, organisms are also exposed to increases in temperature and desiccation, and are then cooled and flooded by the tide. Thus, for a plant to survive in this environment, it must tolerate broad ranges of salinity, temperature, and moisture, as well as a number of other key environmental factors—thus only a select few species make up the mangrove tree community.

Biology: Of the recognized 110 mangrove species, only about 54 species in 20 genera from 16 families constitute the "true mangroves", species that occur almost exclusively in mangrove habitats. Demonstrating convergent evolution, many of these species found similar solutions to the tropical conditions of variable salinity, tidal range (inundation), anaerobic soils and intense sunlight. Plant biodiversity is generally low in a given mangal. The greatest biodiversity occurs in the mangal of New Guinea, Indonesia and Malaysia.

Adaptations to Low Oxygen: Red mangroves, which can survive in the most inundated areas, prop themselves above the water level with stilt roots and can then absorb air through pores in their bark (lenticels). Black mangroves live on higher ground and make many pneumatophores (specialised root-like structures which stick up out of the soil like straws for breathing) which are also covered in lenticels.

These "breathing tubes" typically reach heights of up to 30 cm, and in some species, over 3 m. The four types of pneumatophores are stilt or prop type, snorkel or peg type, knee type, and ribbon or plank type. Knee and ribbon types may be combined with buttress roots at the base of the tree. The roots also contain wide aerenchyma to facilitate transport within the plants.

Limiting Salt Intake: Red mangroves exclude salt by having significantly impermeable roots which are highly suberised (impregnated with suberin), acting as an ultra-filtration mechanism to exclude sodium salts from the rest of the plant. Analysis of water inside mangroves has shown 90% to 97% of salt has been excluded at the roots. In a frequently cited concept that has become known as the "sacrificial leaf", salt which does accumulate in the shoot (sprout) then concentrates in old leaves, which the plant then sheds. However, recent research suggests the older, yellowing leaves have no more measurable salt content than the other, greener leaves. Red mangroves can also store salt in cell vacuoles. As seen in the photograph on the right, white or grey mangroves can secrete salts directly; they have two salt glands at each leaf base (correlating with their name—they are covered in white salt crystals).

Limiting Water Loss: Because of the limited fresh water available in salty intertidal soils, mangroves limit the amount of water they lose through their leaves. They can restrict the opening of their stomata (pores on the leaf surfaces, which exchange carbon dioxide gas and water vapour during photosynthesis). They also vary the orientation of their leaves to avoid the harsh midday sun and so reduce evaporation from the leaves. Anthony Calfo, a noted aquarium author, observed anecdotally a red mangrove in captivity only grows if its leaves are misted with fresh water several times a week, simulating frequent tropical rainstorms.

Nutrient Uptake: Because the soil is perpetually waterlogged, little free oxygen is available. Anaerobic bacteria liberate nitrogen gas, soluble ferrum (iron), inorganic phosphates, sulfides and methane, which make the soil much less nutritious. Pneumatophores (aerial roots) allow mangroves to absorb gases directly from the atmosphere, and other nutrients such as iron, from the inhospitable soil. Mangroves store gases directly inside the roots, processing them even when the roots are submerged during high tide.

Increasing Survival of Off Spring: In this harsh environment, mangroves have evolved a special mechanism to help their offspring survive. Mangrove seeds are buoyant and are therefore suited to water dispersal. Unlike most plants, whose seeds germinate in soil, many mangroves (*e.g.* red mangrove) are viviparous, whose seeds germinate while still attached to the parent tree. Once germinated, the seedling grows either within the fruit (*e.g. Aegialitis*, *Avicennia* and *Aegiceras*), or out through the fruit (*e.g. Rhizophora*, *Ceriops*, *Bruguiera* and *Nypa*) to form a propagule (a ready-to-go seedling) which can produce its own food via photosynthesis.

The mature propagule then drops into the water, which can transport it great distances. Propagules can survive desiccation and remain dormant for over a year before arriving in a suitable environment. Once a propagule is ready to root, its density changes so the elongated shape now floats vertically rather than horizontally. In this position, it is more likely to lodge in the mud and root. If it does not root, it can alter its density and drift again in search of more favorable conditions.

Importance of Mangroves

1. They are the buffer zone between the land and the sea.
2. Mangroves protect the soil from erosion.
3. They play an invaluable role as a nature's shield against cyclones, ecological disasters and as protector of shorelines.

54. HORTICULTURE 15820

Physiology of Mango Flowering

Donaka Dayeswari

Ph.D. Scholar, Dept. of Fruit Science, College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, Andhra Pradesh-534101

Mango is a commercially important tropical fruit crop of India. Mango trees are polygamous bearing both perfect and hermaphrodite flowers. Perfect flower has both pistil and staminate structures. Hermaphrodite is purely male or staminate flowers. Both types of flowers are born on same inflorescence. The mango inflorescence is basically terminal. The number of flowers in the panicle may vary from 1000 to 6000 depending on the veriety. Mango flowers are small (5-10mm) in diameter, have a 10 part perianth consisting of five Sepals and petals that are ovate. Flowering is a decisive factor in the productivity of mango. The process involves shoot initiation followed by floral differentiation of apical bud and panicle emergence (Murti and Upreti, 2000). Variability of mango flowering depends upon cultivar, tree age, environmental condition and growth conditions in the dry or humid tropics.

Shoot initiation: Vegetative shoots bear only leaves, generative shoots produce inflorescences and mixed shoots produce both leaves and inflorescences within the same nodes. Growth commences with the first events involved in cell division and elongation of dormant cells specifically in leaf primordia (vegetative shoots), axillary meristems (generative shoots). Under north Indian conditions, March-April and May-June are the most important periods for the emergence of new shoots. Under south Indian conditions, two active flushes occurring from February to June and October to November. In western India, three main growth flushes in February to March, March to April and October to November were reported. Shoot initiation is driven by different factors that determine whether the developing shoots will be vegetative or reproductive. Frequent flush events occur in young trees and in mature trees in conditions of high nitrogen and abundance of water. Other factors that stimulate initiation of shoot development include stem pruning, defoliation, foliar nitrogen sprays.

Vegetative Shoots Undergo Distinct Changes from Early Shoot Development to Maturation of Leaves

1. **Elongation green stage (EGL):** Initially the shoots are light green in colour.
2. **Limp red leaf (LRL) stage:** They acquire reddish colour two weeks after initiation of bud break and little lignifications resulting in vertical hanging down of leaves from stems during this stage. New leaves soon after return to light green and continue to strengthen by increased lignifications in the cell walls.
3. **Mature green leaf (MGL) stage:** One to two months after LRL stage turning to dark green colour reaching mature green leaf (MGL).

Time of flowering: Flower bud differentiation occurs in October - December. Flowering initiated as early as from November - January.

Duration of flowering: The flowering period of mango is usually of a short duration of 4 to 5 weeks. Low temperatures may extend it, whereas higher temperatures may shorten it. The mango tree does not flower simultaneously in all directions.

Sex ratio: Two types of flowers found in mango which are perfect flower and hermaphrodite flower. Percentage of perfect flowers varies between 0.75 in Rumani and 70.0 in Langra. The sex ratio in different cultivars is also influenced by the environment. Lower temperature during the period of panicle development results in an increased proportion of male flowers.

Fruit set: The initial fruit set in mango is directly related to the proportion of perfect flowers. But the final retention has nothing to do with it and appears to be a genetic characteristic. For instance, the initial fruit set in the cv. Langra is very high and impressive, but the ultimate retention is better in the cv. Dashehari which has a relatively lower proportion of perfect flowers.

Pollination and Fruit Set: The mango is a highly Cross pollinated crop and pollination takes place through insects. In nature, more than 50 percent of the flowers do not receive any pollen grain. The Initial fruit set following self pollination is rather negligible (0-1.5%) as compared to that of cross pollination (6.5-23.0 %). Self pollinated fruitlets were invariably smaller and majority of them dropped down within four weeks after pollination.

The Causes of this Phenomenon in the Self-Pollinated Fruitlets

1. The fertilized ovules got aborted due to abnormalities in the embryo and endosperm and also due to over growth of cells of the nucellus.
2. The level of auxin-like substances was higher in the cross pollinated fruitlets as compared to that of self pollinated ones.
3. Cross pollinated fruitlets act as a stronger physiological sink in which nutrients and other metabolites move preferentially, as compared to the selfed fruitlets.
4. The levels of RNA and DNA are also found to be low in the self- pollinated fruitlets.

Factors governing flowering in mango: Flowering mechanism in mango is a complex phenomenon. Besides genotypes, it depends on environmental factors. Usually new vegetative flush appears and become mature, on which flowering occurs. After withdrawal of rainfall and dry spell, winter begins which triggers flowering in mango. Flowering is influenced by Physiological and Environmental factors.

Physiological Factors

Florigenic promoter: Existence of florigenic promoter (FP) induces flowering in angiosperms. Florigenic promoter is continuously synthesized in mango leaves and its synthesis is governed by temperature. FP is translocated through phloem to apical buds. Fp is temperature regulated and vegetative promoter (VP) is age dependent. High ratio of FP/VP favours floral induction, Low FP/VP favours vegetative growth and Intermediate ratios favours mixed shoots. FP is upregulated on exposure to cool temperature (<18° C) in sub-tropical conditions. In tropics, regardless of temperature, floral induction occurs in terminal stems that have to attain appropriate age of at least 4-5 months depending on cultivar. VP is gibberellin or closely associated with gibberellin synthesis pathway. To induce flowering in tropical conditions, the levels of VP must drop to sufficiently low levels with stem age (4months) to raise the FP/VP ratio.

Environmental Factors

Temperature: One of the main environmental factors influencing mango flowering is temperature. Cool temperatures of 15°C day/10°C night induce flowering in subtropical condition. Under tropical conditions, the minimum temperature of 13°C for seven days favored flower bud differentiation in mango cultivars. The low temperatures (19 °C in day and 13 °C in night) are favorable for flower bud differentiation. Flower bud differentiation was delayed by high temperature and super abundant rainfall in subtropical monsoon climate zones. Flowering affected by cool temperatures in high altitude conditions. Very high and very low temperature during flowering is harmful to pollen and tree fails to flower. The main limiting factor of mango tree survival is severe frost. Thus, mango is best grown in areas that are frost free.

Role of phytohormones and carbohydrates in flowering of mango: Basic mechanism underlying mango flowering, involving an interaction between temperature dependent florigenic promoter and an age regulated vegetative promoter. The high ratio of florigenic promoter under low temperature conditions contributing to floral development. Florigenic promoter is graft transferable and short-lived. It has the potential to move long distances during cool conditions. Carbohydrates in the tissues are anticipated as driving force in the transport of florigenic promoter. FP has strong link to phytohormonal factors, which act in association with carbohydrate production and supply for the expression of floral responses. Flowering has strong links to the phytohormonal synthesis in the developing reproductive organs. Besides depicted as a driving force for the transport of FP, carbohydrates also play an important role in floral induction process in many crops. The adequate availability or supply of carbohydrate reserves is crucial to floral bud development and floral initiation. A high endogenous ratio of carbon to nitrogen in plants is stimulatory to flowering whereas a low C: N ratio favours vegetative growth. In mango, the initiation of flowering mainly depends on maintenance of higher C/N ratio. This built up in C:N ratio is vital for floral growth. The positive association of floral bud initiation with C: N ratio shows that the increase in carbohydrate availability and translocation is highly essential for the floral initiation in mango.

Role of gibberellins: In many perennial fruit species including mango, gibberellins have been shown to suppress floral process. GA delays inflorescence initiation in cool temperatures and thereby prevents initiation of reproductive shoots of mango. The mechanisms involved in the inhibition of floral initiation by gibberellins is that it enhances the synthesis and production of other hormones and modifies assimilate partitioning to suit for inhibitions in flowering. The endogenous level of gibberellins was also high in “off” year shoot-tips than in “on” year shoot-tips. Therefore, failure of flowering during the “off” year may be associated with a higher gibberellins levels in the shoot-tips. The role of gibberellins in mango flowering is further confirmed from the finding of Upreti *et al.* (2013) and Abdel Rahim *et al.* (2011) that paclobutrazol inhibited gibberellins in mango buds concomitant with profuse induction in flowering.

Role of auxins: Auxins influence flowering in many perennial plants and increasing trends in auxins in many perennials is vital to floral induction.

Role of cytokinins: Cytokinins are compounds with a structure resembling adenine which promotes cell division. These compounds are considered as important regulator of shoot meristematic activity and their high production in apical meristem during active growth facilitates reproductive morphogenesis.

Role of ethylene: Ethylene plays important role in floral induction. Higher ethylene concentration in Neelum was found at flowering stage compared to juvenile. Various indirect evidences linked to ethylene production such as extrusion of latex in terminal buds at flower initiation and leaf epinasty near apex during panicle growth also confirm involvement of ethylene in mango flowering process. KNO_3 has been shown to stimulate flowering under tropical condition in a number of mango cultivars. As KNO_3 is suggested to induce ethylene production and efficacy of KNO_3 is suppressed by ethylene biosynthesis inhibitors, the involvement of ethylene appear an important factor in mango flower process.

Role of abscisic acid: ABA regulates stress responsive adaptations in plants. As stress conditions are required for floral morphogenesis, its increased concentrations are expected to facilitate floral growth though stress adaptive mechanism involving the stress responsive genes. It also has influence on flowering through its effects on sucrose metabolism. The shoots of ‘Dashehari’ during ‘On’ year had relatively higher levels of this inhibitors during flower bud initiation than the shoots of ‘off’ year trees. This indicated that the inhibitors are important in the initiation of flowering in mango.

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55. HORTICULTURE 15830

Nutritional Quality of 21st Century Vegetable

B. Ashok Kumar

Dept. of Vegetable Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India-741252

- Scientific Name- Sauropus androgenous Merr.
- Family- Euphorbiaceae
- No - 2n=20
- Origin- Indo-Burma region

Origin and Distribution: It is known to be originated in Indo-Burma regions. The crop was first introduced to the Agricultural Research Stations of Tamil Nadu and called popularly here as "Thavarai Murungai". In India it is called as madhura keera. The crop is confined to Sikkim Himalayas, Khasi, Abour and Arka Hills at 1,200 elevations and in western ghats of Kerala (South India) from Wynad northwards at altitudes to 300-1200 m. The crop considered as minor leafy vegetable in India. Apart from India, crop is also grown in Indonesia, Malaysia and Singapore.

Nutritional and Medicinal Uses: Chekurmanis is known as multivitamin and multimineral leafy vegetable as it contains abundant amount of vitamins, proteins and minerals. The leaves especially freshly picked ones are rich source of vitamin-A (9250 IU) and carotenoids. It is rich in Vitamin C (6.8-7.4% as compared to 3.2 in amaranthus), Iron (23% DV) and Zinc (10% DV). It also contains optimum quantity of vitamins B and C, protein and minerals. The overall nutrient content is highest in mature green leaves. The bio accessibility of iron and zinc was significantly higher in the tender leaves.

The tender shoots and leaves are used in culinary purpose and salad. Leaves are used for dying food and they can also be used as feed for cattle and poultry. The cut pieces of leaves are cooked and along with coconut flour used in curry and vadai preparation.

Consumption of chekurmanis has been reported as being associated with bronchiolitis obliterans (Ruay-Sheng *et al.* 1996). The plant extract showed anti-inflammatory effects on nitric oxide inhibitory activity and antioxidant activity. The juice of leaves minced with roots of pomegranate and used against eye diseases.

However, a study has suggested that excessive consumption of juiced Katuk leaves (due to its popularity for body weight control in Taiwan in the mid '90s) can cause lung damage, due to its high concentrations of the alkaloid papaverine. The alkaloid content of chekurmanis leaves was significantly reduced upon pressure cooking.

Table-1 Nutritional Composition of Chekurmanis
(All the values are per 100 gms. of at different stages of edible portion)

Constituent	Content
Protein	22.0 g
Dietary fibre	34-36%
Iron	3.89-4.50 mg
Zinc	1.26-1.48 mg
Niacin (vit-B3)	69-74 mg
Vitamin-A	7400 to 9250
Vitamin-E	17.6 to 15.6 mg/100 g
Alkaloid (mature leaves)	1740 mg/ 100 g
Alkaloid (tender leaves)	1439 mg/100 g

Reference: Platel and Srinivas, 2017

Botanical Description: Chekurmanis is a perennial leafy vegetable reaches upto height of 2.5m. The plant is a multi stemmed shrub with dark green oval shape leaves of 5–6 cm long. The flowering comes in summer season. The inflorescence is axillary with small reddish monoecious flowers. The cross pollination is option as it has protogyny nature of flower.

Image-1 edible part and entire field of Chekurmanis

Cultivation Practices: The crop requires tropical climate for optimum leaf yield and growth ceases during winter season. It grows well in all types of soils and tolerates slightly neutral to alkaline conditions. It is a perennial crop multiplied through vegetative propagation by stem cuttings. The semi hardwood cuttings of 20-30cm length are optimum. These cuttings are planted during May-June with 10-15 cm apart. The growth regulators like IAA/IBA @50ppm treatment to cuttings before planting enhances rooting. It is a drought crop requires no extra fertilizers but FYM or compost @5t/ha is applied as initial dose. The irrigation is scheduled during summer months to increase number of branches and leaf yield. The plants trimmed to 1m to increase no. of laterals and easy harvest. The crop is ready for first clipping from 3-4 months after planting, when the plant reaches about 60cm height. Generally, crop is free from disease and insect-pest but a small amount of leaf damage through leaf minor.

The average annual yield is 30-50 t/ha with per plant yield of 1-3 kg/year.

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56. HORTICULTURE 15837

Cultivation of Leafy Vegetables A Better Way to Enhance Farmers Income

Nagarjun P.

Ph.D. Scholar, Department of Agronomy, University of Agricultural Sciences, GKVK, Bengaluru-560065

**Corresponding Author E. Mail: nagarjunp009@gmail.com*

Dark green leafy vegetables are an excellent source of fiber, folate, and carotenoids. These vegetables also contain vitamins C and K and the minerals iron and calcium. In addition, dark green leafy vegetables act as antioxidants in the body. To lead a healthy life your body needs an adequate amount of minerals and nutrients which lets you to do the daily activities. So it's not just the amount of food that your body intakes everyday which keeps you fit and healthy. Vegetables are the correct source of iron which makes your body resistant in doing the daily activities. There are many kinds of vegetables which contain iron and green vegetables contain the highest percentage of iron. The iron which is provided in the green vegetables has many benefits for all of the people around the planet. Green vegetables can cure the ailment which people suffer due to low hemoglobin in a short span of time. So, it also affects our body the correct way. Eating enough vegetables each day is important than compared to fish, egg or chicken which helps you maintain your ideal health.

Green leafy vegetables are the best source of folic acid which is of great significance for pregnant women. Greens are rich in calcium, iron, potassium and zinc and these are the reasons why all the doctors advise to make green vegetables a part of almost every diet. These minerals are the essential elements that are required for human health. Eating lots of vegetables makes your diet a low-fat, high-fiber diet and this helps in reducing blood pressure and reduces risk of heart disease, stroke, diabetes, and cancer. Intake of green vegetables can helps in reducing excess weight of your body and achieves the ideal weight which you have craved for.

Amaranth

Amaranth is the most popular leafy vegetable of south India mostly cultivated in Kerala, Tamil nadu, Karnataka, Maharashtra, Andhra Pradesh, Telangana. Amaranth leaves or amaranth greens (above ground parts) are healthy leafy vegetables that are widely consumed all over India. It can be grown throughout the year. Local names of Amaranth in India: Thotakura/Kuraku (Telugu), Mulai Keerai (Tamil), Cheera (Malayalam), Danthu soppu/Danthu (Karnataka), Rajgeera (Marathi), Rajagaro (Gujarati).

Important health benefits of amaranth leaves are: Amaranth leaves help in lowering cholesterol, leaves good for diabetes, helps in digestion, reduces the risk of calcium deficiency and also preventing skin related infections.

Coriander

It is a very old annual herb and belongs to the family of Apiaceae and coriander is indispensable spice in Indian kitchen. It gives good flavor to dish, because of this property coriander seed and fresh leaves are commonly used in every kitchen to prepare various dishes. The fresh leaves are an important ingredient in many Indian foods (such as curries, chutneys, salads and many fried dishes). Coriander leaves constitute one of the richest source of vitamin C. All parts of the coriander plant are eatable. This is the daily required leafy vegetable in kitchen. Local names of Coriander in India:- Kothimbir / Dhane (Marathi), Dhaniya / dhaniya patta / dhania patta/ Hara Patta

(Hindi), Malliyila (Malayalam), Kothimeera / Dhaniyalu (Telugu), Kottamalli (Tamil), Kottambari Soppu (Kannada), Dhonay paatha (engali), Kothmiri, Dhana (Gujarati), Hara Patta (Punjabi).

Health Benefits of Coriander: Coriander helps in skin related disorders, Coriander seeds helps in reducing cough, helps in reducing blood pressure, helps in reducing Diarrhea and reduces the cholesterol levels in the blood.

Fenugreek

Popularly known as "methi" in India and used an important condiments and also a flavoring agent in many food preparations. The young leaves are used as vegetable consumed in daily cooking. The fenugreek leaves are quite rich in protein minerals and Vitamin C. Fenugreek can be used both as herb (the leaves of the plant) and also spice (the seed). This crop is commercially cultivated for its seeds but there is a huge demand for fenugreek as a leafy vegetable. Local names of Fenugreek in India:- Methi (Hindi, Oriya, Bangla, Punjabi, Urdu), Methya (Marathi), Menthya (Kannada), Vendayam (Tamil), Menthulu/Menthyalu (Telugu), Uluva (Malayalam).

Mint

It is an old and important aromatic perennial herb, popularly known as "Pudina" in India. Mint is an energizing herb that can add flavor to many dishes. Mint is used in cooking as a flavouring agent and mint oil used for flavouring mouth washes, tooth pastes. Mint belongs to "Labiates" family. Pudina is an important ingredient in preparation many spicy foods especially in South India.

Health Benefits of Mint (or) Pudina: helps in digestion/stomach disorders, it reduces nausea & headache, helps to solve respiratory disorders and coughs, very helpful for asthma patients and also helps in reducing body weight.

Spinach

Spinach is a hot season leafy vegetable grown across all India, Known for lush green foliage spinach is rich in iron, vitamins and anti-oxidants. Spinach crop can be harvested after 6-8 weeks from planting. In warm climate spinach tends to produce seeds rather than growing the foliage. So harvesting it at right time is very important. It is called as 'Palak' in Hindi, Palak (Marathi & Hindi), Visalacheera (Malayalam), Pasali (Tamil), Palakura (Telugu) and Palaka (Kannada). Day by day this crop is gaining much importance in South India especially in urban areas.

Curry Leaves

Curry leaves are one of the highly popular and oldest herb used in India. As the name suggests curry leaves are herbs which are added to curries and soups. The nutrients found in curry leaves, per 100 g, include 60 g of moisture, 6 grams of protein, 1 gram of fat, 16 g of carbohydrate, 6 grams of dietary fiber, and 4 grams of minerals such as calcium, phosphorus, iron, nicotinic acid, vitamin A and vitamin C. Other names of Curry Leaves:- Curry leaves are called by different name in India like kariveppilai in Tamil, kariveppaku in Telugu, karipatta in Hindi and karibevu in Kannada.

Since there is a huge demand for these leafy vegetables and also cultivation these crops are very simple, short duration, requires less area, labour, minimum plant protection, easily cultivated as an intercrop in between the rows of annual as well as perennial crops, very low cost of cultivation. If the farmers nearby cities cultivate this leafy vegetables can get better income if a proper planning is made with in a small area a multiple crops can be grown and can obtain higher economic returns.

57. HORTICULTURE 15844

Edible Flowers

Aakanksha Mahindrakar*

Ph.D. Scholar, Department of Floriculture and Landscape Architecture, K.R.C.C.H., Arabhavi

**Corresponding Author E. Mail: aaakankshaaa@gmail.com*

Edible flowers are flowers that can be eaten and can be preserved for future use using techniques such as drying, freezing or steeping in oil. They can be used in drinks, jellies, salads, soups, syrups and many dishes.

History of Edible Flowers

- The culinary use of flowers dates back 1000's of years with the first recorded mention being in 140 B.C.
- The Romans used mallow, rose and violets. Italian and Hispanic cultures gave us stuffed squash blossoms and Asian Indians used rose petals in many recipes.
- Chartreuse, a classic green liqueur developed in France in the 17 century by making use of carnation petals.
- Dandelions were one of the bitter herbs referred to in the Old Testament of the Bible.

Why Flowers are Edible?

Flowers are rich in nectar and pollen, and some are high in vitamins and minerals. Flowers are also nearly calorie free.

Example: Roses—especially rose hips are very high in vitamin C, marigolds and nasturtiums contain vitamin C, and dandelion blossoms contain vitamins A and C.

TABLE 1: Edible flowers of different plants

Ornamentals	Calendula, Chrysanthemum, Carnation, Bachelor's button, Day lily, Hollyhock, Honey suckle, Jasmine, Verbena, Peony, Phlox, Marigold, Dandelions, Nasturtiums, Jhonny jump ups, Violets, Yucca
Vegetables	Garlic, okra, Broccoli, Pea, Radish, Squash
Fruits	Apple, Citrus, Guava, Elderberry.
Medicinal & Aromatic	Lavender, Linden, Rosemary, Scented Geranium, Spearmint, Dill.

Flowers can be used as floral liquor, candied flowers, flower butter, flower Jelly, flower syrup, blossom ice cubes, flower petal tea, garnishing food items, laxatives, jellies, salads, lemonade, antidepressant, cholesterol lowering statins, anti histamine.

Risks Associated: Some flowers are toxic, others may be edible only after appropriate preparations. Toxic flowers may be misidentified as edible when gathered. Allergic reactions are possible, especially from eating pollen. Both gathered flowers and those from a commercial grower may have been sprayed with toxic pesticides. Damaged, dirty or insect-ridden flowers may be unsafe to eat. Some flowers are not safe if eaten often.

TABLE 2: Flowers for natural color extraction

Pigments	Flowers	Color
Anthocynidins	Hibiscus, Rose hips.	Red to pink
Betalaines	*Mesembryanthemum edule, Portulaca spp.*	Red to pink
Carotenes/ Carthemine	Safflower	Yellow-orange
Crocetin	*Crocus sativus* (saffron)	Yellow-orange
Lutein / xanthophyll	*Tagetes, Solidago, Antirrhinum*	Yellow-orange
Azulene	German chamomile, *Achillea millefolium*	Blue

Utilization of natural colors: used in food and drinks, poultry and fishery, textiles, cosmetics, inks and paints and Pharmaceuticals etc.,

How to Choose Edible Flowers

1. Decide what purpose you want edible flowers: Candied flowers (candied violets), sugared (roses) Adding to pickles, jams, vinegars, syrups, sugar or for decorative purposes - garnishes for plates, cakes and more
2. Familiarize yourself with some of the more common culinary flowers: Nasturtiums are usually -stuffed, crystallized or as garnish. Dandelions should be picked when they are young, they have sweet honey like flavor. Roses are used for decorations on ice cream, dessert garnishes, jellies, jams, flavored butters, rosewater.
3. Prepare flowers: Harvest the flowers: the best time to harvest flowers is just after the dew has dried, early to mid morning or early evening after the heat of sun has faded provided the flowers appear in good condition. Do not pick in the middle of the day, as the heat can dry out the flavor and cause a drop in both flavor and color. Remove stamen and pistil: White, pithy parts and any large stamens or pistils are usually bitter and can often be chewy.
4. Clean the flowers: Shake the flowers to remove insects, debris, and bits of dirt. If the flowers remain dirty wash it gently with a colander or tea strainer. Carefully use a fine and soft spray of water, as flowers are fragile and bruise easily. If the flower is especially delicate, just a brief soak will suffice. The flowers will retain their odor and color providing they dry quickly and that they are not exposed to direct sunlight. Dry on kitchen towels: Arrange on paper towels and allow time to air dry.
5. Use flowers according to recipe and garnishing needs.

Conclusion: A general rule of thumb is that the flowers of vegetables and herbs are safe to eat. Some of the important edible flowers include chrysanthemum, day lilies, primrose, gladiolus, jasmine, lilac, basil, peony, and even yucca. Flowers can be stored in the refrigerator for up to 10 days, provided that they are in a sealed container. Place a moist paper towel at the base of the container. If the flowers are limp, they can be revitalized by floating them on icy water for a few minutes.

Avoid consuming flowers that may have been sprayed with chemical pesticides. Do not eat flowers from a florist shop. **Poisonous flowers** like Lilies of the valley, Foxgloves, Azalea, Oleander, Crocus, Daffodil, Rhododendron and Sweet pea (*Lathyrus odoratus*) should be avoided

58. HORTICULTURE 15845

Genetic Resources of Loose Flowers and Ornamental Crops for Breeding Programmes

P. Manimaran

Ph.D. Scholar, Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore - 641 003
**Corresponding Author E. Mail: mmhorts@gmail.com*

INTRODUCTION: There are a wide variety of ways in which plant genetic resources are used in crop breeding programmes. These depend upon the problems which the breeder is trying to solve, the resources at hand to solve them, the reproductive biology of the crop, and the availability of appropriate genetic resources collections. The important fact is that all breeding programmes depend on genetic resources of one type or another to make progress in improving yield, disease or pest resistance, and Product quality of the crop, forage or ornamental plants they are responsible for. This paper considers in general terms some of the important ways in which genetic resources collections are used in modern plant breeding programmes, and illustrates the general principles with an example of different uses of a very good national genetic resources collection in a breeding programme currently in its initial stages in Namibia.

First a word about the scope of the term "genetic resources," which encompasses all sources of useful plant traits or specific genes for a given crop. These can be conveniently grouped into four broad categories they are products of other breeding programmes, landrace varieties, wild relatives, products of genetic engineering.

Jasmine

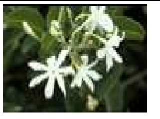
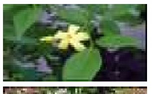
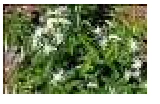
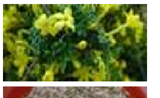
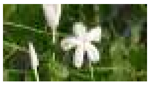
Jasmine (*Jasminum spp*) is one of the oldest flower cultivated by man for various purposes. In India it is cultivated throughout the country and especially in south india. In, recent years the demand for high grade perfume has greatly increased and there is tremendous scope for the development of essential oil industry based on this plant.

Species and Cultivars of Jasmine: The genus belongs to the family Oleaceae. Jasminum genus has more than 200 species.

Commercial Species

Botanical name	Common name
Jasminum sambac	Malligai / Gundu malli / Arabian / Tuscan jasmine
Jasminum auriculatum	Mullai
Jasminum grandiflorum	Italian jasmine, Royal Spanish Jasmine Jathimalli
Jasminum multiflorum (Syn. *J. pubecsens*)	Furry jasmine, downy jasmine, Star jasmine, Pin wheel jasmine

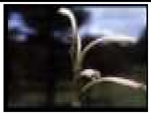
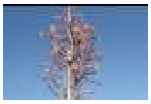
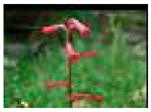
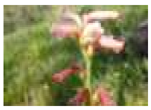
Desirable Traits in Genetic Resources of Jasmine

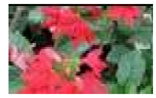
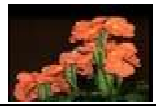
S. No.	Species/ Variety	Desirable trait(s)	
1.	*J. calophyllum*	- Year-round flowering - Free from pest and disease	
2.	*J. flexile*	- Free from pest and disease	
3.	*J. humile*	- Used in perfumery	
4.	*J. nitidum* *(Syn. J. laurifolium)*	- Year-round flowering - Long flower buds (4 cm) - Free from pest and disease	
5.	*J. parkeri*	- Dwarfness - Hardiness	
6.	*J. auriculatum* (Parimullai)	- Resistant to gall mite - Yield 8 t/ha, Concrete recovery: 0.29%	
7.	CO. 2 Mullai	-Tolerant to phyllody -Yield: 10 t/ha, Concrete recovery: 0.36%	
8.	*J. grandiflorum* Arka Surabhi (IIHR, Bangalore)	- Tolerance for drought condition - Flower yield is 10 t/ha - Concrete recovery – 0.35%	

Tuberose

Tuberose (*Polianthes tuberosa*), is an ornamental bulbous plant, native to Mexico. It is one of the most important cut flowers in tropical and subtropical areas. The long spikes of flowers are excellent for cut flowers and people like their sweet fragrance.

Desirable Traits in Genetic Resources of Tuberose

S. No.	Species	Desirable trait (s)	
1.	*P. durangensis*	- Flowers are sessile erect Curved purplish with age	
2.	*P. geminiflora*	- Flowers are light orange-red in colour	
3.	*P. graminifolia*	- Deep red in colour	
4.	*P. platyphylla* (Natural crossing of the wild red and white sp. of tuberose)	-Flowers are white tinged with red	

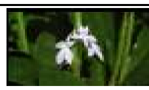
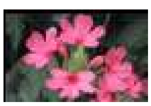
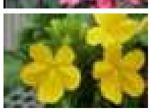
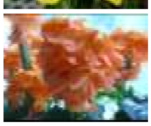
		fluctuations	
5.	Sebaculis Red (tetraploid)	-Highly tolerant to nematodes	
6.	Vijaya Kanakambaram	-Profuse flowering	
7.	Maruvur Arasi	-Long flower stalk – 75 flowers	
8.	Dr. A.P.J. Abdul Kalam	- long shelf life - Year round flowering	
9.	Hybrid (TNAU)	- Tolerant to nematode-fungal complex	

Crossandra

Importance: Crossandra- Fire Cracker flower. Mostly crossandra flowers are used for hair adornment. This is commercially important due to its attractive colour. These are used in combination with jasmine for making garlands and for adornments for the women of south India.

Species: There are about 20-25 species but only few like *Crossandra infundibuliformis, C. guineensis*, *C. mucronata*, *C. nilotica* and C. *subacaulis* are cultivated.

Desirable Traits in Genetic Resources of Crossandra

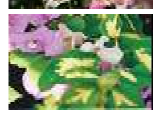
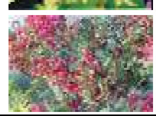
S. No.	Species/variety	Desirable trait(s)	
1.	*C. guinensis*	- Spineless	
2.	*C. nilotica*	- Partial shade tolerant	
3.	*C. flava*	- Flowers bright yellow	
4.	Fortuna (selection)	- Improved root system - Resistant to temperature	

Bougainvillea

Introduction: Bougainvillea is a genus of flowering plants native to South America from Brazil west to Peru and south to southern Argentina (Chubut Province). Different authors accept between four and 18 species in the genus. They are thorny, woody vines growing anywhere from 1 to 12 meters tall, scrambling over other plants with their spiky thorns. The thorns are tipped with a black, waxy substance. They are evergreen where rainfall occurs all year, or deciduous if there is a dry season.

Bougainvillea are relatively pest-free plants, but may suffer from worms, snails and aphids. The larvae of some Lepidoptera species also use them as food plants.

Desirable Traits in Genetic Resources of Bougainvillea

S. No.	Variety/Cultivar	Desirable trait (s)	
1.	Mahara	Multibracted variety	
2.	Cherry Blossom	Multibracted variety	
3.	Thimma	Variegated foliage	
4.	Partha	Bicoloured variety	

59. HORTICULTURE 15853

Ethylene Evolution and Management in Fruits

A. Roy and B. Khamari

College of Agriculture, OUAT, Bhubaneswar, 751003, Odisha

Ethylene (C2H4) also known as ethane, is a gaseous organic compound that is the simplest of the alkene chemical structures (alkenes contain a carbon-carbon double bond). Ethylene is the most commercially produced organic compound in the world and is used in many industrial applications. Ethylene is also a gaseous plant hormone. The hormone effects of ethylene on general plant growth were first noted in 1864 when leakage from gas street lighting systems caused stunting and deformation of nearby plants. In 1901 Neljubow identified the active component of the gas to be ethylene but it was not until 1934 that Gane identified that plants could synthesise ethylene and in 1935 Crocker proposed ethylene to be the hormone responsible for fruit ripening and senescence of vegetative tissues. Research has since demonstrated that ethylene has an important role in many plant development processes, including seed germination, vegetative growth, leaf abscission, flowering, senescence and fruit ripening. Ethylene also plays a role in response to water stress, chilling and mechanical injury.

Ripening and Respiration

Ripening is a term applied to fruit that describes the transition from physiological maturity to senescence (ageing and death of the plant tissues). It is a developmental stage evolved to facilitate reproduction by preparing the seed-bearing organ for detachment from the plant. Ripening is the start of significant biochemical and physiological transformations, such as changes in skin colour, internal flesh softening, aroma development and sweetening. Ripening generally begins after fruit has reached maximum size and is physiologically mature.

Respiration is a process of oxidative breakdown (catabolism) of complex molecules into simpler molecules, yielding energy, water, carbon dioxide and simpler molecules needed for other cellular biochemical reactions required for ripening. The respiration rate per unit of fruit weight is (as a general rule) highest in immature fruit, with the respiration rate declining with age. Thus respiration rate of fruit is an indicator of overall metabolic activity level, progression of ripening and potential storage life of the fruit (*i.e.* a low respiration rate means that the energy reserves will take longer to be consumed and the fruit can be stored for longer).

Some fruits show a significant variation to the pattern of declining respiration rate during their ripening. They exhibit a distinct increase in respiration rates (a respiratory climacteric) of varying intensity and duration, commensurate with ripening. Fruit that exhibit this characteristic increase in respiration rate are classified as 'climacteric' whereas fruit that follow the pattern of steadily declining respiration rate through ripening are classified as 'non-climacteric'.

Ethylene Effects on Respiration

All fruit produce at least small quantities of ethylene during ripening and the internal ethylene concentrations of non-climacteric fruit varies little during their growth and ripening. Exposing non-climacteric fruit to external concentrations of ethylene can transiently increase their respiration rate proportionally to ethylene concentrations. This transient increase in respiration rate may be evoked more than once but ethylene exposure hastens their senescence, shortening their storage life and potentially causing a loss of eating quality. Climacteric fruit produce much larger quantities of ethylene, although the internal ethylene concentrations vary significantly between fruit types. For most climacteric fruit a sharp increase in internal ethylene concentration precedes or is coincident with a dramatic increase in respiration rate. The increasing ethylene concentration triggers the increase in respiration rate (metabolic activity) and attendant biochemical and physiological transformations that occur during ripening.

Mode of action: Ethylene receptors are in active state in the absence of ethylene and this allows normal growth of fruit to continue. When ethylene is produced naturally during ripening, following a physical stress or when applied artificially, it binds to the receptor and switches it off leading to a series of events causing ripening or any other response.

Ethylene action can be affected: By altering the amount of receptors, By interfering with the binding sites of ethylene to its receptors, By interfering at site of receptor where a metal ion, possibly copper is needed for binding, By altering the affinity of the receptor to bind by changing the Oxygen and carbon dioxide levels. Studies revealed that silver ions inhibit the action of ethylene when applied to fruit. The gaseous cyclic olefin,1-methylcyclopropene (1-MCP) inhibited ethylene action by binding irreversibly to ethylene receptors.

Methods of Reducing Ethylene Concentration

Avoidance of ethylene accumulation by providing ventilation in storage rooms, provided, no large temperature variation exists between external air and storage room.

Oxidation with potassium permanganate: Ethylene in the atmosphere can be oxidised to carbon dioxide and water by using chemicals like potassium permanganate which is coated on an inert inorganic porous support like alumina or expanded mica or any other.

Oxidation with ozone: Ozone being gaseous readily mixes with ethylene and acts as a suitable oxidising agent destroying ethylene. But Ozone is highly reactive and corrodes metal pipes and fittings of refrigeration equipment, reacts with paper products used to package produce, readily injures the produce and can be toxic to humans at relatively low concentrations.

Other oxidants: Activated charcoal - brominated will effectively oxidise the ethylene but it may release bromine gas when it comes in contact with excess water.

- Tetrazines which react specifically with ethylene are more efficient in ethylene scavenging but are unstable in the presence of moisture.
- Silver thiosulphate is used in ornamentals where in the silver ion blocks ethylene binding site.
- 1-Methylcyclopropene is a potential replacement to silver. It is successfully used as ethylene inhibitor applied in gaseous form. It binds irreversibly to the ethylene receptor sites. It is registered for commercial use as Smartfresh™ and is commercially used in apples extending the storage life by delaying softening of the flesh.
- Ethylene synthesis inhibitors like Aminoethoxy vinylglycine (AVG) and Aminooxyaceticacid (AOA) are used in ornamentals after harvest. Preharvest application of AVG on apple allows it to reach greater maturity and colour prior to harvest. But these confer protection against endogenously produced ethylene only but not exogenous application if any.

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Theologis A. (1992) One rotten apple spoils the whole bushel: The role of ethylene in fruit ripening. Cell, *Vol.20, Issue 2;181-184.*

60. MUSHROOM CULTIVATION AND PROCESSING 15793

Mushroom Bio-Diversity in the Nilgiris Biosphere Region of Western Ghats

*Valarmathi P. and Ladhalakshmi D.

Scientist, Dept. of Plant Pathology, ICAR-IIRR, Hyderabad

**Corresponding Author E. Mail: valarpath@gmail.com*

A taxonomic study on members of Agaricales of Nilgiris Biosphere Region in Tamil Nadu state was made. A total number of 130 species in 42 genera belonging to 12 families have been described. Out of the 130 species, 79 species were new addition to the Indian Agaricus Flora, 21 new taxa have been proposed and 30 species although already reported from different parts of India but have been reported for the first time from Nilgiris region under these study. Some of the important mushroom species available in the biosphere reserve are *Agaricus, Pleurotus, Calocybe, Tricholoma, Flammulina, Lentinus etc.,*

Agaricus

Agaricus is a large and important genus of mushrooms containing both edible and poisonous species, with possibly over 300 members worldwide. The genus includes the common ("button") mushroom (*Agaricus bisporus*), and the Field mushroom (*Agaricus campestris*). Members of *Agaricus* are characterized by having a fleshy cap or *pileus*, from the underside of which grow a number of radiating plates or gills on which are produced the naked spores. Members of *Agaricus* also have a stem or *stipe*, which elevates the pileus above the object on which the mushroom grows, and a partial veil, which protects the developing gills and later forms a ring or annulus on the stalk. List of species:

Agaricus arvensis, A. arvensis var. exquisite, A. arvensis var. macrolepis, A. augustus, A. bisporus, A. bitorquis, A. campestris and A. silvicola.

Pleurotus

Pleurotus is a genus of gilled mushrooms which includes one of the most widely eaten mushrooms, the oyster mushroom. *Pleurotus* species are characterized by a white spore print, attached to decurrent gills, often with an eccentric (off center) stipe, or no stipe at all. They always grow on wood on nature, usually on dead standing trees or on fallen logs. The common name "oyster mushroom" comes from the white shell-like appearance of the fruiting body, not from the taste. List of species: *P. australis*, *P. citrinopileatus, P. djamor, P. eryngii, P. eousmus, P. ostreatus,*

P. saior caju and *P. flabellatus*	
Calocybe	
Calocybe is a genus of mushroom, including St. George's mushroom, which is edible. List of species: Calocybe alneti, Calocybe atropapillata, Calocybe bipigmentata, Calocybe carnea, Calocybe cerina, Calocybe chrysentern, Calocybe civilis, Calocybe clusii, Calocybe coniceps, Calocybe constricta and Calocybe indica.	
Tricholoma	
The genus *Tricholoma* contains a large number of fairly fleshy white-spored gilled mushrooms which are found worldwide generally growing in woodlands. These are ectomycorrhizal fungi, existing in a symbiotic relationship with various species of coniferous or broad-leaved trees. List of species: Tricholoma argyraceum, Tricholoma lobayense, Tricholoma equestre, Tricholoma magnivelare, Tricholoma matsutake, Tricholoma pardinum and Tricholoma sulphureum.	
Flammulina	
List of species: Flammulina velutipes, Flammulina callistosporioides, Flammulina elastica, Flammulina fennae, Flammulina ferrugineolutea, Flammulina mediterranea and Flammulina mexicana.	
Lentinus	
Mushrooms having a definite cap with a fertile surface consisting of gills. The fruiting body usually also has a stem, although that may be lateral or absent (usually then the mushroom is growing from wood). Known as Shiitake mushroom. List of species: Lentinus erosus, L. crinitus, L. erosus, L. favoloides, L. glabratus, L. graminicola, Lentinus edodes, Lentinus shiitake, Lentinus tonkinensis and Lentinus mellianus.	

61. POST-HARVEST MANAGEMENT 15387

Recent Trends in Packaging of Fruits

Swapnil D. Deshmukh, Pravin L. Deshmukh and Ranjit S. Patil

Ph.D. Scholar, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

India is the second largest producer of fruits with 12.3 MT/ ha productivity. However, still India is not in position to provide recommended quantity (120 g/capita/day) of fruits for balanced diet to its citizens. Increase in the productivity is one of the possible ways to meet out the need of the population. However, increasing the productivity has limited scope because of higher input cost. Therefore, second feasible option is the hidden harvesting. This includes, post - harvest losses of fruits which vary from 30 - 35 % of total production depending upon the fruits and season. This loss occurs because of poor post - harvest management of fruits.

Increasing production efficiency and decreasing post- harvest wastage with using the different packaging techniques could be counted as the best solution to these problems. The main objective of packaging is to extend the shelf life and prevent undesirable changes. The packaging of fruits is required for efficient handling and marketing, better eye appeal and better shelf life by reducing mechanical damage and water loss. The proper packaging protects the fruits from dirt, physiological and pathological deterioration during further handling. Efficient packaging of horticultural produce in uniform size, reduces the need for repeated weighing and can facilitate handling, stacking, loading, unloading, better storage, long transportation, transshipment and marketing.

Principles in Preventing Fruits Losses

1. Destroy the micro organisms and prevent recontamination from outside.
2. Alter the environment to prevent or retard the growth of undesirable organisms contamination.

After Harvesting the Fruits, the following Processes take Place

1) Respiration 2) Ethylene synthesis 3) Ripening 4) Deterioration 5) Microbial growth and 6) Transpiration, loss of moisture in the product.

What is Package and Packaging?

The device or container perform one or more these functions, it is considered a **Package** and **Packaging** is the technology of enclosing or protecting products for distribution, storage, sale, and use.

There are mainly 3 "Ps" of Packaging *i.e.* Protection, Preservation and Promotion.

Characteristics of Good Packaging

- Protection against bruising and physical injury.
- Protection against microbial contamination and deterioration.
- Provide ventilation for respiration and exchange of gases.
- Protect against moisture / weight loss.
- Slow down respiration rate, delay ripening and increase storage life.
- Control ethylene concentrations in the package.

Recent Trends of Packaging

- **Modified Atmosphere Packaging (MAP):** Removal of air from the package and replacing it with a single or mixture of gases. Atmosphere low in O_2 (1-5%) and high in CO_2 (5-10%). LDPE, PVC, polypropylene and Polyester. Alternative to low temperature storage.
- **Controlled Atmosphere Packaging (CAP):** Control of O_2 and CO_2 concentration around fresh produce. Apple, Banana, Pear, Cabbage etc. CA is more appropriate for long term storage. PVC and LDPE have best O_2/CO_2 permeability ratio for fresh vegetables.
- **Vacuum packaging:** Eliminating the air in the package. Reduces the level of O_2 and N_2 in package. Flexible monolayer or multi-layer films are used.
  It eliminates oxidation, preserves delicate flavours, freezer burn, moisture contamination, maintains natural moisture.
- **Shrink wrap:** Individual fruit is loosely sealed in a flexible film. Film is shrunk tightly around the produce. The main advantage is the ability to control moisture loss. LDPE or LLDPE used for shrink wrap.
- **Active packaging:** Incorporation of certain additives into the packaging films changes the condition of the packed foods. Active packaging techniques can be divided into two categories- absorbers or scavengers
- **Intelligent packaging:** Sensors that notify consumers that the product is impaired and they may begin to undo the harmful changes that have occurred in the food product. Rodrigues and Han categories intelligent packaging into two *i.e.* simple intelligent packaging and interactive or responsive intelligent packaging. Two types of devices are there, 1) External indicators and 2) Internal indicators.
  The indicators that increase the efficiency of information flow and effective communication between the product and the consumer. Time-temperature and other indicators Biosensor Bar code Ethylene sensor.
- **Nano particle Coating:** Surface coating of fruits with different nanoparticles blend with CMC, Gaur gum and wax showed significant results in prolonging shelf life of fruits. After synthesis of nanoparticles, it should be blend with required quantity of guar gum, CMC or wax. Fruits are thoroughly wash in 100 mg per liter sodium hypocloride for 15 min and kept at ambient temperature to remove surface liquid. Then the fruits are immersed in the already prepared solution of nanoparticles for 3 min and after drying kept in board cartoons with a small holes at each four sides.

62. PLANT PATHOLOGY 15414

Red Alert: Deadly Disease on its Way

V. Umesh Kumar[1], Loyavar Ramchander[1] Samrat Laha[1] and P. Sudheer Kumar[2]

[1]*Ph.D. Research Scholar, Dept. of GPB, BCKV, West Bengal-741252*

[2]*Ph.D. Research Scholar, Dept. of Agricultural Entomology, BCKV, West Bengal-741252*

INTRODUCTION: Wheat blast is caused by the fungus *Magnaporthe oryzae Triticum* pathotype (MoT) is a seed borne pathogen, transmitted from spike to seed, and from infected seeds to seedlings. Outbreaks caused by fungal diseases have increased in frequency and are a recurrent threat to global food security. One example is blast, a fungal disease of rice, wheat, and other grasses, that can destroy enough food supply to sustain millions of people, first incidence of wheat blast affected approximately 15% of Bangladesh's total wheat area. An independent patho genomics analysis confirmed that the Bangladeshi wheat blast fungus was most likely moved in from South America. Now it has entered into Indian territory from Bangladesh and been reported in a few pockets in Nadia and Murshidabad districts of Bengal around 1,000 hectares had been affected by the disease, which was first noticed at the Jalangi block of Murshidabad district. However, in most of the parts of Bihar and Bengal, farmers sow the HD 2967 variety, which has inbuilt capacity to deal with the fungus. The potential for the wheat blast to cause widespread losses demands immediate action to understand and manage this explosive disease. To date, the wheat blast is considered an intractable and dangerous disease and fungicides have shown limited efficacy.

Symptoms: Strains of the *M. oryzae Triticum* pathotype can affect all above-ground parts of the plant. Grains from blast infected spikes from highly susceptible cultivars are often small, shriveled and deformed, with low test weight. These grains are often discarded during the post-harvest process of threshing or winnowing. Mature lesions often have a dark brown to reddish-brown margin that stops lesion expansion, and they also often have yellow chlorotic halos. Individual lesions are generally eye-spot shaped (sometimes elliptical), but they coalesce in moderate to severely infected seedlings, sometimes resulting in the total death of the plant. Lesions can also rarely be seen on the leaf collar, culm, culm nodes, and stem. Highest yield losses occur when spike infections begin during flowering or early grain formation. *Fusarium* head blight, which has similar spike symptoms, impacts wheat production around the world. The most visible symptom of the wheat blast in the field is bleaching of the spike. An infection in the rachis or peduncle can block the translocation of photosynthates and kill the upper parts of the spike. brown to dark-gray margins. Grain fill is better when MoT infections occur later in the season; however, later infections may increase the chance of seed transmission of the pathogen with infected seeds.

Wheat blast lesions on spikes, leaves and stems. Partial (**a**) or total (**b**) spike sterility depends on susceptibility of cultivar, time, and point of infection. (**c**) Gray sporulating lesions on an upper, younger leaf showing distinct yellow chlorotic halos. (**d**) Gray sporulating lesions on lower canopy senescent leaves. (**e**) Lesions on stems show pale tan centers with brown margins after sporulation has finished

Detection Methods: Disease management strategies require accurate detection of low levels of a pathogen before disease symptoms are easily observed. *Magnaporthe oryzae* specific transposable element sequences such as Pot2, MGR583 and MoTeR have been useful for identification of *M. oryzae*, but they do not differentiate MoT isolates from isolates of other host-specific pathotypes. Recently, a quantitative loop-mediated isothermal amplification (qLAMP) assay was coupled with a spore trap system for quantification of airborne inoculum of the Lolium pathotype in turf field plots in the U.S. This proof of concept study demonstrated detection of as few as 10 conidia up to 12 days before symptoms developed in inoculated turf grass plots. It is currently unknown if this assay would also detect the closely related MoT isolates. Whole genome analysis to identify DNA sequences that differentiate MoT isolates from other host specific forms including MoT isolates. A polymerase chain reaction (PCR) based diagnostic assay using the sequence MoT shows specificity and sensitivity in laboratory studies and is now being developed as a tool for detecting the wheat blast pathogen in the field and in wheat seed or grain lots from affected areas. Deploying effective diagnostic assays is urgently needed.

Disease Management: Although there is evidence in South America that fungicides can provide some level of head blast control, other results suggest that their efficacy may be limited and insufficient. The consensus opinion is that fungicides are not effective in controlling wheat head blast if warm, rainy weather occurs during the heading stage. fungicide applications were only effective on flag leaves, but not on heads. fungicides can partially control wheat head blast and offer better control on cultivars with at least moderate levels of resistance. Cruz *et al.* (2015a) proposed that earlier fungicide applications might reduce MoT inoculum from basal leaves and thus lower the risk of fungal infections on spikes. Because the wheat blast pathogen is seed borne, another management strategy is seed treatment with fungicides. For this reason, fungicide treatment of seed lots originating from fields affected by blast should be mandatory. Extensive use of strobilurin (QoI) fungicides in Brazil has led to widespread distribution of cyt b mutations conferring resistance in strains isolated from wheat and other grasses. Therefore, fungicide resistance in the MoT population should be routinely monitored. Burning standing crops to prevent the disease from spreading to the rest of the country.

However, MoT infected/infested seeds can serve as a vehicle for the introduction of the fungus into non-endemic areas. General guidelines to promote safe germplasm movement, including standard seed production and preparation procedures, should be implemented. Field inspections, harvest procedures, and storehouse maintenance, in addition to seed testing, treatment, and packing, should be implemented prior to movement of germplasm. Deep plowing of infected plant residues and elimination of possible alternate hosts have also been recommended. An integrated approach will aid in reducing the likelihood of boom and bust cycles and increase the lifetime of resistance genes. Strict quarantine measures should be implemented specially on Bangladeshi agricultural imports.

Development of Disease Resistant Varieties: Identification and deployment of novel sources of resistance imperative and the search for effective resistance are underway in Bangladesh, Bolivia, Brazil, and Paraguay. Modern technologies, including advanced plant breeding and phenotyping platforms, should be used to discover novel sources of resistance and speed up development of resistant germplasm. Germplasm exchange of wheat germplasm is critical for identification and testing of new resistance resources Genetic Resistance to wheat blast remains elusive despite intense searches for sources of resistance since 1985. Similar to the rice blast pathosystem, genetic studies show that wheat blast follows a gene for gene relationship. Studies also show significant isolate by cultivar interactions and multiple virulence differences (physiological races) within MoT populations. Although wheat blast can be both a spike and a leaf disease, poor correlation is observed between the two reactions, possibly indicating different resistance mechanisms. Both qualitative and quantitative blast resistance is present in wheat, but the former is mainly validated at the seedling stage, and further studies are needed for verification at the adult plant and spike stages. In addition to the previously discussed wheat R genes that prevent infection by *M. oryzae* isolates of the *Oryza, Setaria and Avena* pathotypes, four wheat R genes have been identified against MoT strains. Rmg2 and Rmg3 from bread wheat variety Thatcher confer seedling resistance to MoT strains isolated from 1990 to 1992, However, Rmg7 does not confer resistance to the recent MoT isolates, and Rmg8 remains to be tested with current MoT isolates and with natural field populations. These results and others suggest that the current MoT population has become more aggressive toward wheat and that it has already overcome some resistance sources. Silicon treatment enhances resistance to wheat blast Cruz *et al.* (2016c) identified a wheat head blast resistance trait contained in a wild wheat chromosome segment (the 2NS translocation segment from *Aegilops ventricosa*). Field tests in Bolivia in 2014 and 2015 confirmed that the 2NS segment confers head blast resistance under natural epidemic conditions. The 2NS-chromosome fragment has already been incorporated into diverse cultivated wheat varieties due to its useful rust and nematode R genes. Popular Wheat varieties derived from the CIMMYT line, Milan, were released in the past due to their relatively high levels of head blast resistance in the field and Milan contains the 2NS segment. Hybridization between 2NS and non-2NS lines with promising head blast resistance is necessary. Therefore, it is recommended that breeders around the world use 2NS-based cultivars as resistant parents. However, it is important to note that not all lines with 2NS show a significant reduction in the head blast and resistant parents should be selected with caution. The long-term success of breeding for blast resistance will be influenced by:

i) Availability, diversity, and type of genetic resistance,
ii) Screening methodology and selection environment for tracking resistance
iii) Nature of the pathogen and diversity of virulence in the population.

FUTURE CHALLENGES: The 2NS-based cultivars are currently the best sources of resistance to wheat head blast, but this resistance must be backed up with additional resistance. So far, only a few promising lines with non-2NS resistance have been identified under controlled environment conditions and testing of these lines under natural epidemic conditions is pending. It is critical to clarify which alternative hosts can harbor the MoT pathotype this requires research on the ecology of *M. oryzae* pathotypes that threaten wheat and disease epidemiology of wheat blast Precision phenotyping platforms are required to increase the efficiency of discovery of novel sources of resistance. On a parallel front, effort should include testing if any of the cloned rice R genes will function to protect wheat against blast. Remote sensing, "ground truth", Transgenic, genome-editing strategies based on the detailed understanding of the fungal infection process and wheat resistance mechanisms could provide longer-term solutions, which means that foundational research on wheat blast disease should also become a priority.

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63. PLANT PATHOLOGY 15484

Interaction between Plant Pathogenic Virus and Vector in Related to Aphid and Whitefly

*[1]Swathi Yadav Kattula, [2]Srasvan Kumar G. and [3]Devika Rani D.

[1]Senior Research Fellow, NIPHM, Hyderabad-500030

[2]Research Scholar Banaras Hindu University, Varanasi-221005

[3]Ph.D. Research Scholar, University of Agricultural Sciences, GKVK, Banglore-65

*Corresponding Author E. Mail: swathiyadavkattula@gmail.com

The majority of plant viruses that cause disease in agricultural crops rely on biotic vectors for transmission and survival. The largest class of plant virus-transmitting vectors are insects but other vectors include mites, nematodes and fungi. The best - characterized plant viral insect vectors are aphids, thrips, leafhoppers, plant hoppers and whiteflies.

Hogenhout *et al*., (2008) mentioned that modes of viral transmission by vectors include non-persistent, semi-persistent and persistent. Non-persistent plant viruses are retained in the insect stylet. Semi-persistent viruses are internalized in the insect by binding to chitin lining the gut, but do not appear to enter tissues. Persistent viruses are taken up into and retained by insect tissues and are characterized by invading the salivary glands. Persistent viruses can be further divided into circulative, non – propagative and circulative propagative.

Non persistent viruses like *Potyviruses, Cucumoviruses, Carlaviruses* needs Helper Component (virus protein) for binding to cuticle or for attaching to inner cuticle of stylet, and forms “Molecular Bridge”. It allows temporary retention. Other non persistent viruses like *Cucumo viruses* (CuMV), bind directly to the culticular lining of the insect mouthparts through Capsid Component of virus (Syller *et al*., 2005).

Circulative viruses must escape the insect gut and spread to neighboring organs to reach the salivary glands for transmission. They enter the epithelial cells & pass by specific receptor mediated endocytosis and exocytosis (Gray *et al*., 2003).

Virus interactions with these vectors are diverse, but there are some commonalities. Generally the infection cycle begins with the vector encountering the virus in the plant and the virus is acquired by the vector. The virus must then persist in or on the vector long enough for the virus to be transported to a new host and delivered into the plant cell (Yang *et al*., 2012).

The infection of (ToLCV), in tomato (*Lycopersicon esculentum* L.) and milk weed (*Euphorbia geniculata* L.) was influenced by biology of the whitefly vectors of the disease. More fecundity was observed both in indigenous and B-biotype whitefly population on infected tomato plants (Shilpa *et al*., 2013)

Tomato yellow leaf curl virus (TYLCV), a *Begomo virus* is vectored by the whitefly *Bemisia tabaci*. TYLCV transmission depends upon a 63-kDa GroEL protein produced by the vector’s endosymbiotic bacteria. *B. tabaci* is a species complex comprising several genetically distinct biotypes that show different secondary- symbiont fauna (Gottlieb *et al*., 2010).

Insect vectors act as “flying syringes”. Vector is the only means of virus spread in nature. The different coat proteins of circulative viruses responsible for binding & determines the specificity to virus transmission, different cellular protein in vectors serve as binding sites, GroEL homologues produced by endosymbionts is most characterized binding proteins.

Endocytosis and exocytosis are major paths in insect vector for virus to move to salivary gland. Virus infection to vector causes several behavioural & physiological changes. GroEL proteins produced by endosymbionts are showing interactions with virus coat proteins, in that way it is the reason for higher virus transmission (Gray *et al*., 2003).

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64. PLANT PATHOLOGY 15517

Induced Structural and Biochemical Defence Mechanisms of Plants against Pathogens

K. Kamesh Krishnamoorthy[1]* and K. Karthik Subramaniam[2]

[1]Ph.D. Scholar, Tamil Nadu Agricultural University, Coimbatore-641003
[2]PG Scholar, Sri Sathya Sai Institute of Higher Learning, Anantapur, A.P

Induced Structural and Biochemical Defence Mechanisms of Plants against Pathogens

Medieval castle housing kings had soldiers to protect them against enemy attack. Similar to these medieval castle, plants also have developed certain defence mechanisms against plant pathogens. These include some pre-existing defence mechanisms. However some times during a very high intensity pathogen attack the pre-existing defence mechanisms are not enough to protect the plant against infection. At this particular point induced structural and biochemical defence mechanisms come into picture.

Induced Structural Defence Mechanisms

The host defence system in plants creates blockages or barriers which prevent the further spread of the pathogen. They are the following

1. **Lignifications**: in this the plant cell wall undergoes lignification following a pathogen attack. This lignification provides a barrier to the pathogen hyphal penetration and also act as an impermeable barrier to the free movement of nutrients resulting in starvation of pathogen.
2. **Suberization**: the infected cells get surrounded by suberized cells which isolates them from healthy tissues and protects the healthy tissues from infection. The best example of suberization is formation of cork layer. This is a natural healing mechanism of plants.
3. **Abscission layers**: this is defined as a gap developed between cell layers for dropping off older plant parts. Shot holes in leaves of fruit trees are a common example of this.
4. **Tyloses:** these are the protrusion of xylem parenchymatous cell walls into the xylem vessels. These structures physically block the xylem vessels restricting movement of material thus preventing the movement of the pathogen.
5. **Gum deposition**: different kinds of gums are produced by many plants around lesions caused by pathogen infection. These are deposited quickly in the intercellular spaces and within the cells surrounding the locus of infection resulting in the formation of an impermeable barrier for the movement of pathogen.

Induced Biochemical Defence Mechanisms

These are mainly connected with chemical reactions within a plant system following attack by a pathogen.

1. **Phenolic compounds:** compounds formed in response to an infection or an injury. The two pathways involved in the synthesis of phenolic compounds are shikkimic acid and acetic acid pathway.
   Examples of phenolic compounds produced by plants are caffeic acid (sweet potato), chlorogenic acid (carrot) and phloretin (apple).
2. **Phytoalexins**: these are defined as low molecular weight antimicrobial substances produced by plants in response to a pathogen infection. Their production in plants is mostly associated with hypersensitive response.

Examples of phytoalexins are rishitin in potato, gossypol in cotton and capsidiol in pepper.

Hypersensitivity as a Defence Mechanism

Hypersensitive response or hypersensitivity is defined as a process where there is a necrotic death of a plant tissue following infection by a pathogen at a locus in a plant part. The point of pathogen attack is thus completely necrotized and synthesis of antimicrobial substances starts taking place.

Inactivation of Chemical Weapons of Plant Pathogen

Enzymes and toxins produced by the plant pathogen to degrade the plant layers are inactivated by various mechanisms developed in plants.

In immature grapes presence of tannins inhibits the pathogen Botrytis cinerea. In tomato and cotton, resistant plants have developed a mechanism to metabolize the toxin fusaric acid into non toxic forms.

Conclusion: The induced structural and biochemical defence mechanisms in plants serve as an effective barrier against plant pathogens. These have the capacity to carefully destroy the pathogen infection loci in the plant.

65. PLANT PATHOLOGY 15772

Integrated Management of Wheat Rust

Jhumishree Meher and Raina Bajpai

Department of Mycology and Plant Pathology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh

INTRODUCTION: Integrated disease management is the practice of using a range of measures to prevent and manage diseases in crops. Hazard analysis is used to identify the potential for infection so that preventive or curative measures can be put in place to minimize the risk of disease infection and spread. It is a broad-based approach that integrates practices for economic control of diseases. But in addition to these traditional measures, monitoring environmental factors (temperature, moisture, soil pH, nutrients, etc.), disease forecasting, and establishing economic thresholds are important to the management scheme. Rust is one of the most devastating disease of wheat causing heavy loss in yield. For effective integrated management of wheat rust diseases close monitoring, international collaboration and strengthening of national capacities are crucial. Preventive approaches are the most effective and environmentally friendly means of wheat rust management of which, use of resistant cultivars being the most effective tool. Thus, emphasis must be given to breeding resistant varieties and seed multiplication with the aim of making these seeds available to farmers as quickly as possible.

Stem Rust (Black Rust): Stem rust is caused by the fungus *Puccinia graminis* f. sp. *tritici*. In addition to wheat it can also attack barley, rye and triticale. Stem rust produces reddish-brown spore masses in oval, elongated or spindle-shaped pustules on the stems and leaves. Unlike leaf rust, pustules erupt through both sides of the leaves. Ruptured pustules release masses of stem rust spores, which are disseminated by wind and other carriers (Fig-1).

Leaf Rust (Brown Rust): Leaf rust is caused by the fungus *Puccinia triticinia* (previously called *Puccinia recondite* f. sp. *tritici*). The disease can also infect rye and triticale. Leaf rust produces reddish-orange coloured spores which occur in small, 1.5 mm, circular to oval-shaped pustules. These are found on the top surface of the leaves, distinguishing leaf rust from stem rust which is found on both surfaces of the leaf (Fig-2).

Stripe Rust (Yellow Rust): Stripe rust is caused by the fungus *Puccinia striiformis*. It is easily distinguished from other wheat rusts by the orange-yellow spores, which produce small, closely packed pustules developing into stripes along the length of the leaf veins. The spores occur on the upper surface of the leaves, the leaf sheaths, awns and inside of the glumes (Fig-3).

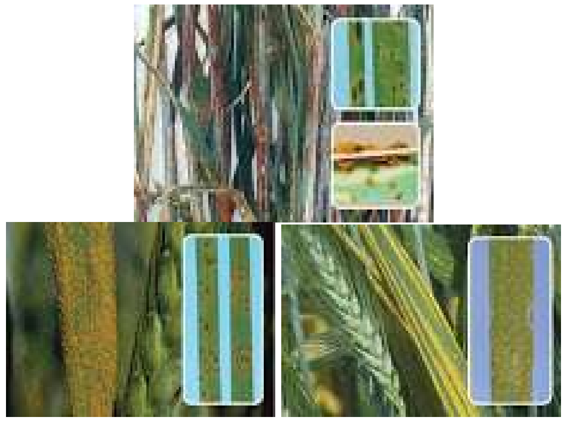

Fig 1: Stem rust **Fig 2:** Leaf rust **Fig 3:** Stripe rust

Management

1. Cultural Methods

a) ***Proper selection of geographical area***: Many fungal and bacterial diseases are more severe in wet areas than in dry areas.

b) ***Proper selection of the field***: Proper selection of field will help in the management of many diseases, especially the soil borne diseases. Raising of a particular crop year after year in the same field makes the soil sick, where disease incidence and severity may be more.

c) ***Crop rotation***: Crop rotation with leguminous and oil seed crops is helpful in controlling disease.

d) ***Disease escaping varieties***: Certain varieties of crops escape the disease damage because of their growth characteristics. Ex: Early maturing varieties of wheat escape the damage due to rust.

e) ***Seed inspection and certification***: Crops grown for seed purpose are inspected periodically for the presence of diseases that are disseminated by seed.

f) ***Eradication of alternate and collateral hosts***: Eradication of alternate hosts will help in management of many plant diseases. Ex: Barberry eradication program in France and USA reduced the severity of black stem rust of wheat.

g) ***Manures and fertilizers***: Excessive nitrogen application aggravates disease like wheat rust and yellow spot, whereas, phosphorous and potash application increases the resistance of the host. Addition of farm yard manure or organic manures such as green manure, 60-100 t/ha, helps to manage the diseases.

h) ***Seed treatment:*** Some seed treatments effective against stripe rust (*e.g.* products containing Triadimenol and Flutriafol) may reduce coleoptile length, and this should be considered at sowing time. ***i) Changing time of sowing***: Pathogens are able to infect susceptible plants under certain environmental conditions only. Ex: Infection of black stem rust of wheat (*Puccinia graminis tritici*) is more in late sowing; hence, early sowing helps in reduction of stem rust incidence.

i) ***Seed rate and plant density***: Close spacing raises atmospheric humidity and favours sporulation by many pathogenic fungi. Farmers consider these factors in spacing, row orientation, and fertilizer schedules. Recent changes in production practices may have effects on stem rust.

2. Physical Methods

a) **Soil solarization**: Soil solarization or slow soil pasteurization is the hydro/thermal soil heating accomplished by covering moist soil with polyethylene sheets as soil mulch during summer months for 4-6 weeks.

b) **Soil sterilization:** Soil can be sterilized in green houses and sometimes in seed beds by aerated steam or hot water.

c) **Hot water or Hot air treatment**: Hot water treatment or hot air treatment will prevent the seed borne loose smut of wheat (52^{0}C for 10 min).

3. Host Plant Resistance

In general, there are two types of resistance to stripe rust. They are, major gene resistance and adult plant resistance. These resistance sources may be used either alone or in combination.

Major gene resistance is a race specific resistance that is very effective against some strains of rust, but ineffective against others. Typically when these major genes are first deployed they are completely effective, but through mutation of the rust these resistances are often short lived in wheat as they are overcome or "broken down" by the pathogen. An example of this is the acquisition of virulence toward the Yr17 gene deployed in many varieties.

Adult plant resistance (APR) is a resistance that is widely used. APR genes are often partial resistance genes that work by slowing down the rate of epidemic development. They do not stop the disease progress completely.

There are a number of APR genes used in commercial wheats. The relative effectiveness of APR genes can be influenced by factors such as:

- Temperature (they often working better at higher temperatures).
- Crop nitrogen status (there may be a delayed onset in high nitrogen status crops).
- The wheat variety that they are deployed in.
- The number of APR genes present (their effects are often additive).

Resistant varieties: Sonalika, NP 700 & 800, Lerma Rojo and Safed Lerma, RH-124.

4. Chemical Methods

- Fungicides that inhibit the synthesis of sterols [sterol biosynthesis inhibitors (SBIs) or demethylation inhibitors (DMIs)] are particularly effective, but the cost of application is generally prohibitive for routine use in most wheat-growing areas.
- spray dithiocarbamates like zineb@0.25% or Mancozeb@0.25%
- Seed dressing with Plantavax@0.1% followed by two sprays with the same chemical.

66. PLANT PATHOLOGY 15779

Mechanisms of Variability in Different Groups of Plant Pathogens

Jabbar Sab*, Jayappa and Gurudevi V. Navali

Ph.D. Scholar, Department of Plant Pathology, UAS, GKVK, Bangalore-560065
**Corresponding Author E. Mail: jabbar4410@gmail.com*

Pathogen Variability

Pathogens have developed varied range of mechanism of variability. The following mechanisms discussed. New variability in pathogens may be created in the following ways: 1) Mutation 2) Sexual reproduction, 3) Heterokaryosis, 4) Para sexual reproduction, 5) Vegetative Incompatibility 6) Heteroploidy.

General Mechanisms of Variability

Two mechanisms of variability, namely mutation and recombination, occur in both plants and pathogens.

Mutation: A mutation is a more or less abrupt change in the genetic material of an organism, which is then transmitted in a hereditary fashion to the progeny. Mutations represent changes in the sequence of bases in the DNA either through substitution of one base for another or through addition or deletion of one or many base pairs. Additional changes may be brought about by amplification of particular segments of DNA to multiple copies; by insertion or excision of a transposable element, *i.e.*, a movable DNA segment, into a coding or regulatory sequence of a gene; and by inversion of a DNA segment (Bertram, 2000). On average, one mutation occurs for every million copies of a gene per generation. Since the average fungus genome consists of about 10,000 genes, one cell in a hundred could be a mutant or, stated differently, there are many mutants in every colony of a fungus or a bacterium, etc.

Sexual Reproduction: Recombination occurs primarily during the sexual reproduction of plants, fungi, and nematodes whenever two haploid (n) nuclei, containing genetic material that may differ in many loci, unite to form a diploid (2n) nucleus, called a zygote. The zygote, sooner or later, divides meiotically and produces new haploid cells (gametes, spores, mycelium). Recombination of genetic factors (different genes or alleles of the same genes) occurs during the meiotic division of the zygote as a result of genetic crossovers in which parts of chromatids (and the genes they carry) of one chromosome of a pair are exchanged with parts of chromatids of the other chromosome of the pair. Recombination of the genes of two parental nuclei takes place in the zygote, and the eventual haploid nuclei or gametes resulting after meiosis are different both from the gametes that produced the zygote and from one another. Recombination can also occur during mitotic cell division in the course of growth of an individual and it is thought to account for a significant amount of genetic exchange in fungi. In the fungi, haploid nuclei or gametes often divide mitotically to produce haploid mycelium and spores, which results in genetically different groups of relatively homogeneous individuals that may produce large populations asexually until the next sexual cycle.

Specialized Mechanisms of Variability in Pathogens: Certain mechanisms for generating variability appear to operate only in certain kinds of organisms or to operate in a rather different manner than those described as general mechanisms of variability. These specialized mechanisms of variability include heterokaryosis, heteroploidy, and parasexualism in fungi; conjugation, transformation, and transduction in bacteria; and genetic recombination in viruses.

Sexual-like Processes in Fungi

Heterokaryosis: In some fungi, hyphae or parts of hyphae contain nuclei, which are genetically different, generally of two different kinds. This condition is known as heterokaryosis. The phenomenon is commonly brought about by hyphal anastomosis between mycelia of two parental genotypes. In Ascomycotina and Basidiomycotina some fungi possess cells containing numerous nuclei and these may be heterokaryotic. The underlying implication of this state is that the fungus may respond to selection by varying the proportion of the dissimilar nuclei in the cells. There can be no doubt that heterokaryosis is involved in the production of fungal variation in *Cochliobolus sativus*, *Leptosphaeria avenaria* and *Helminthosporium gramineum*.

Parasexualism: Parasexualism is the process by which genetic recombinations can occur within fungal heterokaryons. This comes about by the occasional fusion of the two nuclei and formation of a diploid nucleus. During multiplication, crossing-over occurs in a few mitotic divisions and results in the appearance of genetic recombinants as the diploid nucleus progressively and rapidly loses individual chromosomes to revert to its haploid state (Pontecorvo, 1956). Considering that fungi exist and grow primarily as adjacent hyphae that may form heterokaryons as a result of anastomoses or fertilization, the frequency of parasexualism and therefore of genetic variability through parasexualism may equal or surpass that brought about by sexual reproduction.

Vegetative Incompatibility: In many fungi, vegetative hyphae of the same colony, or of two colonies of the same species, coming in contact with each other, often fuse, and the fusion is called **hyphal anastomosis**. If, however, hyphae coming in contact belong not to different strains of the fungus but of the same species, no fusion of hyphae takes place and the phenomenon is called vegetative incompatibility (or somatic or heterokaryon incompatibility). In only a few filamentous fungi, such as the species *Thanatephorus cucumeris*, the telomorph of *Rhizoctonia solani*, does fusion incompatibility occur between distantly related strains that appear to be different species, but when it does occur, it prevents both vegetative fusion and sexual fusion and, thereby, does not allow the exchange of genetic material. It has been suggested, therefore, that perhaps the different fusion incompatibility groups constitute different biological species still unrecognized within the broad species of *T. cucumeris.* When hyphae from two colonies that belong to different postfusion incompatibility groups meet, the hyphae fuse, but subsequently the protoplasm in the two fused hyphal compartments and some adjacent ones is destroyed and a demarcation zone of sparse and sometimes dark mycelium is produced. Such postfusion incompatibility is the result of interaction between two alleles of the same vegetative compatibility locusand is called allelic incompatibility. Vegetative incompatibility appears to be a defense mechanism that protects individuals from harmful nuclei, mitochondria, plasmids, and viruses that could reach them from other cells through anastomosis.

Heteroploidy: Heteroploidy is the existence of cells, tissues, or whole organisms with numbers of chromosomes per nucleus that are different from the normal 1n or 2n complement for the particular organism. Heteroploids may be haploids, diploids, triploids, or tetraploids or they may be aneuploids, *i.e.*, have one, two, three, or more extra chromosomes or are missing one or more chromosomes from the normal euploid number (*e.g.*, n+1). In several studies, spores of the same fungus were found to contain nuclei with chromosome numbers ranging from 2 to 12 per nucleus and also diploids and polyploids. Heteroploidy has been observed repeatedly in fungi and has been shown to affect the growth rate, spore size and rate of spore production, hyphal color, enzyme activities, and pathogenicity. It has been shown, for example, that some heteroploids, such as diploids of the normally haploid fungus *Verticillium alboatrum*, the cause of wilt in cotton, lose the ability to infect cotton plants even when derived from highly virulent haploids. How much of the variability in pathogenicity in nature is due to heteroploidy is still unknown.

Sexual-like Processes in Bacteria and Horizontal Gene Transfer

New biotypes of bacteria seem to arise with varying frequency by means of at least three sexual-like processes. It is probable that similar processes occur in mollicutes.

1. **Conjugation** occurs when two compatible bacteria come in contact with one another and a small portion of the chromosome or plasmid from one bacterium is transferred to the other through a conjugation bridge or pilus.
2. In **transformation**, bacterial cells are transformed genetically by absorbing and incorporating in their own cells genetic material secreted by, or released during rupture of, other bacteria.
3. In **transduction**, a bacterial virus (phage) transfers genetic material from the bacterium in which the phage was produced to the bacterium it infects next.

Fig: 1 Mechanisms of variability in bacteria

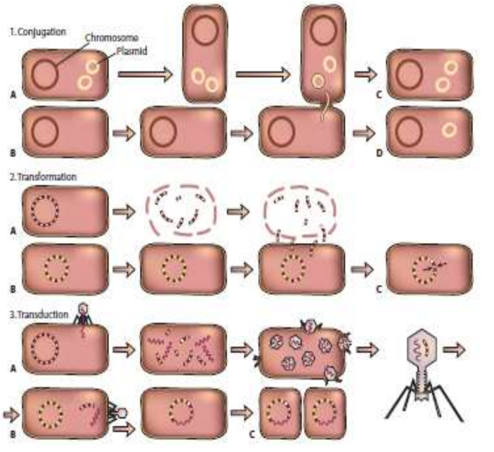

FIG. 1: Mechanism of variability in bacteria through sexual-like processes.

The transfer of genetic information in this manner is not always limited to members of the same species or even genus (**vertical inheritance**). For example, gram-negative bacteria can transmit genetic material readily across species; *Agrobacterium* transmits genes across kingdom barriers to plants. Such events are called **horizontal gene transfers.**

Genetic Recombination in Viruses

Recombination, may results from mixed infection of two strains of the virus, occurs mostly during replication, mutation and results from nucleotide changes in the coding regions due to addition or deletion or replacement, ultimately leads to functional changes in the genes.

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67. PLANT PATHOLOGY 15815

Camp-PKA Pathway in Fungal Pathogenesis

Suneeta Pedada

M.Sc. (Ag.), Department of Plant Pathology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore-641003

**Corresponding Author E. Mail: suneeag16@gmail.com*

The cyclic adenosine monophosphate dependent protein kinase A (cAMP-PKA) signaling pathway is a G-protein-coupled receptor (GPCR)-triggered signaling cascade used in cell communication. Adenosine 3', 5'-cyclic monophosphate (cAMP) is a nucleotide that acts as a key second messenger in numerous signal transduction pathways. cAMP regulates various cellular functions, including cell growth and differentiation, gene transcription and protein expression (Yan *et al.*, 2016). It plays an important role in diverse physiological processes of multiple pathogens.

When a GPCR is activated by its extracellular ligand, a conformational change is induced in the receptor that is transmitted to an attached intracellular heterotrimeric G protein complex. The Gs alpha subunit of the stimulated G protein complex exchanges GDP for GTP and is released from the complex. In a cAMP-dependent pathway, the activated Gs alpha subunit binds to and activates an enzyme called adenylyl cyclase, which, in turn, catalyzes the conversion of ATP into cAMP. Increased concentration of cAMP leads to the activation of PKA which in turn phosphorylates a number of proteins at serine or threonine residues and involves further in protein synthesis also. Downregulation of protein kinase A occurs by a feedback mechanism and uses a number of cAMP hydrolyzing phosphodiesterase (PDE) enzymes, which belong to the substrates activated by PKA. Phosphodiesterase quickly converts cAMP to AMP, thus reducing the amount of cAMP that can activate protein kinase A (Byrne *et al.*, 2016).

In barley powdery mildew fungus *Blumeria graminis*, both MAPK and the cAMP signaling are involved in regulating appressorium development (Kinane and Oliver, 2003). In *Ustilago maydis*, the cAMP signaling pathway plays a critical role in regulating hyphal growth and pathogenic development. Strains blocked in the cAMP signaling pathway, such as the gpa3 (Ga subunit), uac1 (adenylate cyclase), and adr (catalytic subunit of PKA) deletion mutants, are nonpathogenic and grow filamentously (Basse and Steinberg, 2004). Likewise, in *Magnaporthe grisea* causing rice blast, surface recognition and the initiation of appressorium formation are mediated by the cAMP signaling, late stages of appressorium formation and penetration are regulated by the *PMK1* pathway. The *pmk1* deletion mutant fails to form appressoria but still recognizes hydrophobic surfaces and responds to cAMP (Xu, 2000).

In root and vascular pathogens, like *F. oxysporum* the *fgb1* (Gß) deletion mutant was with reduced virulence, but it had an unaltered Fmk1 phosphorylation level and is defective in hyphal growth. Exogenous cAMP reverses part but not all of the *fgb1* growth phenotypes. Therefore, Fgb1 may act upstream from the cAMP signaling but not the Fmk1 pathway. Fmk1 and Fgb1 appear to be components of distinct signaling pathways with overlapping functions (Delgado-Jarana, 2005). MAPKs are also known to interact with the cAMP signaling in pathogenesis, differentiation, and stress response in *U. maydis*, *C. neoformans*, and other fungi (Lee *et al.*, 2003).

Further characterization of these signal transduction pathways and their interaction in various fungal pathogens is necessary for a better understanding of fungal development and pathogenesis. The efficiency of the research methods commonly used for elucidating the cAMP signaling pathway must be improved. The high-throughput and high-content screening technologies developed in recent years may be applied to increase the speed of screening for inhibitors and agonists of the cAMP signaling pathway, and may also improve the efficiency of novel drug research and development (Yan *et al.*, 2016).

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68. PLANT PATHOLOGY 15816

Impact of Climate Change on Plant Diseases

Shweta Meshram

Ph.D. Research Scholar, Indian Agricultural Research Institute, New Delhi

Background: Global climate changed ever since due to industrial revolution, increase in major greenhouse gases like CO_2, methane, nitrous oxide and tropospheric ozone. Latest increase in temperature by 2100year is approx. 0.9 to 3.5°C according to Intergovernmental Panel on Climate Change (IPCC). Annual mean temperature increase is 1.2^0C since 20th century and in January-February 2017 winters recorded highest temperature 2.95^0Cfrom baseline. Present CO_2 level recorded by NASA is 400 ppm.

Climate change: It refers to any change in weather condition over a large area for prolong time whether due to natural variability or human activity. It has impacted Plant diseases in following aspects:

1. **Geographical distribution of Host and pathogen:** Warming has caused pole ward shift of Agriculture practices hence pathogen too, such as Barley yellow dwarf virus is more severe in mild winters.
2. **Physiology of host pathogen interaction due to elevated CO_2:**
   a) **Effects on plants:** Increase in photosynthesis, Change in plant canopy, if more canopy then more humidity and more foliar pathogen attacks.
   b) **Effects on pathogen:** Delayed in initial inoculum establishment in case of *Colletotrichum gleosporoides* or in some cases high multiplication rate in powdery mildew of barley *Erysiphe graminis*.
3. Physiology of host pathogen interaction due to elevated Temperature:
   a) **Effects on plants:** Positive and Negative effect on Yield such as wheat yield Increases and rice yield decreases 1-10%.
   b) **Effects on plants:** Increased number of generations per season in *Phytopththora* spp. pathogen also increased survival of overwintering pathogen.
   c) **Effects on host resistance:** Temperature more than 20 inactivate pg3 and pg4 genes in wheat against wheat rust whereas Xa7 more effective at high temperature.

General impact on plant diseases: Altering disease triangle (host, pathogen and environment) component. Other changes depends on type of vegetation, precipitation and moisture stress and type of pathogen such as following-

1. **Impact on fungal diseases:** Evolution of new races, pathogen survival and UV-B can modify pathogen sensitivity *E.g.*: *Septoria tritici.*
2. **Impact on Bacterial diseases:** *Agrobacterium* population increases at high temperature during winters. *Erwinia amylovora* on apple survival on debris increases.
3. **Impact on viral diseases:** Infected oats with barley yellow dwarf virus showed increased biomass in elevated carbon. Tobacco viral diseases reduced severity under increased temperature due to altered physiology of plant. In winter's recently high aphid movements has been reported which is main vector of Potyviruses.

New Epidemiological Approach for Combating Climate Change Problems in Plant Disease Management

Epidemiology model: Epidemiological modelling can be a powerful tool for plant disease assessment policy development and disease prevention and management. It can be categorized in following type:

1. **Virtual plant model:** Plant canopy taken as 3D structure to study diseases and virtual plant model simulates plant canopy architecture to study disease under climatic change.
2. **Ecological niche modelling:** It is a correlative model that predict species potential geographical range based on two types of one is biological data nad other one meteorological data. *E.g.*: Simulation of wheat blotch distribution in Asia.
3. **Geographical information system (GIS):** It is continuously used to evaluate and to model spatial distribution of plant diseases. *E.g.*: Using GIS *Phytophthora* blight of pigeon pea was monitored in Deccan plateau of India.
4. **Simulation Modelling:** It is an effective approach for reducing the impact of global and climate change on crop diseases. Various simulation model and crop growth model are used for climate change. *E.g.*: BLASTSIM FOR rice leaf blast and BLITCAST for late blight o potato.

Sustainable management of climate change: It requires development and adaptation of improved industrial and agriculture practices that reduces the emission of greenhouse gases. Strict legislative strategies coordinated with social and economic efforts for devotement of integrated practices.

69. PLANT PATHOLOGY 15826

Rice False Smut Disease an Emerging Problem in Rice Cultivation

R. K. Singh, Sumit Kumar Pandey and P. Masurkar

Department of Mycology and Plant Pathology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) India

**Corresponding Author E. Mail: skpandey.mpp@gmail.com*

INTRODUCTION: Rice (*Oryzae sativa*) belongs to the grass family *Oryzeae*, and is one of the leading food crops in the world. Rice is the second most cultivated cereal after wheat and the most important staple food in Asia. It is reported to feed approximately one half of the world's population. It is known as a semi-aquatic, annual grass plant and is found growing in a wide range of soil types and water regimes: irrigated, rainfed lowland, upland, and flood prone areas depending on where it is produced. India is one of the largest rice growing country and grown in almost all the states of India contributing about 42 per cent to the country's food grain production and provides livelihood to about 70 per cent of the population. The rice crop is subjected to more than forty diseases, which are one of the factors, for low yields of rice in the world including India.

False smut of rice (*Ustilaginoidea virens*) is one of the major emerging and destructive disease in rice production. In recent years it has been emerged as the most devastating grain disease in majority of the rice growing areas of India due to cultivation of high fertilizer responsive cultivars and hybrids, heavy application of nitrogenous fertilizer and apparent change in climate. In severe cases the number of infected grains reached even more than 100 per panicle. False smut disease of rice is also known as 'Lakshmi disease' because occurrence of this disease was recognized as a symbol of bumper harvest. False smut of rice, caused by *Ustilaginoidea virens* (Cooke) Takah., is a common disease in rice panicles. Disease was first reported in India (1878) and was considered as a secondary disease due to their sporadic occurrence (Ladhalakshmi *et al.* 2012). The disease causes both quantitative and qualitative losses. The losses in grain yield occur due to chaffiness, reduction in test weight and sterility of the spikelets neighboring smut balls. The yield losses have been estimated to vary between 0.2 - 49%. The chlamydospores also contaminate the rice grains and straws with their antimitotic cyclic peptides. Rice false smut disease not only results in rice yield loss, but also contaminates rice grains and feed, and even more importantly, generates mycotoxins as Ustiloxin that are poisonous to humans and animals and creates concerns for food and feed safety. Ustiloxins are unique tetrapeptides and Ustiloxins A–F was isolated from the water extracts of false smut balls. The toxins cause mycotoxicosis and inhibit the polymerization of brain tubulin at micromolar concentrations.

The disease is caused by a fungus *Ustilaginoidea virens* is a flower-infecting fungus that forms false smut balls in rice panicle and has long been considered a minor disease, but recently it occurred frequently and emerged as a major disease in rice production. The symptoms are visible only after flowering when the fungus transforms the individual grains of the panicle into globose structures or yellowed carbonaceous masses. False smut galls have been emerging about 20 days after the initial infection of kernels of the rice panicle during flowering of the rice plant. The false smut pathogen can infect rice florets at flowering stage where it destroys the ovary and leaves the style, stigma and anther buried intact in the spore mass. The fungus transforms grains into the ball-like colonies which we called false smut balls (FSBs). The color of rice FSBs gradually changes which at first are covered by a silvery-white membrane that ruptures exposing yellow-orange chlamydospores subsequently turning green, olive-green, and then greenish black at maturity. *U. virens* produces conidia, secondary conidia, chlamydospores, sclerotia and ascospores, all of which are capable for causing infection. *U. virens* overwinters by producing fungal structures called sclerotia, which contain chlamydospores (resting spores) and compact masses of mycelia. These structures enable the fungus to survive for at least 4 months under field conditions.

During its life cycle, *U. virens* produces a reproductive stage, which consists of the sexual ascospores, and an asexual stage known as a chlamydospore. Both stages play a very important role in the initial steps of the *U. virens* infection process. *U. virens* produces both sexual (sclerotia) and asexual (chlamydospores) stages in it s life cycle. Sclerotia are the major source of primary inoculum. In nature, over wintered sclerotia germinate and produce ascospores and coincides with the anthesis of rice crop. Such ascospores lodge on the floral parts and initiate infection. Air-borne chlamydospores play an important role in the secondary infection which is a major part of disease cycle which become drastic with high relative humidity, low temperature and rainfall accompanied by cloudy days during flowering.

The disease affects the grains and the symptoms produced are visible only after flowering hence farmers remain unnoticed about this disease in the field before flowering and could not apply or manage the crop by adopting preventive measure. When they noticed in the field it becomes late to control the disease by using chemicals therefore there is an urgent need to develop suitable/appropriate disease management strategies before the disease visible in the field and cause havoc. In view of this, the rice false smut disease is emerging as one of the potential threats to rice cultivation.

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70. PLANT PATHOLOGY 15833

Citrus Greening and their Management

Bhupendra Thakre

Subject Matter Specialist (Plant Pathology), JNKVV, Zonal Agriculture Research Station, Chhindwara
**Corresponding Author E. Mail: bhupendra_thakrejnkvv@ rediffmail.com*

INTRODUCTION: Citrus Greening, also known as Huanglongbing (HLB), is considered to be the most destructive disease of citrus. Once a tree is infected, there is no effective control or cure for the disease. This disease poses no threat to humans or animals, but can destroy all types of citrus trees, including orange, grapefruit, lemon, lime, kumquat, tangerine, and relatives like orange jasmine. This disease is a serious threat to our South Texas citrus industry. Infected trees may produce misshapen, unmarketable, bitter fruit. Citrus greening reduces the quantity and quality of citrus fruits, eventually rendering infected trees useless. An infected tree produces fruit that is unsuitable for sale as fresh fruit or for juice. The Asian citrus psyllid, which spreads citrus greening, is no bigger than the head of a pin. The infected insect spreads the disease as it feeds on the leaves and stems of citrus trees. Once the Asian citrus psyllid picks up the disease, it carries it for the rest of its life. Citrus greening is then spread by moving infected plants and plant materials such as bud wood and even leaves.

History: Citrus greening disease is a disease of citrus caused by a vector-transmitted pathogen. The causative agents are motile bacteria, *Candidatus* Liberibacter spp. The disease is vectored and transmitted by the Asian citrus psyllid, *Diaphorina citri*, and the African citrus psyllid, *Trioza erytreae*, also known as the two-spotted citrus psyllid. It has also been shown to be graft-transmissible. Three different types of HLB are currently known: The heat-tolerant Asian form, and the heat-sensitive African and American forms. The disease was first described in 1929 and first reported in China in 1943.

The first symptom of huanglongbing is usually the appearance of a yellow shoot on a tree, hence the name huanglongbing which literally means yellow dragon disease. Progressive yellowing of the entire canopy follows: leaves turn pale-yellow, show symptoms of zinc or manganese deficiency, or display blotchy mottling, and are reduced in size. Blotchy mottle is the most characteristic symptom, but is not specific to huanglongbing. Stubborn disease [*Spiroplasma citri*], severe forms of *Citrus tristeza virus* (CTV), species of *Phytophthora*, waterlogging and the use of marcots can produce similar blotchy mottle patterns. Symptoms of zinc deficiency are also associated with the early stages of citrus blight (a disease of unconfirmed aetiology). Huanglongbing bacteria, however, do not induce the xylem dysfunction and wilting observed in blighted trees. Dual infection of trees with HLB and CTV is common with reports suggesting that these trees have more severe symptoms Chronically infected trees are sparsely foliated and show extensive twig dieback. The fruits are often small, lopsided and poorly coloured (hence the origin of the name greening). They often contain aborted seeds. Similar fruit symptoms are also observed with CTV infection.

Transmission and Spread: The Asian Citrus Psyllid transmits the greening bacterium. The psyllid was first found in June 1998. Psyllid eggs are 0.3 mm long, elongated and almond-shaped. The newly laid eggs are pale in color, then become yellow and turn to an orange color as the time approaches for hatching Nymphs are 0.25 to 1.7 mm and yellowish orange. Larger nymphs can be seen with the naked eye usually found on the young flush. The nymphs are sessile and move slowly if disrupted. They secrete sticky waxy secretions similar to honeydew produced by aphids which causes sooty mold. The adults are 3 to 4 mm long. They have a brown mottled body and feed at a 30 degree angle. They can usually be found on the underside of leaves and move quickly.

Pathogen: *Liberibacter candidatus* spp. are phloem-limited plant pathogenic bacteria. The phloem system of the plant transports sugars, which are the food source of the plant, bidirectionally through the plant. The phloem system of the plants transports the products of photosynthesis (sugars) from sources of photosynthetic activity (leaves) in the plant to sinks (flowers, fruits, roots, seeds).

Psyllids are the main means of transmission to plants. An infected psyllid feeds on a healthy tree and injects the bacterium into the phloem. Once a tree is infected with the bacterium, there is no known cure for the disease. This in part is because the bacterium is inside the vascular system of the plant (systemic) and is therefore very difficult to access.

Prevention and Control: Biological control of the two psyllid vectors was achieved successfully in Reunion with hymenopteran psyllid parasites: *Tamarixia radiata*introduced from India against *Diaphorina citri*, Control of the psyllids, together with destruction of *Liberibacter*-infected trees and use of *Liberibacter*-free material for replantings have led to the almost total elimination of huanglongbing in Reunion. Unfortunately, biological control of the psyllids cannot be achieved in most countries because the psyllid parasites are themselves hosts for parasitic insects. Care was taken not to introduce these hyperparasites into Reunion when biological control was initiated.

Chemical Control For control of the liberibacters, injection of antibiotics and especially tetracycline into the trunk of affected sweet orange trees in South Africa has resulted in at least partial recovery of the trees. However, tetracycline is bacteriostatic not bacteriocidal and has to be injected repeatedly. It is also phytotoxic. Its use on a large scale might have adverse effects on the environment. For these reasons, its use has decreased in recent years. In Indonesia, a nation-wide,

Cultural Method In areas where the disease is not present, the most effective means to control the disease is to prevent its introduction or that of the vectors through strict quarantine measures. Inclusion of the alternative hosts in this strategy is also important

71. PLANT PATHOLOGY 15838

Aflatoxin Contamination of Indian Senna (*Cassia angustifolia* Vahl.): An Emerging Threat to Indian Export

N. Shiva and M. Karthick

Ph.D. Scholar, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore-641003

INTRODUCTION: Senna is a member of family, Fabaceae and native to Yemen and parts of Pakisthan. Gujarat and Saudi Arabia. It grows wild near the Nile river, Arabian peninsula, India and Somalia. *Cassia angustifolia* reportedly introduced first in Tirunelveli district in Tamil Nadu during the mid-eighteenth century from European countries and hence referred as Tinnevelly Senna. In India the species is cultivated both as irrigated and rain fed crop in Tamil Nadu, Rajasthan and Gujarat. Senna leaves and pods are used for medicinal purposes. Dried young leaves, flowers and 3-5 days old pods are used as source of raw drug. The leaves and pods of senna (*C. angustifolia*) contain sennosides A, B, C, D, which are well known for the preparation of laxatives and purgatives all over the world. In European Countries, it is used as herbal tea. In world market, there are two sources of senna raw drug, one is Tinnevelly Senna, which has gone from India and the other is Alexandrian senna (*Cassia acutifolia*) that has gone from Arabian Countries.

Importance: India is the largest producer and exporter of senna leaves, pods and total sennosides in the world market. India exports senna leaves and pods and there is a continuous rise in the export from 4 crore in the year 2005-06 to 47 crore in 2009-10 (DMAPR, 2015) with an annual earning of nearly Rs.45 million. Almost all the senna leaves produced in India are exported to foreign countries and the major portion is transported to London market. The crop is grown in about 25,000 ha, mainly in Southern districts of Tamil Nadu *viz.*, Tuticorin, Tirunelveli, Ramanathapuram, Virudhunagar and Madurai districts. Although all parts contain sennosides, the leaves and pods contain maximum content which ranges from 1-5.3 % in Indian senna.

Mycotoxin

Mycotoxins are toxic secondary metabolites produced by moulds such as Aspergillus, Penicillium, Fusarium and Alternaria (Zain, 2011). Mycotoxins can be defined as "fungal metabolites that when ingested, inhaled or absorbed through the skin cause illness or human and animal death". Mycotoxins are metabolic products of fungi capable of producing acute or chronic toxic effects (Eg: Carcinogenic, Mutagenic and Teratogenic) (FSSAI, 2012). The storage time of dried senna pods in India lies between a few weeks and several months. The warm, humid storage conditions

(30±5°C and 60 to 80% relative humidity) in south Indian warehouses in general favour mycotoxin (Aflatoxin) contamination produced by *Aspergillus flavus* Link. and *Aspergillus parasiticus* Van. in stored senna goods.

Medicical Consequences of Aflatoxins (AFs): Aflatoxins are amongst the most powerful mutagens and carcinogens known. The EU has one of the strictest regulations with the maximum tolerated limit of aflatoxin in consumable items of 2 μg/kg for aflatoxin B1 and 4 μg/kg for the sum of aflatoxins B1, B2, G1 and G2. The International Agency of Research on Cancer (IARC) has classified aflatoxins as Group 1 human carcinogen (IARC, 1993). Aflatoxins and hepatitis B virus (HBV) infection synergistically develop approximately thirty-fold higher hepatocellular carcinoma risk in aflatoxin-exposed HBV-positive individuals, as compared to HBV-negative persons. Other toxic effects of aflatoxins include genotoxicity, teratogenicity and immunosuppressive activity.

Aflatoxin (AF) Production in Senna Pods: The distribution of aflatoxin contamination in senna products varies at harvest, drying and storage period. Where the flowers and leaves were not contaminated, 23% of green pods and 70% of ripe pods dried on the plants proved to be contaminated with aflatoxin. The amount of insect damage had a great influence on the aflatoxin load as the insect damaged pods will lead to higher incidence of *A. flavus* and *A. parasiticus* concurrently the aflatoxin contamination is also high. In Tamil Nadu, Tobacco moth *Ephestia elutella* (Hubner) (Lepidoptera: Pyralidae) damaged senna pods showed the higher aflatoxin contamination than undamaged healthy pods (Muller and Basedow, 2004).

Most fresh samples of pods show low aflatoxin concentrations but a few may already highly contaminated before drying. More than 75% of fresh sample contains aflatoxin concentrations below the acceptable limit in the EU. Due to the receding active substances in the drying pods it influences the fungi to produce the secondary metabolities. The conventional solar drying of samples will endorse significant higher aflatoxin concentrations than before drying because the samples with low inoculum concentrations had much higher aflatoxin increases than samples which were already highly contaminated before drying. When pods were dried in the shade, the increase of aflatoxin content will be even higher due to the increase in warm and humid condition. The severity of aflatoxin contamination in the pods is influenced by the decrease in active substances of pods and drying temperature. Rain and temperature influence the phases differently with dry, hot conditions favoring the first and warm, wet conditions favoring the second.

Diagnosis of AF Production in Harvested Pods

The aflatoxin in the contaminated pods are not visually identified as the pathogen infection in pods alone can be identified visually or microscopically based on the presence of green coloured conidiophore bearing conidia on the philades. The analytical method to identify and quantify the AFs level in the contaminated pods includes Thin layer chromatography (TLC), High performance liquid chromatography (HPLC) and Enzyme linked immunosorbent assay (ELISA). TLC has been widely used.

Conclusion: Being a leading medicinal herb exported from India, Indian senna is used in pharmaceutical industry as a good source of laxative and as herbal drink in many countries. The high level aflatoxin contamination in the products of senna pods may lead to lethal effects for consumers. Since no chemical managements can be used, the antimicrobial principle of microbial or plant origin in controlling Aspergillus colonization and detoxifying the aflatoxin level in senna has to be well studied for the future lead in senna industries.

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72. PLANT PATHOLOGY 15859

Techniques for Mycotoxin Detection

Puttaraja G. Havanura and Basavaraj Teli

Department of Mycology and Plant Pathology, Institute of Agriculture Sciences, Banaras Hindu University, Varanasi, 221005

Mycotoxins are toxic secondary metabolites produced fungi and these toxic chemicals are capable of causing disease and death in animals and human being. The toxins are produced by *Aspergillus, Penicillium, paecilomyces and Fusarium* species of fungi that contaminates foodstuffs like cereals, corn, feed grains, fruits, milk, oilseeds, meat and meat products in pre and post-harvest condition.

About 25% of food in the world is contaminated with one or the other mycotoxin and circulating in food chain. Several instances of food contamination with mycotoxins; Aflotoxins, Ochratoxins, Fumonisins, Trichothecenes, vomintoxin, nivalenol and T-2 and HT-2 toxin produced by various fungal species and cause severe ill effects on animals and human these are potential carcinogenic, teratogenic, immunosuppressive, toxic effects on liver, kidney, skin irritation, neuro-toxic and severe defects in birth.

The effective management of mycotoxin contaminated food requires knowledge of detection of mycotoxin by various techniques. Mycotoxin can detected by several techniques like ELISA, HPLC (high performance liquid chromatography) along with detectors, biosensors and other immunoassay based technologies; lateral flow devices for quick and qualitative estimation of mycotoxin for field use. Different technologies are used based on the requirement of sensitivity, quick detection and ease of use in different conditions.

Methods for Mycotoxin Detection.

ELISA (Enzyme Linked Immunosorbent Assay): Most extensively used method for screening of food materials with high sensitivity of 0.1 ngg−1 detection. The technique based on antigen (mycotoxin) and mycotoxin-specific antibody interaction. There are 2 methods of ELISA are commonly used.

Direct Competitive Elisa: The extract from food sample is mixed with enzyme conjugate associated mycotoxin. It is added on microtiter plate already coated with toxin specific antibody and incubation to bind the toxin on antibody by competing with toxin associated enzyme-conjugate. Remove unbound material by washing and add substrate for quantification of toxin by measuring intensity of color produced with the help of spectrometer.

Indirect Elisa: The mycotoxin sample is coated on microtitre plate and addition of mycotoxin specific antibody, incubate then wash to remove unbound antibodies, addition of secondary antibody-enzyme conjugate, incubation and wash to remove unbound conjugate. Then addition of enzyme substrate for quantification of mycotoxin indirectly by measuring amount of color formed from colorless substrate attached to secondary antibody with the help of spectrophotometry.

Chromatographic Methods.

High Performance Liquid Chromatography (HPLC): Most widely used method in which the components of mycotoxins are separated based on polarity of toxin molecules in columns (normal and reversed-phase columns) containing different stationary phase according to the physical and chemical properties of toxin. End products are analyzed by UV or fluorescence detectors. Toxins have inherent fluorescence detected by HPLC-fluorescence detector or by mass spectrometry with UV detector in HPLC system.

Thin Layer Chromatography (TLC): The thin layer of organic acid is supported on the solid material like silica gel. The components separated by liquid phase are detected by fluorescence or UV spectrometer. One of most rapid and economic method of mycotoxin detection. Large number of samples can be screened with moderate accuracy quantitatively or semi-quantitatively.

Capillary Electrophoresis: Separation of toxin components by electrophoretic method in which separation is based on mass and charge. Highly sensitive for detection of toxin with the help of fluorescence material.

Gas Chromatography: The method requires mycotoxin compounds should be volatile or otherwise, it is derivatised by silylation or polyfluoro acylation reaction. The components are separated based on relative volatality and polarity of compounds. Estimation of toxin both qualitatively and quantitatively with flame ionization, mass spectroscopy or Fourier transform infrared spectroscopy detectors. It is not used commercially because of availability of other simple and rapid techniques.

Lateral Flow Test: The chromatographic technique involves antibody-antigen interaction. The strip consist of sample pad, membrane, absorbent pad, conjugate pad and adhesive backing. The extractant from the food sample placed on sample pad, In conjugate pad the mycotoxin present in sample bound to the toxin-specific antibody gold particle complex. Mycotoxin- antibody complex along with second antibody-gold complex migrate along membrane consist of zone of control and test on which second antibody and toxin-antibody dried respectively. The complex of toxin-antibody captured and concentrated and form visible colored line in test zone.

Sensors for Mycotoxin Detection.

Surface Plasmon Resonance: In this technique, the excited state of electron charge density waves (plasmons) in thin film of gold foil is fixed on glass prism creates the sensitive surface. Antigen-specific antibodies are embedded onto gold foil. The intensity and angle of reflected light depends on the resonance of plasmons. The binding of toxin to specific sensor surface results into change in the resonance angle indicates the presence of specific toxin in food sample and the intensity of light indicates amount of toxin.

Fiber Optic Devices: The technique involves introduction of light into optical fibers undergo total internal reflection and small portion of light exits in the form of evanescent waves perpendicular to optical fiber. Antigens of toxin mixed with fluorescence material is made to bind on antibodies present on the surface of fiber then wash to remove the unbound antigens. The amount of fluorescence is detected by specific detector and change in the refractive index is proportional to amount of toxin.

Receptors

Aptamers: These are single-stranded nucleic acids consist of short, 20-90 oligonucleotides bind to large variety of proteins or toxins with high specificity and affinity. These are produced by the process called SELEX by in vitro selection. The capacity of aptamers to fold into three-dimensional conformations specific to mycotoxins. Several advantages over antibody; in vitro synthesis, very less variability, inexpensive production of chemical, high thermal and chemical stability along with the solvent during extraction of mycotoxin from food sample. Quantification of toxin done by fluorescence or other methods.

DNA Receptors: Use of DNA receptors involves affinity of mycotoxin to the DNA. The hybridization of DNA probe and toxin is detected by guanine oxidation through DNA based electronic biosensor. But the major disadvantages are low level of sensitivity and selectivity to toxin.

MIPs (Molecularly Imprinted Polymers): MIPs are cross-linked functional polymers obtained synthetically with analyte (toxin) in question. The formation of polymer, complementary to the conformation of toxin. Then remove toxin thus space created is toxin specific in MIPs. These can be used for detection of mycotoxin with high specificity.

FUTURE PROSPECTUS: Based on requirement, different methods standardised for their sensitivity, reproducibility and ease of use in commercial mycotoxin detection in large food samples with high accuracy by utilizing modern synthetic receptors like aptamers, DNA based receptors and MIPs and advancement in detectors for improved quantification of mycotoxins.

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73. PLANT PATHOLOGY 15861

Plant Pathogen Interaction

RenukaTatte

Ph.D. Scholar, Department of Plant Pathology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Plant pathogen interactions tells us about how pathogen recognizes its suitable host, plant senses presence of an enemy and what cellular events follow eventually. In nature occurrence of disease is an abnormal phenomenon as in most of the cases plants are resistant to most of the microbes present around them. Occurrence of disease requires four basic elements, a susceptible host, a virulent pathogen, suitable environmental conditions and time.

Recognition between Plant and Pathogen

Recognition between plant and pathogen occurs via receptors present on surface of plant cell which recognize molecular patterns produced by pathogen. Pathogen produces two categories of signature molecules

1. MAMP's (Microbe associated molecular patterns, eg. Flagellin, EF-Tu),
2. *Avr* (Avirulence gene product, effector molecule). Accordingly even plants possess two different types of receptors.
   a) MAMP's Receptors (receptors which will identify MAMP's produced by pathogen (eg. FLS2) these are Receptor like kinases (RLK's).
   b) R gene (which interacts with *Avr* gene product). In Basal level resistance there is interaction between MAMP's/ MAMP's receptors (RLK's).

a) MAMPS's (Microbe Associated Molecular Pattern): These are highly conserved structures present in pathogens which are required by them for their survival and are highly conserved, they have not changed much in due course of evolution. Thus, these patterns even if pose a threat to pathogen, the pathogen cannot discard it as it are a core element for its survival. Its absence affects the fitness and survival of pathogen. Eg. Flagellin in bacteria, EF-Tu in Fungi.

b) Effector Molecules (Avr Gene Product): These molecules impart attacking ability to a pathogen. They suppress basal defenses and make the pathogen virulent. Plants have co-evolved with their pathogens, the R genes of plants are specific to these effector molecules, and they have co-evolved with effector molecules to recognize them, activate specific defense mechanism of plants. In nature every effector molecule (Avr1) has its matching resistance gene (R1), "gene for gene hypothesis". In absence of a specific R gene in plant *Avr* gene is effective in causing disease, but when it faces it's matching R gene it fails to produce any disease symptoms as R gene renders *Avr* gene paralyzed.

Pathogen Elicitors

Various pathogens, especially fungi and bacteria, release a variety of substances in their immediate environment that act as nonspecific elicitors of pathogen recognition by the host. Such nonspecific elicitors include toxins, glycoproteins, carbohydrates, fatty acids, peptides, and pectic enzymes. In various host–pathogen combinations, certain substances secreted by the pathogen, such as *avr* gene products, *hrp* gene products, and suppressor molecules, act as specific pathogen elicitors of recognition by the specific host plant.

Host Plant Receptors

The location of host receptors that recognize pathogen elicitors is not generally known, but several of those studied appear to exist outside or on the cell membrane, whereas others apparently occur intracellular. In the powdery mildew of cereals, a soluble carbohydrate that acts as an elicitor from the wheat powdery mildew fungus *Blumeria graminis* f. sp. tritici is recognized by a broad range of cereals (barley, oat, rye, rice, and maize) in which it induces the expression of all defense related genes tested and also induced resistance to subsequent attacks with the fungus.

74. NEMATOLOGY 15768

Meloidogyne graminicola: A Burning Problem in Rice

[1]Saroj Yadav and Jaydeep Patil*

*Department of Plant Protection, SOA, LPU, Phagwara, Punjab, 144411

[1]Department of Nematology, College of Agriculture, CCS HAU Hisar, Haryana, India.

*Corresponding Author E. Mail: sarojhau29@gmail.com

INTRODUCTION: Rice (*Oryza sativa* L.) is one of the most important food crops in the world. It is used as staple food for majority of the world populations, predominantly in Asia where more than 90% of world rice is grown and consumed. Out of the total rice area under cultivation, 53% is irrigated, 31% is lowland rainfed and 13% is upland and 3% is under deep water. Rice is grown extensively in India and area under rice cultivation has increased to a greater extent during the last 10 years. India ranked second largest producer of rice on the world map. Rice crop is affected by several abiotic and biotic stresses, of which plant parasitic nematodes constitute an important component and account for yield losses to the extent of 90%. The major nematode pests associated with rice are *Ditylenchus angustus, Aphelenchoides besseyi, Hirschmanniella* spp., *Heterodera oryzicola* and *Meloidogyne graminicola.* However, rice root-knot nematode (*M. graminicola*) happens to be the most important pest and is prevalent in major rice producing countries of the world (Jain *et al.,* 2012). Rice is quite susceptible to root-knot nematode and is attacked by *Meloidogyne incognita, Meloidogyne graminicola, Meloidogyne triticoryzae, Meloidogyne javanica, Meloidogyne oryzae* and *Meloidogyne arenaria* (Gaur and Pankaj, 2010). Amongst these species, *M. graminicola* is a primary pest of rice and poses a substantial threat to rice cultivation in particular Southeast Asia where around 90% of the world rice is grown and consumed (Dutta *et al.,* 2012). The ecological conditions suitable for the cultivation of rice crop are very well congenial for the multiplication of nematodes infecting rice.

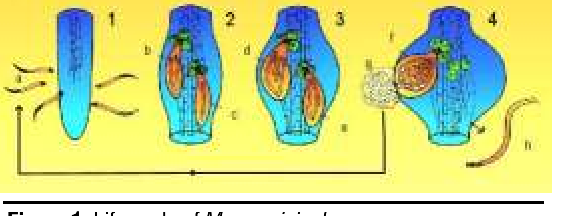

Figure 1. Life cycle of *M. graminicola*

Distribution: Different species of *Meloidogyne* are found in different countries of the world. *M. graminicola* is distributed in countries like S.E. Asia, Burma, Bangladesh, Laos, Thailand, Vietnam, India, China, Philippines, Nepal and USA. In India, *M. graminicola* which was earlier found in West Bengal, Odisha, Assam, Kerala only, has also spread to newer areas of Uttar Pradesh, Delhi, Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, Tamil Nadu, Karnataka, and recently to Gujarat as per the reports from various co-operating centres of All India Coordinated Research Project (Nematodes) (Jain *et al.* 2012).

Yield loss: Depending on the severity of disease, losses caused by *M. graminicola* may vary accordingly. Losses also differ with cropping systems in which the rice is grown. Netscher and Erlan reported that *M. graminicola* caused 28 to 87% yield loss in upland rice in Indonesia. Jairajpuri and Baqri reported grain yield losses from 16 to 32%. Soriano *et al.* recorded 11 to 73% yield losses by this nematode under simulation of intermittently flooded rice, whereas under simulated upland conditions, yield loss varied between 20 and 98%. Padgham *et al.* also reported 16 to 20% yield loss caused by *M. graminicola* in low land rainfed rice in Bangladesh. On upland rice, *M. graminicola* causes 16-32% loss in grain yield due to incomplete filling of kernels. Severe infestations of the root-knot nematode on rice was observed in Mandya district of Karnataka state covering an area of 1500 ha.

Host range: Wide host range of *M. graminicola* may be the reason for its ability to cause severe losses in different cropping system. It was first reported on barnyard grass, *Echinochloa colonum* (Golden and Birchfield, 1965). Subsequently it was found that it readily attacks several grasses, bush bean, oats, sorghum, pearl millet, wheat and oats, were good hosts of this nematode (Dabur *et al.,* 2004). Among the entire host, rice being consider as a major economically important host. Anamika *et al.* assess the disease incidence and intensity of root-knot disease on rice and vegetable crops in 21 districts of Uttar Pradesh (India). On the basis of incidence, population density and associated damage on affected crops, *Meloidogyne* species were considered to be the most important parasites of the crops under local condition.

Symptomology

1. Characteristic hook-like galls on roots.
2. Newly emerged leaves appear distorted and crinkled along the margins.
3. Stunting.
4. Chlorosis.
5. Heavily infected plants flower and mature early.
6. The roots of the host plants can be examined for hook-like galling. They can be stained to determine the presence and populations of *M. graminicola*.
7. The juveniles of *M. graminicola* can be extracted from the roots of the host plants.

Management Strategies

There are cultural, biological, physical, mechanical, use of resistant varieties and chemical control that are available for the rice root-knot nematode. For example, cultural control includes continuous flooding, raising the rice seedlings in flooded soils, and crop rotation. These practices will help prevent root invasion by the nematodes. Soil solarization, bare fallow period and planting cover crops such as sesame and cowpea has been reported to decrease nematodes. Rotation crop like marigold (*Tagetes sp.*) is also effective in lowering root knot nematode populations because of its nematicidal properties.

- It has been recommended that to ensure higher rice yields in *M. graminicola* infested fields, use of non-host crop rotation (groundnut, mustard, blackgram and potato) or fallows ideally for two sessions can help in bringing down the populations of rice root-knot nematode.
- Use of resistant genotypes such as ARC-12620, INRC-2002, CR-94-CCRP-51 which have shown resistance against *M. graminicola* can be taken up in the affected areas.
- Nursery bed treatment with carbofuran at 0.3 g a.i./m2 and its field application at 1 kg a.i./ha 40 days after transplanting reduced the nematode populations.
- Use of neem cake at 100 g/m2 in the nursery area incorporated 15 days prior to the sowing checks the build up of rice root-knot nematode.
- Summer solarisation of nursery beds of rice for 15 days under tropical and subtropical conditions followed by nursery bed treatment with carbofuran at 0.3 g a.i./m^2 + main field application of carbofuran at 1 kg a.i./ha 40 days after transplanting has been recommended against *M. graminicola* infesting rice.

75. ENTOMOLOGY 15432

Spider Venom Peptides; Structure, Pharmacology and their Potential for Management of Insect Pests

Shrilakshmi R. G.

Ph.D. Scholar, Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad - 580-005, Karnataka.

**Corresponding Author E. Mail: shreegaikwad955@gmail.com*

Over 10,000 arthropod species are currently considered to be pest organisms which accounts for destruction of nearly 14% of the world's annual crop production and transmit many pathogens (Oerke and Dehne, 2004). Presently, arthropod pests are managed predominantly through the use of chemical insecticides. Unfortunately, the use of these agrochemicals has resulted in development of insecticide-resistant arthropods. Bioinsecticides represent a new generation of insecticides that utilize organisms or their derivatives (*e.g.*, transgenic plants, recombinant baculoviruses, toxin-fusion proteins, venom peptides and peptidomimetics) and show promises as environmental-friendly alternatives to conventional agrochemicals (Windley *et al.*, 2012).

Spider venoms are an incredibly rich source of disulfide insecticidal peptides that have been tuned over millions of years to target a wide range of receptors and ion channels in the insect nervous system. These peptides can act individually, or as part of larger toxin cabals to rapidly immobilize envenomated prey owing to their debilitating effects on nervous system function. They are highly stable in the insect gut and hemolymph many of them are orally active. Thus, spider-venom peptides can be used as bioinsecticides, or transgenes encoding these peptides can be used to engineer insect-resistant crops or enhanced entomopathogens (King and Hardy, 2013).

The response of the Asian gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae) to a fusion gene consisting of the spider ω-atracotoxin and a sequence coding for the *Bt*-toxin C-peptide, expressed in transgenic poplar plant, *Populus simonii* x *P. nigra* L. (Malphigiales: Salicaceae) has revealed that the growth and development of *L. dispar* were significantly affected by continually feeding on the transgenic poplar, with the larval instars displaying significantly shorter developmental times than those fed on nontransgenic poplar. These results suggest that transgenic poplar is resistant to *L. dispar*. The transgenic poplar expressing fusion protein genes of *Bt* and a spider insecticidal peptide are good candidates for managing the gypsy moth (Cao *et al.*, 2010).

Two families of peptide neurotoxins isolated from the venom of the Australian funnel-web spider, *Hadronyche versuta* are lethal to the lone star tick *Amblyomma americanum* through feeding bioassay Mukherjee *et al.* (2006). Recently a method was developed to isolate spider-venom peptides with high levels of oral insecticidal activity by directly screening for *per os* toxicity and isolated a 34-residue orally active insecticidal peptide (OAIP-1) from venom of the Australian tarantula. The oral LD_{50} for OAIP-1 in *Helicoverpa armigera* was 104.2 ± 0.6 pmol/g, which is the highest *per os* activity reported to date for an insecticidal venom peptide. OAIP-1 is equipotent with synthetic pyrethroids and it acts synergistically with neonicotinoid insecticides. OAIP-1 is likely to be synergized by the gut-lytic activity of the Cry toxin (*Bt*) expressed in insect-resistant transgenic crops and consequently it might be a good candidate for trait stacking with *Bt* Hardy *et al.* (2013).

A large number of disulfide SS-rich insecticidal peptides have been isolated from spider venoms. Many of these have desirable properties for development as bio-insecticides, including high potency, rapid speed of kill, lack of vertebrate toxicity, low production costs and activity against a wide range of crop pests and disease vectors. Moreover, they should be stable in the field owing to their disulfide-rich molecular architecture and their degradation is unlikely to produce toxic residues. Further, these venom peptides have a major advantage over chemical insecticides in transgenes encoding these peptides.

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76. ENTOMOLOGY 15767

Principle of Push-Pull Strategy

Arun Janu and Pritish Jakhar

Department of Entomology, CCS Haryana Agricultural University, Hisar – 125004, Haryana, India

The term push-pull was first conceived as a strategy for insect pest management (IPM) by Pyke *et al.* (1987) in Australia. They investigated the use of repellent and attractive stimuli, deployed in tandem, to manipulate the distribution of *Helicoverpa* spp. in cotton, thereby reducing reliance on insecticides, to which the moths were becoming resistant. The concept was later formalized and refined by Miller & Cowles (1990), who termed the strategy stimulo-deterrent diversion while developing alternatives to insecticides for control of the onion maggot (*Delia antiqua*). In this review, we discuss principle of push-pull strategy as part of IPM strategies in the future.

Principle of Push-Pull strategy

Push-pull strategies use a combination of behavior-modifying stimuli to manipulate the distribution and abundance of pest and/or beneficial insects for pest management. Strategies targeted against pests try to reduce their abundance on the protected resource, for example, a crop or farm animal. The pests are repelled or deterred away from this resource (push) by using stimuli that mask host appearance or are repellent or deterrent. The pests are simultaneously attracted (pull), using highly apparent and attractive stimuli, to other areas such as traps or trap crops where they are concentrated, facilitating their elimination (**Figure 1**). Most work on push-pull strategies has targeted pest behavior, so this review relates mostly to pests, rather than to the manipulation of beneficial organisms. However, the latter case aims to establish a concentrated population on the protected resource to promote biological control, and although stimuli similar to those utilized in the former case are used to achieve this, they act to push the beneficials out of the surrounding area and pull them to where they are required for control. The strategies therefore comprise a two-pronged mechanism to direct the movement and affect the distribution and abundance of the insects (push-pull). Because the stimuli used to achieve this generally act by nontoxic mechanisms, integration with population-reducing methods is also usually needed when the strategies are targeted at pests.

Push-pull strategies bring together various elements of different pest management tactics and provide a framework for their effective deployment. Behavior-modifying stimuli for use in push-pull strategies primarily include visual and chemical cues or signals. Chemical stimuli, in particular semiochemicals, have the most versatility and potential for use in pest management. Habitat diversification strategies (intercropping and trap cropping) have attracted much interest as pest management strategies. For example, trap crops can be plants of a preferred growth stage, cultivar, or species that divert pest pressure from the main crop because they are more attractive. The mechanisms underlying differential pest preference usually involve certain visual or semiochemical stimuli. Trap crops can therefore be used to deliver attractive pest-behavior-modifying stimuli. Biological control and especially conservation biocontrol are additional important strategies in IPM and can be used with push-pull strategies as population-reducing methods.

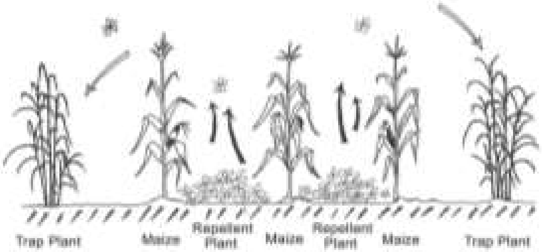

FIGURE 1. Diagrammatic representation of push-pull strategy.

The principles of the push-pull strategy are to maximize control efficacy, efficiency, sustainability, and output, while minimizing negative environmental effects. Each individual component of the strategy is usually not as effective as a broad-spectrum insecticide at reducing pest numbers. However, efficacies are increased through tandem deployment of push and pull components. By concentrating the pests in a predetermined site, the efficiency and efficacy of population-reducing methods can also be maximized. Population reduction by biological control methods or highly selective botanicals is preferred to broad-spectrum, synthetic insecticides. The use of renewable sources, particularly plants, for the production of semiochemicals is encouraged and is becoming possible even for insect-produced semiochemicals. In agricultural systems, the goal is to maximize output from the whole system while minimizing cost, and harvestable intercrops or trap crops, rather than sacrificial crops, should be used wherever possible.

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77. ENTOMOLOGY 15813

RSW (Rugose Spiralling Whitefly): A Menace to Coconut Farmers in Tamil Nadu

[1]Gopalakrishnan R. and [2]Subramanian R.

[1]M.Sc. Scholars, Department of Agricultural Entomology, [2]Department of Plant Pathology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu

**Corresponding Author E. Mail: gopalsmile1104@gmail.com*

INTRODUCTION: Coconut (*Coccus nucifera* L.) is the major plantation crop contributing to the agrarian economy of India and is the third largest producer of coconut with 19.20% share of the world's production. It is grown on 1.94 million ha in 19 states and 3 Union Territories of India producing 15,730 million nuts with an average productivity of 44.27 nuts/ palm/ year (NABARD, 2016). An eriophyid mite, the rhinoceros beetle, red palm weevil, black headed caterpillar and white-grub are considered as the major pests of coconut in India. Recently, an infestation of yet another invasive species, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), commonly known as the rugose spiraling whitefly (RSW), was observed on coconut palm in Pollachi, Tamil Nadu, India.

RSW/ the Gumbo Limbo Spiralling Whitefly

RSW was reported as a pest on gumbo limbo (*Bursera simaruba* L) in Miami-Dade County (South Florida) in 2009 by Florida Department of Agriculture and Consumer Services (FDACS), which referred to it as the gumbo limbo spiraling whitefly. This pest has been classified as the serious threat for coconut palm including many other host plants in Florida (Stocks and Hodges 2012; Kumar *et al.* 2013). This whitefly is believed to have originated from Central America and its incidence limited to Belize, Mexico, Guatemala and Florida in Central and North America (Evans 2008).

RSW in Tamil Nadu, India: The rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Sternorrhyncha: Aleyrodidae), has been recently reported from India (Selvaraj *et al.*, 2016) from Tamil Nadu, Karnataka, Kerala and Andhra Pradesh. It is an invasive pest that attacks a wide range of host plants including palms, woody ornamentals, and fruits. Coconut and banana are among the most preferred host plants.

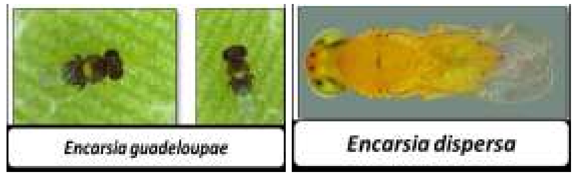
RSW and Symptoms: RSW adults can be distinguished by their large size and the presence of a pair of irregular light brown bands across the wings. Males have long pincer like structures at the end of their abdomen (Stocks and Hodges 2012). The continuous dry spell, availability of host plants in large area and absence of natural enemies had favoured its multiplication.

Host Plants: It mainly infests coconut palms and other broad-leaved hosts in its native range (Martin, 2008). In our surveys, coconut, and banana were found to be common and preferred hosts and smaller infestations were observed on guava, citrus, mango, sapota, bhendi, custard apple, jatropha, and hibiscus. Severe infestation by the whitefly on coconut was observed in Kerala and Tamil Nadu. Heavy sooty mould deposition and near total drying of leaves were observed on coconut and banana plants.

Diagnosis: The eggs are laid in a spiraling pattern and have a very short stalk. The emerging nymph is yellowish and develops white waxy filaments later. The adult whitefly is larger size and in having two pale brown wavy markings on the forewings, one medial and one apical. Martin

(2008) has given a puparium-based illustrated key to separate the genera and species of Aleurodicinae including *Aleurodicus rugioperculatus.*

Management: RSW can be effectively managed by bio control agents rather than going for insecticides since it kills the natural enemy population. The predator and parasitoids reported for RSW includes *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae), an exotic parasitoid of the spiraling whitefly introduced in India in 1999, was found to cause 60–70% parasitism of this whitefly.



Encarsia dispersa Polaszek, a species that was accidentally introduced along with the spiralling whitefly, was also found to parasitize this whitefly and the extent of parasitism was about 5%.

The Kerala Department of Agriculture has recommended spraying a mixture of neem oil, soap, and garlic. CPCRI, Kasargod, has recommended the following measures:

- Spraying starch solution (1%) to dislodge the heavy sooty mould deposition on the leaves of infested plants.
- Use of yellow sticky traps to trap the adult whiteflies
- In case of severe infestation, spray neem oil 0.5%

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78. ENTOMOLOGY 15864

Ecological Engineering: New Dimensions in Insect Ecology

Tanmaya Kumar Bhoi*, Satyapriya Singh and Sunil

Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi - 12, India.
**Corresponding Author E. Mail: bhoitanmaya152@gmail.com*

INTRODUCTION: Ecological engineering is a conscious human activity and should not be confused with the more recently developed term 'Ecosystem Engineering'. Odum (1962) was among the first to use the term 'Ecological Engineering', which was viewed as environmental manipulation by man using small amounts of supplementary energy to control systems in which the main energy drives are still coming from natural sources'. Various disciplines are allied to ecological engineering namely restoration ecology, sustainable agroecology, habitat reconstruction, ecosystem rehabilitation, river and wetland restoration and reclamation ecology. These sub-sets indicate the range of areas in which ecological engineering has been applied (Table), including the restoration of wetlands, treatment and utilisation of wastewater, integrated fish culture systems and mining technology as well as wildlife conservation.

Applications of Ecological Engineering with examples (Mitsch and Jorgensen, 2004)

Applications	Examples
1. Reducing a pollution problem.	Wastewater recycling in wetlands, sludge recycling
2. Ecosystems imitated to reduce problem.	Integrated fishponds
3. Recovery of an ecosystem.	Mine restoration
4. Reduce an environmental problem.	Increase natural pest mortality

Principles

Pimentel (1989) identified several 'Ecotechnological Principles' that strengthen productive and sustainable agricultural systems:

- Adapting and designing the agricultural system to the environment of the region (*e.g.* Choice of appropriate crop species and cultivars).
- Optimizing the use of biological resources in the agroecosystem (*e.g.* use of biological control).
- Developing strategies that induce minimal changes to the natural ecosystem to protect the environment and minimize use of non-renewable resources (*e.g.* appropriate fertilizer formulations and application patterns).

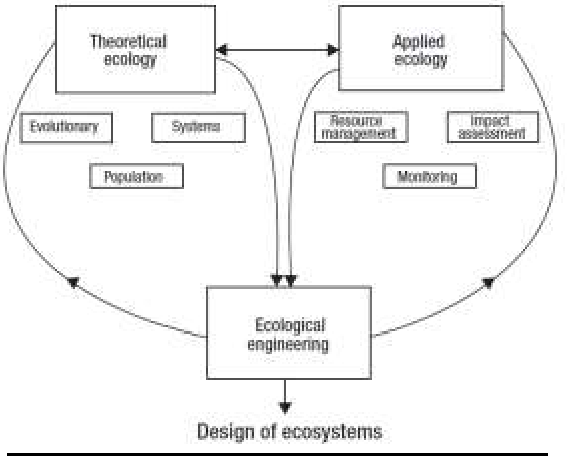
Utility

Reflecting the utility of the ecological engineering paradigm to agriculture, the term 'Agro-ecological engineering' has developed prevalence. It could be argued that all pest management approaches are forms of ecological engineering, irrespective of whether they act on the physical environment, chemical environment or biotic environment. It is, however, the use of cultural techniques to effect habitat manipulation and enhance biological control that most readily fit the philosophy of ecological engineering.

Habitat Manipulation

Habitat manipulation aims to provide the natural enemies of pests with resources such as nectar, pollen, physical refugia, alternative prey, alternative hosts and lekking sites.

It can be considered a subset of conservation biological control methods that alters habitats to improve availability of the resources required by natural enemies for optimal performance. Habitat management may occur at the within-crop, within-farm, or landscape levels. The need for habitat management is directly linked to the biology of specific pests and natural enemies, and the qualities of the environment in which they occur. As a result of frequent and intense disturbance regimes, many agricultural systems are recognized as particularly difficult environments for natural enemies. Many of the proximate factors identified as limiting the effectiveness of natural enemies in agricultural systems (pesticides, lack of adult food, lack of alternative hosts) can be viewed as direct results of the disturbance regimes imposed on these systems. A focus of many past conservation efforts has been to seek more selective pesticides, or to time the use of pesticides to minimize their negative impacts on natural enemies.



The Relationship between ecological engineering, theoretical and applied ecology (Mitsch and Jorgensen, 2004)

Conclusion: Ecological engineering is a human activity that modifies the environment according to ecological principles. Accordingly, it is a useful conceptual framework for considering the practice of habitat manipulation for arthropod pest management. For those involved in habitat manipulation research and development, this is an exciting time. As the discipline moves beyond the first approximation that diversity per se is the route to success, rapid progress is being made in the power and range of methods available to researchers, as well as in the development of theory. As methods and theory are integrated and more widely used, ecological engineering will evolve into a rigorous branch of ecology. Whether or not genetic engineering and ecological engineering achieve synergies or become entrenched as alternative paradigms for pest management, the development of the latter discipline into a more rigorous branch of ecology will allow it to contribute to the challenge of meeting our needs for agricultural products in a sustainable fashion.

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79. SERICULTURE 15811

Mulberry: Queen of Textile Crop

[1]N. Murugan and [2]N. Vairam

[1]Assistant Professor, Department of Sericulture; [2]Assistant Professor, Department of Plant Breeding & Genetics, Imayam Institute of Agriculture and Technology, Thuraiyur, Trichy-621 206.

INTRODUCTION: Mulberry is a multipurpose tree used for leaves, fruits, timber, fuel and wood. Mulberry is a perennial deciduous tree reported to have originated in china (Vavilov 1955). It has more than 20 species and 1000 cultivated varieties. Mulberry grows in warm temperate and subtropical regions. It is a Shrubs or trees with milky sap. Tall tree with a crown height of 5–6 feet from ground level and a stem girth of 4–5 inches or more.

Mulberry (*Morus* spp., Moraceae): The important character of the members of the family Moraceae (especially *Morus* spp.) is the presence of idioblast, which is nothing but the enlarged epidermal cell in the leaf.

Important Mulberry Species are:

M. australis, M. alba, M. nigra, M. multicalis, M. cathayana, M. bombycis, M. serrata, M. rotundiloba, M. rubra, M. tiliaefolia, M. indica, M. sinensis, M. laevigata.

Cultivated Species

1. *Morus alba* L. (White mulberry)
2. *Morus nigra* L.(Black mulberry)
3. *Morus rubra* L. (Red Mulberry)

Mulberry is allogamous-genetically inconsistent. Generally, mulberry has 28 chromosomes (2n=28) n=14 (Haploid); 28 (Diploid); 42 (Triploid); 56 (Tetraploid); 70 (Pentaploid); 84 (Hexaploid); 112 (Octoploid); 308 (Docosaploid). Among the cultivated varieties, tetraploid are more. They are large and yield more. They are resistant to cold and diseases.

Botany: Mulberry is unique in possessing both lobed and unlobed leaves on the same twig (heterophylly). Leaves are alternate, stipulate and serrated on the margin.

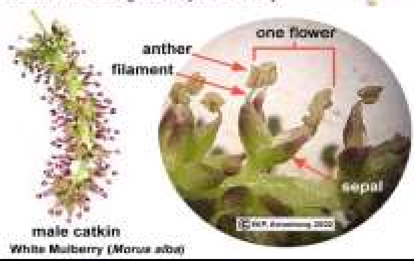
Inflorescence: Heads, racemes, spikes, catkin etc. In *Morus, male flowers are set in catkins and the female* into pseudospikes.

Flowers: Unisexual and plants may be monoecious or dioecious, actinomorphic, tetramerous and hypogynous to epigynous.

Individual fruit is a drupe. Immature fruits are white, green or pale yellow and turn red or pink when ripens.

Economic Part

- Mulberry leaves, particularly white mulberry, are the important sole food source of the silkworm (*Bombyx mori, named after the mulberry genus Morus), the cocoon of which is used to make silk.*



Economic Importance

- The mulberry fruits are also known for its delicious taste and medicinal properties like vaso-tonic, anti-oxidant activity, anti-cancer, anti-viral, anti-inflammatory *etc.*
- They are using for both medical and cosmetic

purposes like to nourish skin and blood, benefit to liver, kidney and treat weakness.

- Rearing of silk worm: The leaves of mulberry are used for growing silk worms. Silk worms produce silk which has great commercial value.
- Paper: bark.

Conclusion: Breeding for superior mulberry genotypes with photosynthetic efficiency and desirable quality characters contributing towards yield, should be the strategy for a successful breeding programme.

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Low Cost Seed Storage Methods for Agricultural Crops

K. Balaji and A. Thanga Hemavathy

Assistant Professor, Department of Pulses, CPBG, TNAU

Traditional banking of seeds between growing seasons has been the key factor driving agricultural advancements. Several methods have been developed to store seeds effectively, because unconventionally processed and stored seeds are often infected by insects and prone to fungal attack, thus hastening the seed deterioration time. As a general estimate, poor storage techniques alone contribute up to 10% of the stored seed loss in the tropics. The techniques available for seed storage are quite varied but selection of a particular method largely depends on the effectiveness and cost of the given method. A post - harvest loss of fruits and vegetable is 22 to 40 per cent, pulses, oilseeds and cereals is 10 to 30 per cent. These losses mainly arise because of improper harvesting methods, problems of threshing, storing, transportation and processing leads to large - scale losses in food grains. Thus, the post - harvest losses obviously have an impact on the economy. Farmers and traditional grain processors have been evolving number of traditional practices through trial and error method, to avoid huge loss that are occurring in stored pulse grains due to insect and pest infestation. Proper storage of food grains is necessary to prevent spoilage, increase keeping quality and for monetary reasons.

Neem Oil in Seed Storage: Neem (*Azadirachta indica*) oil in the seed storage treatment. For 1 kg of pulses seed 20 ml of neem oil was used. Manually farmers applied the neem oil over the seeds to coat the seeds uniformly. Neem oil acted as repellent against several insects such as weevils, red flour beetles (*Tribolium castaneum*), Long headed flour beetle (*Latheticus oryzae*) and fig moth (*Ephestia cautella*), etc. It destroyed a variety of insects mostly attacking legumes at the egg stage itself. The farmers had perceived the specific properties of neem oil like repellence, feeding and ovipositional deterrence, growth inhibition, etc. and used them against the storage pests. Some farmers used neem oil mixed with coconut oil/castor oil (1:1) for treating the seed materials against the storage pests.

Need Seed Kernel Extract Dip Jute Gunny Bags: Neem seed kernal extract (NSKE) treated jute gunny bags are used for storage. For this practice, about 10 kg of neem seed kernels was powdered well and soaked in 100 L of water for nearly 24 hrs. After that, the extract was filtered. Jute gunny bags to be used in storage were then dipped in the NSKE solution for 30 min and shade dried. Later, these NSKE treated jute gunny bags were used in storing seed materials of paddy (*Oryza sativa*), pulses and oil seeds. Farmers believed that the strong odour of neem would repel the storage pests. Another advantage revealed by the farmers is this will in turn enhance the germination and quality.

Neem Leaves against Storage Pests: Neem leaves was added with the grains during storage, it repelled storage pest effectively for the pulses and oilseeds storage pests, viz. pulse beetles (*Callosobruchus maculatus*), lesser grain borers (*Rhyzopertha dominica*). Farmers perceived this method to be very economical and moderately effective (50%) in protecting the storage grains from pests pulse beetles (*Callosobruchus maculatus*), lesser grain borers (*Rhyzopertha dominica*) and other borers. Grains could be stored in this method even up to one year.

Storage of Grains using Camphor: Both cereals and pulses attracted a wide range of storage pests. In this practice, about 1gm of camphor piece per 5 kg of grains was placed as such in the jute gunny bags. This practice of placing camphor inside the grain storage bag repelled the storage pests due to the strong odour emanated from camphor. A short-term storage of grains up to 3 months was possible with this traditional storage method and after that the grains were to be sun-dried and then kept with fresh camphor pieces for subsequent storage.

Storage of Seeds with Lime: Farmers traditionally followed a practice of storing pulse grains along with lime powder. In this practice, 10 gm of lime is dusted about per kg of grains. After thorough mixing they stored them in jute gunny bags. The lime had a property of emitting irritating odour that repelled insects and prevented the grains from damage. By this way, grains could be stored for even one year.

Mud pots in Grain Storage: Farmers perceived that grains and seed materials when stored in earthen pots prevented most of the storage pests. farmers placed a circular ring like structure locally called *Pirimanai* made of paddy (*Oryza sativa*) straw on the floor. Above that ring, they placed the pots filled with grains. The pots were arranged one above the other and the top most pot was then closed with a lid. This arrangement was usually made inside the house at the corner region. The grains or seed materials stored in this mud pots were kept safe away from wide range of storage pests for nearly 6 months. After 6 months the grains were taken out and subjected to sun drying and again stored in mud pots.

Storage of Grains with Sweet Flag: Is an indigenous way of storing grains with sweet flag (*Acorus calamus.)* In this practice, sweet flag was powered and mixed with grains and seeds of pulses, cereals and oil seeds. For treating 1 kg of grains, about 10 gm of sweet flag powder was used. The grains could be stored effectively for 6 months without any pest attack. The strong odour emitted from sweet flag acted as a repellant against all the storage pests.

***Pungam* Leaves in Paddy Storage:** 0Fresh *pungam* (*Pongamia glabra*) leaves were placed as layers in between the gunny bags arranged one above other in storerooms. These leaves acted as a repellent against angoumois grain moth (*Sitotroga cerealella*) and rice weevils (*Sitophilus oryzae*). The strong odour released from *pumgam* leaves avoided the pest attack. Some farmers placed these *pungam* leaves directly in the gunny bags and stored the grains.

Paddy Husk in Managing Storage Pests: In Paddy (*Oryza sativa*), Angoumois grain moth (*Sitotroga cerealella*) and rice weevil (*Sitophilus oryzae*) damage was severe. Farmers stored the paddy grains in earthen pots and placed paddy husk in top layer (5cm) above it. Farmers had found that storage pests unpreferred these earthen pots stored with paddy husk.

Common Salt for Red Gram Storage: Farmers with their indigenous knowledge used common salt in red gram (*Cajanus cajan*) grains storage. 200 gm of salt was mixed for a kg of red gram grains manually. These treated grains were then stored in jute gunny bags and the bags were stitched. Due to this practice, insects were kept away from the stored grains. As salt had abrasive action on insect skin prevents its movement inside the storage containers. Farmers believed that this practice stored red gram grains, for short-term duration of 6-8 months.

Pulse Grains Storage with Ash: Seeds were filled in earthen pot to its ¾th volume and then remaining top 1/4th top was then covered with ash (wood/ cow dung ash). By this way, wide ranges of storage pests like pulse beetles (*Callosobruchus maculatus*), and fig moth (*Ephestia cautella*) were kept under the control for a period of 6-8 months. After 6 months, the grains were exposed to sun and then the ash was spread above the grains surface and kept for storage.

Ash Seed Treatment in Sorghum: Ash was mixed with the sorghum (*Sorghum bicolor*) seeds at the ratio of 1:4. After the ash treatment, sorghum seeds were tied airtight in the jute gunny bags. During storage, grains were subjected to losses by various insects, *e.g.* rice weevil (*Sitophilus oryzae*), rodents (*Tatera indica*) and mite (*Oligonychus indicus*). Farmers using this technology stored the sorghum grains for 6 months without any storage pest problems.

Neem and Thumbai Leaves for Ragi Storage: Neem (*Azadirachta indica*) leaves and *thumbai* leaves are used for storage of Ragi. The strong odour of these leaves keep the storage pests like lesser grain borers (*Rhyzopertha dominica*), saw toothed beetle (*Oryzaephilus surinamemsis*) and flat grain beetle (*Cryptolestes minutus*) away. Neem leaves and *thumbai* being organic repellants were also safe to use.

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Seed Balls for Greening India

*[1]S. Behera, [2]R K Rout and [3]A. K. Padhiary

[1]Krishi Vigyan Kendra, Kalahandi, Odisha; [2]College of Agriculture, Bhawanipatna, Kalhandi, Odisha; [3]Krishi Vigyan Kendra, Sambalpur, Odisha

*Corresponding Author E. Mail: srikrushnabehera.ouat@gmail.com

INTRODUCTION: A seed ball (or seed bomb) is a structure that has been wrapped in soil materials, usually a mixture of clay and compost, and then dried. Essentially, the seed is 'pre-planted' and can be sown by depositing the seed ball anywhere suitable for the species, keeping the seed safely until the proper germination window arises. Seed balls are an easy and sustainable way to cultivate plants in a way that provides a larger window of time when the sowing can occur. To greening vast tracts of wastelands may be accomplished by the use of seed balls. They are a safe delivery system for seeds used in re-vegetation. The idea has its origins in the agriculture practiced by the legendary Masanobu Fukuoka and made popular by his book, 'One Straw Revolution'. There he describes his 'no cultivation' farming. Apart from not ploughing, Fukuoka took to encasing his grain seeds in clay and broadcasting them freely. The seeds lie safely out of reach of birds and ants and dissolve out of the cast and germinate soon as it rains.

Seed balls are a great method of reclaiming areas of your garden that have become thin or barren. The clay vessels that you create for your seeds and soil offer a fun way to plant your seeds while providing protection for the exposed seeds. The soil you wrap inside of the ball offer the seeds an immediate source of nutrients. The seeds remain inside the Seed Ball until rains soak the clay and stimulate the seeds. Seed balls may have been used by the Ancient Egyptians to seed the receding banks of The Nile after annual floods. They have been used in Asia and elsewhere, especially in arid regions, because of their ability to keep the seeds safe until conditions are favourable for germination, and the ease at which they can be distributed.

A pumpkin seed ball growing in lab.

More recently, Japanese agricultural renegade, Masanobu Fukuoka, began exploring the use of seed balls (*nendo dango* in Japanese) to help improve food production in post WW-II Japan. His research and outreach efforts have brought the seed ball back into the public eye.

Today, seed balls are fun for green-minded kids and adults and are also an important tool of the guerrilla gardening movement.

Preparation of Seed Balls

The following procedures are as follows

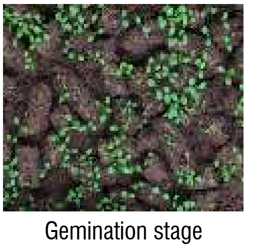
- Add 3 Parts of well decomposed compost into the bucket.
- Blend in 5 parts of dry clay.
- Add 1 to 2 parts of water a little at a time, mixing well after each addition until thick dough like consistency is achieved.
- Some amount of chilli powder is mixed with the mixture, as it deter predators. Artesemias, mints and black pepper which may also deter predators.
- Legume inoculants can be included, which may give good germination.
- Break dough into small pieces and roll them between your hands into seed balls. It is important to keep the seed balls on the small size, around half an inch in diameter and seeds are placed in the middle of the ball. Ensure that only few seeds are place in the ball, as too many seeds per ball may result in creating too much of competition amongst the seeds for survival.
- Finally seed balls are dried in shade and are ready to throw!

Advantage

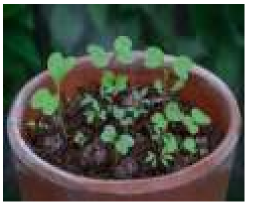
Seed balls are a great tool for making a neglected or unused area beautiful and green again; a quick and effective method for planting on large areas.

- Seed balls are perfect delivery system for reintroducing native plants. Plants that are grown through seed balls would cater to not only human beings but also nurture wild animals like monkeys and birds for fruits.
- Seed balls may help to recover degraded landscape back to productivity.
- Seed balls have been employed to establish new pastures on steep slopes, shallow and exposed bed rocks.
- In urban areas, seed balls are packed and gifted in birthday parties, so share and make the planet earth greener.

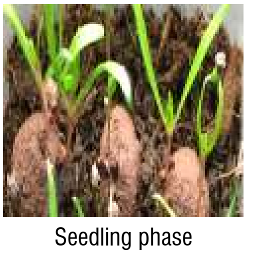
Spherical Seedballs



Gemination stage



Two leaf stage



Seedling phase

Seed Balls vs Seed Bombs?

The only substantial difference is what you call them. "Bomb" sounds more subversive, and so it's gaining popularity among guerrilla gardeners.

When properly made, the seed ball or bomb will have enough seed to ensure germination, but not so many seeds that the plants will choke each other. Since the idea is to grow healthy plants, we use enough seed to ensure good likelihood of germination, but not so many that the seedlings are stressed from crowding and fail to thrive. Some folks who make seed bombs overload them with seed. They look like chia pets when they germinate, but the competing seedlings may not do so well.

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The Role and Importance of Vegetables Industry

Himaj S. Deshmukh

Ph.D. Scholar, Dept. of Agril. Botany, MPKV., Rahuri (M.S.)

**Corresponding Author E. Mail: hdhsdeshmukh1@gmail.com*

Vegetable crop production is one of man's basic skills. Wherever humans have settled for long enough to produce a crop, they have cultivated vegetables for food and for animal fodder. The level of success and productivity originally depended on the local climate, seasons and the range of species cultivated. The cultivated species were developed by selection from local wild plants and subsequently supplemented by plant introductions from other areas, and later still from other continents.

It is now being recognized that, in addition to their role as part of a balanced diet, vegetables can play a vital role in agricultural and social development processes. The Asian Vegetable Research and Development Center (AVRDC, 1998) has produced a plan that includes specific programmes such as the inclusion of vegetables in cereal-based systems and year-round vegetable production systems. The plan recognizes, and takes into account, the social and economic values of vegetables. The pivotal role played by seeds in the development of civilization has been described by MacLeod (2007), who points out that seeds are a means of transferring genetic information from generation to generation, in addition to the essential nutrition and energy for germination, emergence and plant establishment. All of our vegetable species have developed as a result of generations of plants men selecting and growing the next generation from plants that have displayed the most desirable or useful characters or traits.

A successful vegetable production industry is very dependent upon a sustainable supply of satisfactory seeds. At the present time the seed industry plays an important role in both production and distribution of high-quality vegetable seeds. However, there are some communities where 'own seed' or 'on-farm' seed production is still the norm. Market gardens growing for profit, to private gardens, homesteads and subsistence farmers where vegetables are an essential element of the families' own efforts to supplement their diet or income.

Vegetables are also cultivated in some communities for physical recreation or even for a pastime or hobby. There has been an increased interest in 'home-grown' and 'self-sufficiency' in some Western societies; this has arisen from the policy to increase physical activity as a way of improving health, partly following the global financial crises of 2008 and 2009, and in some cases including a desire to produce vegetables 'organically'. In some areas of less-developed countries, vegetables are not only grown for self-sufficiency but also for sale or exchange in village communities. The market growers in many areas have evolved from disposal of surplus crops to deliberate production for sale. With the further extension and development of urban communities and marketing systems, the commercial producer has continued to play an increasingly important role in meeting the vegetable requirements of the population.

Commercial production has extended considerably during recent decades in many parts of the world, as the field and protected cropping vegetable industries endeavour to provide continuity of supply for the fresh markets in urban areas (including supermarkets), the processing industry and export.

There are several reasons for growing vegetables, but the most important ones are that they are essential in the diet: they provide fibre, trace minerals, antioxidants, vitamins, folacin, carbohydrates and protein (Oomen and Grubben, 1978). There is an increased emphasis in developing countries to supplement the staple foods (which include, for example, rice, maize or wheat) with locally produced green vegetables such as *Amaranthus* or Chinese cabbage. There is also a renewed emphasis on the identification of edible indigenous plant species, especially in developing countries where the local wild species have a high nutritious value but also fit into year-round cropping systems (Weinberger and Msuya, 2004).

An important reason why the demand for vegetables has increased in many areas of the world is the development and extension of a wider range of preservation techniques, such as canning, freezing and dehydration. This technology has led to a more diverse range of vegetable types and increased quantities being called for by the processors. Along with this there have been major improvements in the technology of large-scale vegetable production. The significant advances have included the adoption of herbicides suitable for individual crop species leading to crop establishment in a relatively weed-free environment, and the use of precision drilling and adoption of hybrid cultivars to improve crop uniformity and disease resistance. However, the adoption of some hybrid cultivars in which all the plant population matures at the same time is not necessarily an advantage for self-sufficient growers or subsistence farmers, unless the crop has been produced for processing or storage.

The increasing interest in vegetables, found at all levels or scales of production, has led to local, national and international activities to improve vegetable seed supply and quality. It can generally be stated that seed security leads to food security.

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83. AGRIBUSINESS 15808

Agro Processing Opportunities and Challenges in Maharashtra

G. D. Rede[1] and G. B. Adsul[2]

[1]Ph.D. Research Scholar, Department of Agricultural Economics, Bidhan Chandra Krishi Viswavidyalaya, District- Nadia, West Bengal, Mohanpur-741252.

[2]Assistant Professor, College of Agriculture, Dongarshelaki Tanda, Udgir (MS)

*Corresponding Author E. Mail: ganeshrede3156@gmail.com

INTRODUCTION: As agricultural production is increased, there is need to have proportionate improvement in the agro-processing industry. Agro-processing industries refer to those activities that transform agricultural commodities into different forms that add value to the product. Food processing sector is one of the largest sectors in India in terms of production, growth, consumption, and export. India's food processing sector covers fruit and vegetables; spices; meat and poultry; milk and milk products, alcoholic beverages, fisheries, plantation, grain processing and other consumer product groups like chocolates and cocoa products, soya-based products, mineral water, high protein foods etc. There are some advantages like high production of raw material, cheap labour, manpower etc, for food processing industry in the country. The sector is quite diverse and its content ranging from pure commodities being sold to highly sophisticated processing sectors with major value addition taking place. Some sectors like perishable produce especially fruits and vegetables, fisheries, and milk need to develop new systems of co- ordination of production and processing activity. There is a good scope to process paddy, cashew and mango into different products by encouraging processing units in the Maharashtra. Agro processing is defined as "Subset of manufacturing that processes raw materials and intermediate products derived from the agricultural sector. As agricultural production is increased, there is need to have proportionate improvement in the agro-processing industry. Agro-processing industries refer to those activities that transform agricultural commodities into different forms that add value to the product. Agro-processing activities comprise two major categories; primary and secondary operations. Primary processing operations involve activities such as crop drying, shelling/threshing, cleaning, grading, and packaging. These activities are mainly carried out at the farm and only transform the commodity into a slightly different form prior to storage, marketing or further processing. Secondary processing operations entail increasing nutritional or market value of the commodity and the physical form or appearance of the commodity is often totally changed from the original. Some examples of secondary processing are milling grain into flour, grinding groundnuts into peanut butter, pressing oil out of vegetable seeds, pressing juice out of fruit, etc.

Indian Food and Agro Processing Sector

India has the 2nd largest arable land (161 million hectares) in the world. Second-largest grower of fruits and vegetables, but only 2 percent of Indian fruits and vegetables are processed. India is world's third largest producer of agricultural commodities after China and USA. India has the largest livestock population cattle buffaloes 283 mn sheep and goat 183 mn. India is world's largest spice producer, consumer and exporter. The total size of the Indian food industry is around US$220 bn in 2005. Indian food processing industry contributes 1.7% of global food processed industry of that, primary processed food is around $70 bn and the value added segment is about $40 bn. The remaining share is accounted by non-processed food (commodity based). Annual growth rate of the industry is around 9-12%. The contribution of industry to India's GDP is 9% and employment is 19%. India: The industry is mainly unorganized with 75% of the processing units in the unorganized category. The organized category though small, is growing fast. Unorganized players are not registered and they are household/cottage industries having local presence. SSI constitutes around 33% of the total number of companies and are companies with investment less than Rs. 1 Cr in fixed assets.

Maharashtra Food and Agro Processing Sector

Maharashtra is bio-diverse state with 9 agro-climatic zones and varying soil types, suitable fo agricultural development. The state is one of the horticultural sate of India, with more than 13.66 lakh hectares under horticulture and 4 lakh hectare under vegetables. Alphanso Mangos accounts for 90% of India's export in Mangos. Leads the Sugar industry with 200 Sanctioned and 150 productive co-operative sugar mills. The export from Maharashtra for fresh vegetables and fruits accounts for 30% and for processed food products is almost 50%. The state has presently 6,512 small and medium and 322 large scale food processing units. The agricultural production of state is 10.7% of the total of national production. The state is largest producer of- Seedless Grapes (78%), Banana (75%), Mandarian Oranges (75%), Onion (63%), Tomato (42%).

Maharashtra Regional Strengths

1. **Konkan Region-** Paddy, Cashew nut, Mango
2. **Western Maharashtra and Khandesh Region-** Sugarcane, Soyabean, Grapes, Banana, Pomogranate, Vegetables
3. **Marathwada Region-** Cotton, Maize, Oil seeds and Pulses
4. **Vidarbha Region-** Organic Cotton, Mandarin Orange, Pulses and Paddy.

Agro Processing Opportunities

Vast source of raw material: India is one of the largest producers of wheat and rice. Coconuts, cashew nuts, ginger, turmeric and black pepper are widely grown in some parts of the country. India is the second largest producer of groundnuts, fruits and vegetables. That it accounts for about 10 per cent of the world's fruits production with the country topping in the production of mangoes and bananas.

Conventional farming to commercial farming: In recent years, there has been a shift from conventional farming of food grains to horticulture which include fruits, vegetables, ornamental crops, medicinal and aromatic plants, spices, plantation crops which include coconut, cashew nuts and cocoa and allied activities.

Investment Opportunities in Fruit & Vegetable processing: There is a good international demand for certain fresh fruits as well as processed fruits products. Fresh fruits identified as having good export potential are: mango, grapes, and banana.

Investment Potential in Milk Products: Industry profitability has been good and there is very good potential for introduction of new value added products and their export. Being largely imported, manufacture of casein & lactose has good scope in the country. Due to the high processing levels milk products offer a significant opportunity in India.

Change in consumption patterns: Increasing incomes are always accompanied by a change in the food habits. The report observes that the proportionate expenditure on cereals, pulses, edible oil, sugar, salt and spices declines as households climb the expenditure classes in urban India while the opposite happens in the case of milk and milk products, meat, egg and fish, fruits and beverages.

Government Assistance: The Government has introduced several schemes to provide financial assistance for setting up and modernizing of food processing units, creation of infrastructure, support for research and development and human resource development in addition to other promotional measures to encourage the growth of the processed food sector.

Agro Processing Challenges

Affordability and Cost: In developed countries the price of processed foods and fresh foods are more or less, the same. At times, processed foods are even cheaper than fresh food. In India, however, due to a variety of factors processed food prices are substantially higher than fresh food. Given the objectives which are achieved by processing there is a need to take measures to reduce costs and make processed food affordable.

Infrastructure: Deficiencies in infrastructure exist across the sector. The cold storage capacity today caters to less than 15 percent of the produce, this too is of rudimentary nature with over 80 percent designed only to handle potatoes. There is also a paucity of chilling infrastructure for milk and a lack of modern abattoirs for the meat processing sector. Fish processing, more specifically for exports requires a major step-up in infrastructure availability. Physical marketing and warehousing infrastructure also needs to be upgraded.

Financing and credit availability: Inadequate and high cost of credit has been one of the major reasons for thesubdued agri-sector growth. According to industry estimates, rural credit penetration in India is just 15 percent of the all India average of 40 percent. Due to inadequate formal credit delivery mechanism farmers have to rely on informal sources such as money lenders and traders who charge higher interest rates.

Intensive and extensive awareness: Farmers and other cooperatives should be provided extensive training in pre and post harvest management of agro produce and should be educated on the advantages of setting up preprocessing facilities in vicinity to the farms. These facilities may include provision for washing, fumigation, packaging, etc. Efforts could also be made set up agro processing units close to the area of production to avoid wastages in transit.

Quality enhancement: In order to speed up the progress of the food processing industry, it is very essential to produce high quality raw materials that are used for further processing, thus meeting both national and international standards.

Conclusion: The food processing industry in India is gaining equal importance as agriculture or any other industry. It is vital because it acts as a linkage between manufacturing industries and agriculture, which are the most important sectors of the Indian economy. There are some advantages like high production of raw material, cheap labour, manpower etc, for food processing industry in the country. The sector is quite diverse and its content ranging from pure commodities being sold to highly sophisticated processing sectors with major value addition taking place. Some sectors like perishable produce especially fruits and vegetables, fisheries, and milk need to develop new systems of co- ordination of production and processing activity. There is a good scope to process paddy, cashew and mango into different products by encouraging processing units in the Maharashtra. There is a good scope to process paddy, cashew and mango into different products by encouraging processing units in the Maharashtra.

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84. ECONOMICS 15444

Role of Agriculture in Indian Economy

Yasmeen

Ph.D. Scholars, Department of Agricultural Economics, College of Agriculture, UAS, Raichur, Karnataka- 584104

**Corresponding Author E. Mail: itsmeyas786@gmail.com*

INTRODUCTION: Agriculture is the most important sector of Indian Economy. Indian agriculture sector accounts for 18 per cent of India's gross domestic product (GDP) and provides employment to 50% of the countries workforce. India is the world's largest producer of pulses, rice, wheat, spices and spice products. India has many areas to choose for business such as dairy, meat, poultry, fisheries and food grains etc. India has emerged as the second largest producer of fruits and vegetables in the world. According to the data provided by Department of Economics and Statics (DES) the production of food grains for the year 2015-2016 is 274 million tons which is increased when compared to (2012-2013) 247 million tons. This is a good symptom for the Indian economy from the agriculture sector. India remains among main three as far as production of different agricultural things like paddy, wheat, pulses, groundnut, rapeseeds, natural products, vegetables, sugarcane, tea, jute, cotton, tobacco leaves and so on. On the other hand, on advertising front, Indian agribusiness is as yet confronting the issues, for example, low level of business sector reconciliation and integration, availability of dependable and convenient information needed by farmers on different issues in farming.

Seven Important Roles of Agriculture in Indian Economy

1. Contribution to National Income: From the very beginning, agriculture is contributing a major portion to our national income. In 1950-51, agriculture and allied activities contributed about 59 per cent of the total national income. Although the share of agriculture has been declining gradually with the growth of other sectors but the share still remained very high as compared to that of the developed countries of the world. For example, the share of agriculture has declined to

54 per cent in 1960-61, 48 per cent in 1970-71, 40 per cent in 1980-81 and then to 18.0 per cent in 2008-09, whereas in U.K. and U.S.A. agriculture contributes only 3 per cent to the national income of these countries.

2. Source of Livelihood: In India over two-thirds of our working population are engaged directly on agriculture and also similarly depend for their livelihood. According to an estimate, about 66 per cent of our working population is engaged in agriculture at present in comparison to that of 2 to 3 per cent in U.K. and U.S.A., 6 per cent in France and 7 per cent in Australia. Thus the employment pattern of our country is very much common to other under-developed countries of the world.

3. Source of Food Supply: Agriculture is the only major source of food supply as it is providing regular supply of food to such a huge size of population of our country. It has been estimated that about 60 per cent of household consumption is met by agricultural products.

4. Role of Agriculture for Industrial Development: Agriculture in India has been the major source of supply of raw materials to various important industries of our country. Cotton and jute textiles, sugar, vanaspati, edible oil plantation industries (viz. tea, coffee, rubber) and agro-based cottage industries are also regularly collecting their raw materials directly from agriculture.

About 50 per cent of income generated in the manufacturing sector comes from all these agro-based industries in India. Moreover, agriculture can provide a market for industrial products as increase in the level of agricultural income may lead to expansion of market for industrial products.

5. Commercial Importance: Indian Agriculture is playing a very important role both in the internal and external trade of the country. Agricultural products like tea, coffee, sugar, tobacco, spices, cashew-nuts etc. are the main items of our exports and constitute about 50 per cent of our total exports. Besides manufactured jute, cotton textiles and sugar also contribute another 20 per cent of the total exports of the country. Thus nearly 70 per cent of India's exports are originated from agricultural sector. Further, agriculture is helping the country in earning precious foreign exchange to meet the required import bill of the country.

6. Source of Government Revenue: Agriculture is one of the major sources of revenue to both the Central and State Governments of the country. The Government is getting a substantial income from rising land revenue. Some other sectors like railway, roadways are also deriving a good part of their income from the movement of agricultural goods.

7. Role of Agriculture in Economic Planning: The prospect of planning in India also depends much on agricultural sector. A good crop always provides impetus towards a planned economic development of the country by creating a better business climate for the transport system, manufacturing industries, internal trade etc.

A good crop also brings a good amount of finance to the Government for meeting its planned expenditure. Similarly, a bad crop lead to a total depression in business of the country, which ultimately lead to a failure of economic planning. Thus the agricultural sector is playing a very important role in a country like India and the prosperity of the Indian economy still largely depends on agricultural sector. Thus from the foregoing analysis it is observed that agricultural development is the basic precondition of sectoral diversification and development of the economy.

An increasing marketable surplus of agricultural output is very much essential in India for:

1. Increasing supply of food and raw materials at non-inflationary prices
2. Widening the domestic market for industrial products through higher purchasing capacities in the rural sector
3. Facilitating inter-sectoral transfers of capital needed for industrial development along-with infra-structural development
4. Increasing foreign exchange earnings through increasing volume of agricultural exports.

Conclusion: Most of the Indians are directly or indirectly depending on the agriculture. Some are directly attached with the **farming** and some other people are involved in doing business with these goods. India has the capacity to produce the food grains which can make vast difference in Indian Economy. To achieve targeted mark by the government it needs to provide support in case of land, **bank loans** and other machineries to the small farmers along with the big farmers with this we can expect some improvement in Indian economy.

Water Footprint and Virtual Water Trade

Shruthi, K.[1*] and Sangmesh Chendrashekhar[2]

[1]*Ph.D. Scholar, Department of Agricultural Economics, UAS, Raichur- 584104 (Karnataka).*
[2]*Department of Agricultural Economics, UAS, Raichur- 584104 (Karnataka).*
**Corresponding Author E. Mail: shruthik952@gmail.com*

At a global scale, most of the water use occurs in agricultural production, but there are also substantial water volumes consumed and polluted in the industrial and domestic sectors. There has been little attention paid to the fact that, in the end, total water consumption and pollution relate to what and how much products get consumed and to the structure of the global economy that supplies the various consumer goods and services. The organization and characteristics of a production and supply chain strongly influence the volumes of water consumption and pollution that can be associated with a final consumer product. Many researchers have shown that visualizing the hidden water use behind products can help in understanding the global character of fresh water and in quantifying the water resources use by the effects of consumption and trade. The impacts of consumption of a final commodity by use of water resources can only be found by looking at the supply chain and tracing the origins of the product. Uncovering the hidden link between consumption and water use can form the basis for the formulation of new strategies of water governance, thus emerged the concept of water footprint.

The idea of considering water use along supply chains has gained interest after the introduction of the 'water footprint' concept by Hoekstra in 2002. The water footprint of a product is the volume of freshwater used to produce the product, measured over the full supply chain. The water footprint measures the amount of water used to produce each of the goods and services we use. It can be measured for a single process, such as growing rice, for a product, such as a pair of jeans, for the fuel put in car, or for an entire multi-national company. It is a multidimensional indicator, showing water consumption volumes by source and polluted volumes by type of pollution. The water footprint can also tell us how much water is being consumed by a particular country – or globally – in a specific river basin or from an aquifer. It is also possible to look at the direct water footprint, which is the water used directly by the individual(s) and the indirect water footprint as the summation of the water footprints of all the products consumed.

The water footprint has three components: blue, green and grey. The blue water footprint refers to consumption of blue water resources (surface and groundwater) along the supply chain of a product. Consumption refers to loss of water from the available surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time. Irrigated agriculture, industry and domestic water use can each have a blue water footprint. **Green water footprint** is water from precipitation that is stored (it does not become runoff) in the root zone of the soil and evaporated, transpired or incorporated by plants. It is particularly relevant for agricultural, horticultural and forestry products. The grey water footprint is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and to meet existing ambient water quality standards. The grey water footprint considers point source pollution discharged to a freshwater resource directly through a pipe or indirectly through runoff or leaching from the soil, impervious surfaces, or other diffuse sources. Together, these components provide a comprehensive picture of water use by delineating the source of water consumed, either as rainfall/soil moisture or surface/groundwater, and the volume of fresh water required for assimilation of pollutants.

Virtual Water Trade

Virtual water trade (also known as trade in embedded or embodied water) refers to the hidden flow of water if food or other commodities are traded from one place to another. For instance, it takes 1,340 m^3 of water (based on the world average) to produce one metric tonne of wheat. When a country imports one tonne of wheat instead of producing it domestically, it is saving about 1,300 m^3 of real indigenous water. If the importing country is water scarce, the water that is saved can be used towards other ends. If the exporting country is water scarce, however, it has exported 1,300 m^3 of virtual water since the real water used to grow the wheat will no longer be available for other purposes. The water is said to be virtual because once the wheat is grown, the real water used to grow it is no longer actually contained in the wheat. The concept of virtual water helps us realize how much water is needed to produce different goods and services. In semi-arid and arid areas, knowing the virtual water value of a good or service can be useful towards determining how best to use the scarce water available.

The water footprint shows the link between consumer goods or a consumption pattern and water use and pollution. Virtual water trade and water footprint can be seen as part of a bigger story of the globalization of water. When a commodity (or service) is traded, the buyer essentially imports (virtual) water used in the production of the commodity. In the context of international trade, this concept has been applied with a view to optimize the flow of commodities considering the water endowments of nations. Using the principles of international trade, it suggests that water rich countries should produce and export water intensive commodities (which indirectly carry embedded water needed for producing them) to water scarce countries, thereby enabling the water scarce countries to divert their precious water resources to alternative, higher valued uses. Coupling virtual water trade with the water footprint enables to map out the dependencies and to identify the risks in terms of scarcity and pollution. This has implications for food security, economy and diplomacy. For water scarce countries it's beneficial to import virtual water (through import of water intensive products), thus relieving the pressure on the domestic water resources. This happens, for example, in Mediterranean countries, the Middle East and Mexico. Instead it results from protection of their domestic water resources, land availability and land uses. Countries can both import and export virtual water through their international trade relations. Globally, the major gross virtual water exporters are USA, China, India, Brazil, Argentina, Canada, Australia, Indonesia, France and Germany and the major gross virtual water importers are the USA, Japan, Germany, China, Italy, Mexico, France, the UK and the Netherlands.

India is a largest virtual net exporter of water because export of many agricultural products. The analysis of global water use indicated that 90 per cent of India's gross virtual water exports relate to food products. With a rapidly growing population and improving living standards in India, the water requirement of the country is increasing and the per capita availability of water resources is reducing day by day. There is need to bring out policies and schemes for proper planning of water resource utilization for the developing countries like India which has its major export share globally.

Water problems are often closely tied to the structure of the global economy. Many nations save domestic water resources by importing water intensive products and exporting commodities that are less water intensive. National water saving through the import of a product can imply that saving water if the flow is from sites with relatively high water productivity (*i.e.* commodities with a small water footprint) to sites with low water productivity (commodities with a large water footprint). Many countries have significantly externalized their water footprint, importing water intensive goods from elsewhere. This puts pressure on the water resources in the exporting regions, where too often mechanisms for wise water governance and conservation are lacking. National policy makers in water scarce countries are likely to be more interested in national water savings than in global water savings. Not only governments, but also consumers, businesses and civil society communities can play a role in achieving a better management of water resources.

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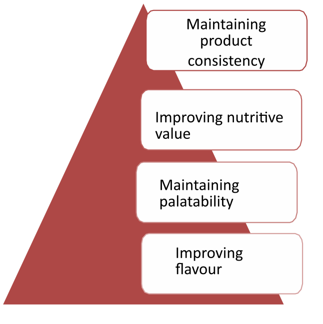
Food Additives: The Facts behind Benefits

Er. Wasiya Farzana[1] and Er. Eresh Kumar Kuruba[2]

Ph.D. Scholars, Department of Agricultural Processing and Food Engineering, IGKV Raipur.

Introduction

- F.A.O. and W.H.O. in 1956 defined food additives as non-nutritive sub-stances added intentionally to food, generally in small quantities, to improve its appearance, flavour, texture, or storage properties.
- The food and drug administration of the United States in collaboration with the food protection committee has defined food additive as a substance or a mixture of substances, other than a basic foodstuff, which is present in a food as a result of any aspect of production, processing, storage, or packaging.



Functions of Food Additives

E-Codes number	Groups of Food Ingredients
E-100	Coloring agents

E-200	Preservatives
E-300	Anti-oxidants
E-400	Thickeners, Stabilizers, Gelling agents, Emulsifiers
E-500	Agents for physical characteristics
E-600	Flavor enhancers

Functions of Food Additives

- Improve the taste or appearance of a processed food. ex: beeswax –glazing agent is used to coat apples
- Improve the keeping quality or stability of a food ex: sorbitol –added to mixed dried fruit
- Improve shelf life or storage time. ex: sulphur dioxide added to sausage meat
- Ensure nutritional value
- Maintain uniform quality and to enhance quality parameters like flavour, colour etc., in large scale production.

E-Codes

- E-codes are codes sometimes found on food labels in the European Union (Great Britain, France, Germany, Spain, Italy, Portugal etc.)
- The codes indicate an ingredient which is some type of food additives.
- The "E" indicates that is a "European Union Approved" food additive.
- Other countries have different food labeling laws.

Classification of Food Additives

1. **Antioxidants**: An antioxidant is a substance which when added to fats and fat containing foods prevents their oxidation and thus prolongs their shelf-life, wholesomeness and palatability
   a) Antioxidants function by interrupting the free radical chain reaction involved in lipid oxidation
   b) It should be effective in low concentration (0.01 to 0.02 per cent) and be fat-soluble
   c) Some antioxidants used in foods are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tertiary butylhydroquinone (TBHQ), propyl gallate (PG), sulphur dioxide, and ascorbic acid.
2. **Preservatives:** Any substance which is capable of inhibiting, retarding or arresting the growth of microorganisms is known as a preservative.
   a) It may be a chemical or a natural substance (sugar, salt, acid)
3. **Sequestrants:** These are also known as chelating agents or metal scavangers since they combine with metals such as iron and copper and remove them from solution.
   a) Traces of metals catalyse oxidation.
   b) Ethylene diamine tetra acetic acid (EDTA), polyphosphates or citric acid.
   c) Calcium and sodium salts of organic acids, calcium chloride, calcium phosphate, tartaric acid, and citric acid, are also examples of sequestrants.
4. **Surface-Active Agents**: These are also known as emulsifiers and are used to stabilize oil in water, water in oil, gas in liquid and gas in solid emulsions.
   a) Besides emulsifiers of natural origin such as lecithin and synthetic ones such as mono and diglycerides and their derivatives, certain fatty acids and their derivatives and bile acid can be used as emulsifying agents.
   b) Synthetic surface active agents, include defoaming compounds and detergents, ex. propylene glycol monosterate and monosodium phosphate.
5. **Colouring Agents**: These are added to a large number of food items to make them attractive and appetizing.
   a) They may be of original origin, *e.g.*, extract from annatto, caramel, carotene, and saffron, or synthetic.
   b) Synthetic dyes, besides providing a larger range of colours than natural substances, are generally superior to the latter in colouring power, uniformity and stability of colour and are cheaper.
6. **Buffers, Acids and Alkaline:** These additives are primarily used to control or adjust the pH of foods and affect properties such as flavour, texture and cooking qualities.
   a) Acid in food may be a natural constituent as in case of fruits, or produced in it by fermentation.
   b) Certain chemicals are also added to adjust the pH, *e.g.*, acetic acid, calcium chloride, calcium citrate, citric acid, lactic acid, mallic acid, sodium acetate, sodium bicarbonate, succinic acid, tartaric acid, sulphuric acid, sodium hydroxide, etc.
7. **Stabilizers and Thickeners**: These substances help to improve the texture of foods, inhibit crystallization of sugar and formation of ice, stabilize emulsions and foams and reduce stickiness of icings on baked products.
   a) They combine with water to form gels and make the food viscous.
   b) Gum Arabic, agar-agar, alginic acid, starch and its derivatives, gelatin, pectin, amylose, carboxymethylcellulose (CMC), carrageenan, hydrolysed vegetable proteins are examples of such additives.
   c) Gravies, pie fillings, cake toppings, chocolate milk drinks, jellies, puddings and salad dressings are some foods that contain stabilizers and thickeners.
8. **Nutrient Supplements**: When foods are processed or stored there may be loss of some nutrients. In order to restore this loss or provide more nutritional value than what nature may have provided nutrient

supplements are added.

Other Additives

- **Firming agents**: These are added to keep the tissues of fruits and vegetables firm, *e.g.*, calcium chloride and aluminium sulphate
- **Clarifying agents**: These are added to remove hazinees or sediment produced by oxidative deterioration in fruit juice, wines, beers, etc., *e.g.*, bentonite, gelatine, synthetic resin
- **Solvents**: Suspended flavouring agents, dyes and other ingredients can be dissolved by adding solvents such as alcohols, acetone, hexane, propylene glycol, glycerine etc.
- **Anti-sticking agents**: *e.g.*, hydrogenated sperm oil
- **Machinery lubricants**: *e.g.*, mineral oil.
- **Meat curing agents**: *e.g.*, sodium nitrite and sodium nitrate
- **Leavening agents**: *e.g.*, ammonium sulphate
- **Freezing agents**: *e.g.*, liquid nitrogen
- **Packing gases**: *e.g.*, inert gases for preventing oxidative changes
- **Enzymes**: *e.g.*, rennin, papain, pectinase
- **Miscellaneous additives**: *e.g.*, acetic acid, caramel, glycerine, phosphoric acid.

The Situations where Food Additives are to be avoided

- In baby foods
- To cover up defects in handling and processing
- To make food attractive and appealing to consumers at the expense of its nutritional quality and safety
- To obtain a desired effect instead of adopting improved processing techniques Where the addition can modify the nutrients in food.

Advantages

- To improve or maintain nutritional value
- To maintain palatability and wholesomeness
- To provide leavening or control acidity/alkalinity
- To enhance flavor or impact desired color
- To maintain product consistency

Disadvantages

- Benzoates can trigger the allergies such as skin rashes and asthma as well as believed to be causing brain damage
- Bromates destroy the nutrients in the foods. It can give rise to nausea and diarrhea
- Butylates are responsible for high blood cholesterol levels as well as impaired liver and kidney function.

Approval for a New Food Additive by the FDA (Food and Drug Administration)

- Must identify new additive
- Give its chemical composition
- State how it is manufactured
- Specify method of measurement
- Proof of intended purpose
- Proof of safety
- Not to be used to deceive

How to Make Food Additives Safe?

- Rinse and scrub fresh fruits and vegetables before consuming them
- Ensure to tear off outer leaves of leafy vegetables
- Remove the skin and fat from meat, fish and poultry, if they have been preserved and froze.

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Management Approaches

Mahammad Shafi Rupanagudi Shaik

Department of Extension Education, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar-385 506. Gujarat, India.

INTRODUCTION: Organisational behaviour is a discursive subject and much has been written about it. The study of organisations and management has therefore to proceed on a broad front. It is the comparative study of the different approaches that will yield benefits to the manager. The study of organisations, their structure and management is important for the manager. Identification of major trends in management and organisational behaviour, and the work of leading writers, provide a perspective on concepts and ideas.

The Modern Period (1960 to present). After, 1960 management thought has been turning somewhat away from the extreme human relations ideas particularly regarding the direct relation between morale and productivity. Present management thinking wishes equal emphasis on man and machine. The modern business ideologists have recognized the social responsibilities of business activities and thinking on similar lines. During the period, the principles of management reached a stage of refinement and perfection. The formation of big companies resulted in the separation of ownership and management.

This change in ownership pattern inevitably brought in 'salaried and professional managers' in place of 'owner managers'. The giving of control to the hired management resulted in the wider use of scientific methods of management. But at the same time the professional management has become socially responsible to various sections of society such as customers, shareholders, suppliers, employees, trade unions and other Government agencies.

Main Approaches to Management

1. Classical – including scientific management and bureaucracy; 2. Human relations – including neo-human relations; 3. Systems; 4. Contingency.

The Classical Approach

The classical writers thought of the organisation in terms of its purpose and formal structure. They placed emphasis on the planning of work, the technical requirements of the organisation, principles of management, and the assumption of rational and logical behaviour.

Sets of Principles: The classical writers (also variously known as the formal or scientific management writers – although scientific management is really only a part of the classical approach) were concerned with improving the organisation structure as a means of increasing efficiency.

Mooney and Riley set out a number of common principles which relate to all types of organisations. They place particular attention on:1. **The principle of co-ordination –** the need for people to act together with unity of action, the exercise of authority and the need for discipline; 2. **The scalar principle** – the hierarchy of organisation, the grading of duties and the process of delegation; and 3. **The functional principle –** specialisation and the distinction between different kinds of duties.

Evaluation of the Classical Approach: The classical approach prompted the start of a more systematic view of management and attempted to provide some common principles applicable to all organisations. These principles are still of relevance in that they offer a useful starting 1. The particular situational variables of each individual organisation; and2. the psychological and social factors relating to members of the organisation.

Major Sub-Groupings: Two major 'sub-groupings' of the classical approach are: 1. Scientific management, and 2. Bureaucracy.

Scientific Management

A major contributor to this approach was *F. W. Taylor (1856–1917), the 'father' of* scientific management. Taylor believed that in the same way that there is a best machine for each job, so there is a best working method by which people should undertake their jobs. He considered that all work processes could be analysed into discrete tasks and that by scientific method it was possible to find the 'one best way' to perform each task. Each job was broken down into component parts, each part timed and the parts rearranged into the most efficient method of working.

Principles to Guide Management: Taylor was a believer in the rational–economic needs concept of motivation. Workers would be motivated by obtaining the highest possible wages through working in the most efficient and productive way. Taylor was concerned with finding more efficient methods and procedures for co-ordination and control of work. He set out a number of principles to guide management. These principles are usually summarised as:1. The development of a true science for each person's work; 2. The scientific selection, training and development of the workers; 3. Co-operation with the workers to ensure work is carried out in the prescribed way; 4. The division of work and responsibility between management and the workers. mic needs concept of motivation.

Bureaucracy

A form of structure to be found in many large-scale organisations is bureaucracy. Its importance in the development of organisation theory means that it is often regarded as a sub-division under the classical heading and studied as a separate approach to management and the organisation of work.

Main Characteristics of Bureaucracies: 1. The tasks of the organisation are allocated as official duties among the various positions. 2. There is an implied clear-cut division of labour and a high level of specialisation. 3. A hierarchical authority applies to the organisation of offices and positions. 4. Employment by the organisation is based on technical qualifications and constitutes a lifelong career for the officials. 5. Uniformity of decisions and actions is achieved through formally established systems of rules and regulations. Together with a structure of authority, this enables the coordination of various activities within the organisation. 6. An impersonal orientation is expected from officials in their dealings with clients and other officials. This is designed to result in rational judgements by officials in the performance of their duties.

Criticisms of Bureaucracy: Weber's concept of bureaucracy has a number of disadvantages and has been subject to severe criticism. The over-emphasis on rules and procedures, record keeping and paperwork may become more important in its own right than as a means to an end.

1. Officials may develop a dependence upon bureaucratic status, symbols and rules. 2. Initiative may be stifled and when a situation is not covered by a complete set of rules or procedures there may be a lack of flexibility or adaptation to changing circumstances. 3. Position and responsibilities in the organisation can lead to officious bureaucratic behaviour. There may also be a tendency to conceal administrative procedures from outsiders. 4. Impersonal relations can lead to stereotyped

behaviour and a lack of responsiveness to individual incidents or problems.

The Human Relations Approach

During the 1920s, the years of the Great Depression, greater attention began to be paid to the social factors at work and to the behaviour of employees within an organisation – that is, to human relations.

The Hawthorne Experiments: The turning point in the development of the human relations movement ('behavioural' and 'informal' are alternative headings sometimes given to this approach) came with the famous experiments at the Hawthorne plant of the Western Electric Company near Chicago, America (1924–32) and the subsequent publication of the research findings. There were four main phases to the Hawthorne experiments: 1. The illumination experiments; 2. The relay assembly test room;3. The interviewing programme; 4. The bank wiring observation room.

Social System Approach

Understanding the behaviour of groups & individuals.

Features: 1. Social System, a system of cultural relationship 2. Relationship exist between external and internal environment of the organisation. 3. Formal Organisation-Cultural relationships of social groups working within the organisation. 4. Co-operation necessary 5. Efforts directed -harmony between goals of organisation& goals of groups

Contingency or Situational Approach

The contingency approach is the latest approach to the existing management approaches. The contingency theory aims at integrating theory with practice in systems framework. The behaviour of an organisation is said to be contingent on forces of environment. "Hence, a contingency approach is an approach, where behaviour of one sub-unit is dependent on its environment and relationship to other units or sub-units that have some control over the sequences desired by that sub- unit." Thus behaviour within an organisation is contingent on environment, and if a manager wants to change the behaviour of any part of the organization, he must try to change the situation influencing it.

Features of Contingency Approach: 1. The contingency approach does not accept the universality of management theory. It stresses that there is no one best way of doing things. 2. Managerial policies and practices to be effective, must adjust to changes in environment. 3. It should improve diagnostic skills so as to anticipate and ready for environmental changes. 4. Managers should have sufficient human relations skill to accommodate and stabilise change. 5. Finally, it should apply the contingency model in designing the organization, developing its information and communication system,

Empirical Approach

Study of managerial experiences and cases (mgt)

Features: 1. Study of Managerial Experiences 2. Managerial experience passed from participation to students for continuity in knowledge management. 3. Study of Successful & failure cases help practicing managers. 4. Theoretical research combined with practical experiences.

Quantitative or Mathematical Approach or Management Science Approach

The main feature of this school is the use of mixed teams of scientists from several disciplines. It uses scientific techniques for providing quantitative base for managerial decisions. The exponents of this school view management as a system of logical process. It can be expressed in terms of mathematical symbols and relationships or models. Different mathematical and quantitative techniques or tools, such as linear programming, simulation and queuing, are being increasingly used in almost all the areas of management for studying a wide range of problems.

Operational Approach

1. Management is a process. 2. This school concentrates on the role and functions of managers and distils the principles to be followed by them.

Features: 1. Functions of managers remain same 2. Functions of management 3. core of good management 4. Framework of management 5. Principles of management

Decision Theory Approach

Manager –Decision maker

Organisation–Decision making unit.

Features: 1. Management is decision making. 2. Members of Organisation -decision makers and problem solvers. 3. Decision making -control point in management 4. ncreasing efficiency -the quality of decision 5. MIS, process & techniques of decision making are the subject matter of study.

Human Behaviour Approach

Organisation People

a) Interpersonal Behaviour Approach -Individual Psychology. b) Group Behaviour Approach - Organisation Behaviour

Features 1. Draws heavily from psychology & sociology. 2. Understand human relations. 3. Emphasis on greater productivity through motivation & good human relations 4. Motivation, leadership, participative management & group dynamics are core of this approach.

Social Action

Social action represents a contribution from sociologists to the study of organisations. The goals of the individual, and the means selected and actions taken to achieve these goals, are affected by the individual's perception of the situation. Social action looks to the individual's own definition of the situation as a basis for explaining behaviour. Conflict of interests is seen as normal behaviour and part of organisational life.

Bowey suggests-The three essential principles of action theory can be summarised as below: 1. Sociology is concerned not just with behaviour but with 'meaningful action'. 2. Particular meanings persist through reaffirmation in actions. 3. Actions can also lead to changes in meanings. 4. She gives four additional concepts, taken from systems theory, on which analysis of large-scale behaviour can be based in accordance with an action approach. **5. Role** – This is needed for the analysis of behaviour in organisations. It explains the similar action of different people in similar situations within the organisation and the expectations held by other people. **6. Relationships** – This is needed to explain the patterns of interaction among people and the behaviours displayed towards one another. **7. Structure** – The relationships among members of an organisation give rise to patterns of action which can be identified as a 'transitory social structure'. The social factors, and non-social factors such as payment systems, methods of production and physical layout, together form the behavioural structure. 8. Process – Human behaviour can be analysed in terms of processes, defined as 'continuous interdependent sequences of actions'. The concept of process is necessary to account for the manner in which organisations exhibit changes in structure.

Postmodernism: With the development of the information and technological age a more recent view of organisations and management is the idea of postmodernism. *Clegg described the postmodern* organisation in terms of the influence of technological determinism, structural flexibility, premised on niches, multiskilled jobs marked by a lack of demarcation, and more complex employment relationships including subcontracting and networking. Postmodernism rejects a rational systems approach to our understanding of organisations and management and to accepted explanations of society and behaviour. Highly flexible, free-flowing and fluid structures with the ability to change quickly to meet present demands form the basis of the new organisation.

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Digital Agriculture: Digitizing Agriculture in India

Ms. Nishu Kanwar Bhati

Ph.D. Scholar, College of Home Science, MPUAT, Udaipur.

Government's "Digital India" project launched on 1st July 2015 envisions empowering citizens with e-access to government services and livelihood related services, among others. The project has three core components, viz. digital infrastructure, digital services and digital literacy. Mobile phone is the preferred delivery medium with focus on mGovernance and mServices.

Given that 68 per cent of India's population is rural and agriculture is the main source of livelihood for 58 per cent of the population, one must consider the role of Digital Agriculture within Digital India. Digital Agriculture can be defined as ICT and data ecosystems to support the development and delivery of timely, targeted (localised) information and services to make farming profitable and sustainable (socially, economically and environmentally) while delivering safe, nutritious and affordable food for ALL. Rural connectivity will be key to providing low cost data and access to information. It would empower rural youth to realise their full potential, farmers to increase their profitability by accessing equitable markets and rural businesses to offer value added services. A few services under the umbrella of digital India, supporting farmers can be listed as under:

- **Soil Health Card:** It aims at promoting Integrated Nutrient Management (INM) through judicious use of chemical fertilisers including secondary and micro nutrients in conjunction with organic manures and bio-fertilisers for improving soil health and its productivity; strengthening of soil and fertiliser testing facilities to provide soil test based recommendations to farmers for improving soil fertility; ensuring quality control requirements of fertilisers, bio-fertilisers and organic fertilisers under Fertiliser Control Order, 1985; upgradation of skill and knowledge of soil testing laboratory staff, extension staff and farmers through training and demonstrations; promoting organic farming practices etc.

- **Pusa Krishi:** With the vision to take technology to the farm fields, Pusa Krishi application was developed. The app helps the farmers to find easy solutions to problems in their farm fields and get information about weather and accordingly take measures to save crops. It also offers information related to new varieties of crops developed by Indian Council of Agriculture Research (ICAR), resource conserving cultivation practices as well as farm machinery and its implementation will help in increasing returns to farmers.
- **mKisan SMS Portal:** It has been conceptualised to give a quantum leap in coverage of farmers and geographical area in a timely, specific, holistic and need based knowledge dissemination among the farmers by leveraging the power of mobile telephony in such a way that all sectors use this platform to not only reach out to the farmers but also to address their concerns and queries.
- **Kisan Suvidha:** It is an omnibus mobile app developed to help farmers get relevant information instantly. The app provide information on various details such as weather, market prices, seeds, fertilizers, pesticides, agriculture machinery, dealers, agro advisories, plant protection and IPM practices etc. Other unique features like extreme weather alerts, market prices of commodity in nearest area and the maximum price in state as well as in India have been added to empower farmers in the best possible manner.
- **FMS:** The FMS software monitors movement of various fertilisers at various stages in their value chain. The website provides information on fertiliser companies dealing with these fertilisers, the rate of concession on each fertiliser, its MRPs and productwise / statewise details of despatch and receipts of fertilisers at different destinations across the country.
- **Farmer portal:** It is envisaged to make available relevant information and services to the farming community and private sector through the use of information and communication technologies, to supplement the existing delivery channels provided for by the department. Farmers' Portal is an endeavour in this direction to create one stop shop for meeting all informational needs relating to Agriculture, Animal Husbandry and Fisheries sectors production, sale/storage of an Indian farmer. With this Indian Farmer will not be required to sift through maze of websites created for specific purposes.
- **eNAM:** National Agriculture Market (NAM) is a pan-India electronic trading portal which networks the existing APMC (Agriculture Produce Marketing Committee) mandis to create a unified national market for agricultural commodities. The NAM Portal provides a single window service for all APMC related information and services. This includes commodity arrivals and prices, buy and sell trade offers and 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.
- **Crop Insurance mobile app:** Itcan be used to calculate the Insurance Premium for notified crops based on area, coverage amount and loan amount in case of loanee farmer. It can also be used to get details of normal sum insured, extended sum insured, premium details and subsidy information of any notified crop in any notified area.
- **Agrimarket app:** The mobile application has been developed with an aim to keep farmers abreast with the crop prices and discourage them to carry-out distress sale. Farmers can get information related to prices of crops in markets within 50km of their own device location using the AgriMarket Mobile App. This app automatically captures the location of the farmers using mobile GPS and fetches the market prices of crops which fall within the range of 50km. The prices of agri commodities are sourced from the Agmarknet portal. Currently, the apps is available in English and Hindi languages.

Digital agriculture will also help achieve the objectives of the National Food Security Act in the most efficient, effective and equitable manner to ensure ALL have access to safe, nutritious and affordable food.

89. FOOD PROCESSING AND PROCESSING 15355

Preservation Techniques of Food by Smoking

Arjuman Banu, Farheen Taj, and Ramya K. G.

KVK, Konehalli, Tiptur Taluk, Tumakuru Dist. Karnataka State

INTRODUCTION: Smoking, in food processing, the exposure of cured meat and fish products to smoke for the purposes of preserving them and increasing their palatability by adding flavour and imparting a rich brown colour. The drying action of the smoke tends to preserve the meat, though many of the chemicals present in wood smoke (*e.g.,* formaldehyde and certain alcohols) are natural preservatives as well. Smoking is one of the oldest of food preservation method. The smoking technique involves hanging the meat or placing it on racks in a chamber designed to contain the smoke. Commercial smokehouses, usually several stories high, often use steampipes to supplement the heat of a natural sawdust fire. Hickory sawdust is the preferred fuel. Generally, smokehouse temperatures vary from 109° to 160° F (43° to 71° C), and smoking periods vary from as short as a few hours to as long as several days, depending on the type of meat and its moisture content. the purpose have successfully used the smoking technique to flavour and preserve not only meat, fowl, and fish but also cheeses, nuts and seeds, hard-boiled eggs, and berries, as well as the variety meats including heart, tongue, and liver is achieved using methods perfected over centuries. (Janes, Hilly Smoked food; 10/10/2001)

Types

Cold Smoking can be used as a flavour enhancer for items such as chicken breasts, beef, pork chops, salmon, scallops, and steak. The item is hung first to develop a pellicle, then can be cold smoked for just long enough to give some flavour. Some cold smoked foods are baked, grilled, steamed, roasted, or sautéed before eating. Smokehouse temperatures for cold smoking are typically done between 20 to 30 °C (68 to 86 °F). In this temperature range, foods take on a smoked flavour, but remain relatively moist. Cold smoking does not cook foods. Meats should be fully cured before cold smoking.

Hot smoking exposes the foods to smoke and heat in a controlled environment. Like cold smoking, the item is hung first to develop a pellicle, then smoked. Although foods that have been hot smoked are often reheated or cooked, they are typically safe to eat without further cooking. Hams and ham hocks are fully cooked once they are properly smoked. Hot smoking occurs within the range of 52 to 80 °C (126 to 176 °F).[6] Within this temperature range, foods are fully cooked, moist, and flavourful. If the smoker is allowed to get hotter than 185 °F (85 °C), the foods will shrink excessively, buckle, or even split. Smoking at high temperatures also reduces yield, as both moisture and fat are "cooked" away.

Smoke roasting or **smoke baking** refers to any process that has the attributes of smoking combined with either roasting or baking. In North America, this smoking method is commonly referred to as "barbecuing", "pit baking", or "pit roasting". It may be done in a smoke roaster, closed wood-fired masonry oven or barbecue pit, any smoker that can reach above 250 °F (121 °C), or in a conventional oven by placing a pan filled with hardwood chips on the floor of the oven so the chips smoulder and produce a smoke bath. However, this should only be done in a well-ventilated area to prevent carbon monoxide poisoning.

Wood Smoke: Hardwoods are made up mostly of three materials: cellulose, hemicellulose, and lignin. Cellulose and hemicellulose are the basic structural material of the wood cells; lignin acts as a kind of cell-bonding glue. Some softwoods, especially pines and firs, hold significant quantities of resin, which produces a harsh-tasting soot when burned; these woods are not often used for smoking. Cellulose and hemicellulose are aggregate sugar molecules; when burnt, they effectively caramelize, producing carbonyls, which provide most of the colour components and sweet, flowery, and fruity aromas. Lignin, a highly complex arrangement of interlocked phenolicmolecules, also produces a number of distinctive aromatic elements when burnt, including smoky, spicy, and pungent compounds such asguaiacol, phenol, and syringol, and sweeter scents such as the vanilla-scented vanillin and clove-like isoeugenol. Guaiacol is the phenolic compound most responsible for the "Smokey" taste, while syringol is the primary contributor to smokyaroma. Wood also contains small quantities of proteins, which contribute roasted flavour's. Many of the odour compounds in wood smoke, especially the phenolic compounds, are unstable, dissipating after a few weeks or months. A number of wood smoke compounds act as preservatives. Phenol and other phenolic compounds in wood smoke are both antioxidants, which slow rancidification of animal fats, and antimicrobials, which slow bacterial growth. Other antimicrobials in wood smoke include formaldehyde, acetic acid, and other organic acids, which give wood smoke a low pH—about 2.5. Some of these compounds are toxic to people as well, and may have health effects in the quantities found in cooking applications.

Since different species of trees have different ratios of components, various types of wood do impart a different flavour to food. The optimal conditions for smoke flavor are low, smouldering temperatures between 570 and 750 °F (299 and 399 °C). This is the temperature of the burning wood itself, not of the smoking environment, which uses much lower temperatures. Woods that are high in lignin content tend to burn hot; to keep them smouldering requires restricted oxygen supplies or a high moisture content.

Types of Smokers

There are a few basic types of smoker designs, each with their own advantages and disadvantages.

Offset smokers: The main characteristics of the offset smoker are that the cooking chamber is usually cylindrical in shape, with a shorter, smaller diameter cylinder attached to the bottom of one end for a firebox. To cook the meat, a small fire is lit in the firebox, where airflow is tightly controlled. The heat and smoke from the fire is drawn through a connecting pipe or opening into the cooking chamber. The heat and smoke cook and flavor the meat before escaping through an exhaust vent at the opposite end of the cooking chamber. Most manufacturers' models are based on this simple but effective design, and this is what most people picture when they think of a "BBQ smoker." Even large capacity commercial units use this same basic design of a separate, smaller fire box and a larger cooking chamber.

Upright drum smoker: The upright drum smoker (also referred to as an ugly drum smoker or UDS) is exactly what its name suggests; an upright steel drum that has been modified for the purpose of pseudo-indirect hot smoking. There are many ways to accomplish this, but the basics include the use of a complete steel drum, a basket to hold charcoal near the bottom, and cooking rack (or racks) near the top; all covered by a vented lid of some sort. They have been built using many different sizes of steel drums (30 US gallons (110 l; 25 imp gal), 55 US gallons (210 l; 46 imp gal), and 85 US gallons (320 l; 71 imp gal) for example), but the most popular size is the common 55 gallon drum. This design is similar to smoking with indirect heat due to the distance from the coals and the racks (typically 24 inches (61 cm)). The temperatures used for smoking are controlled by limiting the amount of air intake at the bottom of the drum, and allowing a similar amount of exhaust out of vents in the lid. UDSs are very efficient with fuel consumption and flexible in their abilities to produce proper smoking conditions, with or without the use of a water pan or drip pan. Most UDS builders/users would say a water pan defeats the true pit BBQ nature of the UDS, as the drippings from the smoked meat should land on the coals, burning up, and imparting a unique flavour one cannot get with a water pan.

Vertical water smoker: A vertical water smoker (also referred to as a bullet smoker because of its shape) is a variation of the upright drum smoker. It uses charcoal or wood to generate smoke and heat, and contains a water bowl between the fire and the cooking grates. The water bowl serves to maintain optimal smoking temperatures and also adds humidity to the smoke chamber. It also creates an effect in which the water vapour and smoke condense together, which adds flavour to smoked foods. In addition, the bowl catches any drippings from the meat that may cause a flare-up. Vertical water smokers are extremely temperature stable and require very little adjustment once the desired temperature has been reached. Because of their relatively low cost and stable temperature, they are sometimes used in barbecue competitions where propane and electric smokers are not allowed.

Propane smoker: A propane smoker is designed to allow the smoking of meat in a somewhat more controlled environment. The primary differences are the sources of heat and of the smoke. In a propane smoker, the heat is generated by a gas burner directly under a steel or iron box containing the wood or charcoal that provides the smoke. The steel box has few vent holes, on the top of the box only. By starving the heated wood of oxygen, it smokes instead of burning. Any combination of woods and charcoal may used. This method uses less wood.

Smoke box method: This more traditional method uses a two-box system: a fire box and a food box. The fire box is typically adjacent or under the cooking box, and can be controlled to a finer degree. The heat and smoke from the fire box exhausts into the food box, where it is used to cook and smoke the meat. These may be as simple as an electric heating element with a pan of wood chips placed on it, although more advanced models have finer temperature controls.

Commercial smoke house: Commercial smokehouses, mostly made from stainless steel, have independent systems for smoke generation and cooking. Smoke generators use friction, an electric coil or a small flame to ignite sawdust on demand. Heat from steam coils or gas flames is balanced with live steam or water sprays to control the temperature and humidity. Elaborate air handling systems reduce hot or cold spots, to reduce variation in the finished product. Racks on wheels or rails are used to hold the product and facilitate movement. (Briefing: Smoked Food The Herald, 2/19/2002)

Preservation

Smoke is an antimicrobial and antioxidant, but smoke alone is insufficient for preserving food in practice, unless combined with another preservation method. The main problem is the smoke compounds adhere only to the outer surfaces of the food; smoke does not actually penetrate far into meat or fish. In modern times, almost all smoking is carried out for its flavour. Artificial smoke flavouring can be purchased as a liquid to mimic the flavour of smoking, but not its preservative qualities. In the past, smoking was a useful preservation tool, in combination with other techniques, most commonly salt-curing or drying. In some cases, particularly in climates without much hot sunshine, smoking was simply an unavoidable side effect of drying over a fire. For some long-smoked foods, the smoking time also served to dry the food. Drying, curing, or other techniques can render the interior of foods inhospitable to bacterial life, while the smoking gives the vulnerable exterior surfaces an extra layer of protection. For oily fish smoking is especially useful, as its antioxidant properties delay surface fat rancidification. (Interior fat is not as exposed to oxygen, which is what causes rancidity.) Some heavily-salted, long-smoked fish can keep without refrigeration for weeks or months. Such heavily-preserved foods usually require a treatment such as boiling in fresh water to make them palatable before eating.

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90. FOOD TECHNOLOGY 15822

Biodegradation of Xenobiotics

P. Jayamma

Assistant Professor, Dept. of Food Safety and Quality Assurance
College of Food Science & Technology, Pulivendula, Kadapa

Biodegradation of Xenobiotics

A xenobiotic compound is a synthetic chemical that is not naturally occurring. Xenobiotics include pesticides, polychlorinated biphenyls (PCBs), munitions, dyes, and chlorinated solvents, among other things. Some xenobiotics are structurally related to natural compounds and can sometimes be degraded slowly by enzymes that degrade the structurally related natural compounds. However, many xenobiotics differ chemically in such a major way from anything organisms have naturally experienced that they degrade extremely slowly, if at all. We focus here on pesticides as an example of the potential of microbial xenobiotics degradation.

Pesticide Catabolism: Some of the most widely distributed xenobiotics are pesticides, which are common components of toxic wastes. Over 1000 pesticides have been marketed foe chemical pest control purposes. Pesticides include herbicides, insecticides, and fungicides. Pesticides display a wide variety of chemistries, including chlorinated, aromatic and nitrogen and phosphorous containing components. Some of these substances can be used as carbon sources and electron donors by microorganisms, whereas others cannot.

If a xenobiotic substance can be biodegraded, it will eventually disappear from a habitat. Such degradation in the soil is desirable because toxic accumulations of the compound are avoided. However, even closely related compounds may differ remarkably in their degradability. Some compounds persist relatively unaltered for years in soils where as others are significantly degraded in only weeks or months. For example, some of the chlorinated insecticides are so recalcitrant that they can persist for several years in soil.

The relative persistence rates of xenobiotics are only approximate because environmental factors-temperature, p^H, aeration, and organic matter content of the soil –also influence decomposition. Moreover disappearance of a pesticide from an ecosystem does not necessarily mean that it was degraded by microorganisms; pesticides can also be removed by volatilization, leaching, or spontaneous chemical breakdown. Substrate availability also governs microbial attack of xenobiotic compounds. Many xenobiotics are quite hydrophobic and poorly soluble in water. Adsorption of these compounds to organic matter and clay in soils and sediments prevents access by organisms. Thus the addition of surfactants or emulsifiers often increases bioavailability, and ultimately biodegradation, of the xenobiotic compound.

Many bacteria and fungi metabolize pesticides and herbicides. Some pesticides can be both carbon and energy sources and are oxidized completely to CO_2 however other compounds are attacked only slightly, if at all. Some compounds may be degraded either partially or totally provided that some other organic material is present as primary energy source. This is a phenomenon called cometabolism. However if the breakdown is only partial, the microbial degradation product may be even more toxic than the original compound. Thus, from an environmental stand point, cometabolism of xenobiotics is not always a good thing.

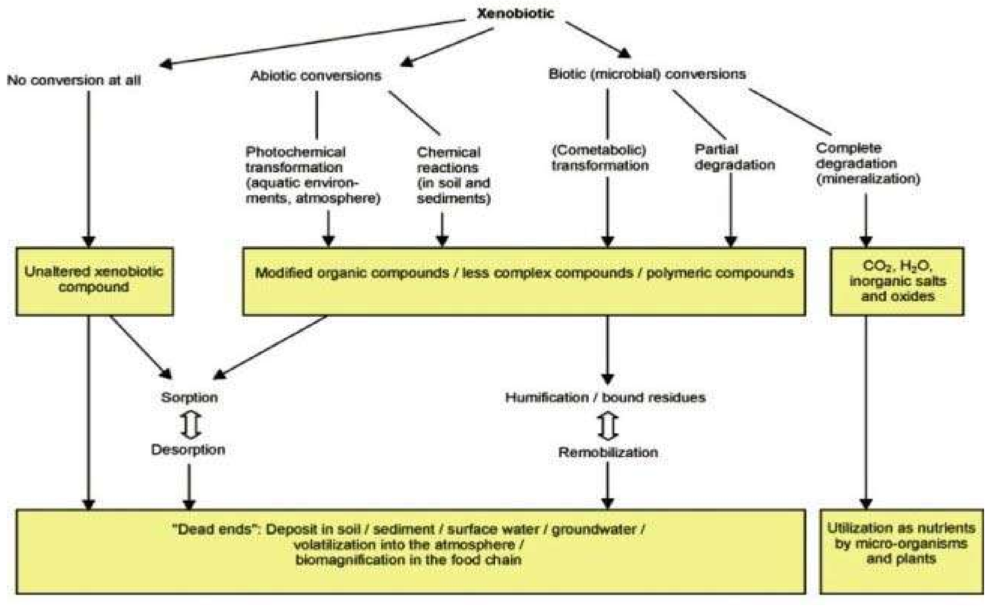

FIGURE 1. Possible environmental fate of a xenobiotic compound

91. FOODS AND NUTRITION 15781

Foxtail Millet: Health and Nutrition Fact

Priyanshu Tripathi

Research Scholar, College of Home Science, MPUAT, Udaipur

INTRODUCTION: Foxtail millet (*Setaria italica* L.) is one of the earliest cultivated crops, extensively grown in the arid and semi-arid regions of Asia and Africa, as well as in some other economically developed countries of the world where it is more commonly used as bird feed. Like most millet varieties, foxtail millet remains under-utilized as a food source. Like most millet varieties, foxtail millet remains under-utilized as a food source.

Nutritive Value: 100 grams of Foxtail millet contains 12 g of moisture, 351 calories, 11.2 g of protein, 4 g of total fat, 63.2 g of carbohydrate and 6.7 g of crude fiber. It grants 803 g of isoleucine, 1764 g of leucine, 103 g of tryptophan, 328 g of threonine, 233 g of lysine, 0.6 mg of thiamin, 63.2 g of carbohydrate, 2.8 mg of iron, 11.2 mg of protein, 3.2 mg of niacin, 4 g of lipid fat, 0.1 mg of riboflavin and 31 mg of calcium.

Health Benefits of Foxtail Millet: Foxtail millets are rich in calories that provide energy and strength to the body to perform activities. It is widely cultivated in India, Africa and China. It is considered as the perfect substitute for the healthy diets.

Controlling Blood Sugar Level: Foxtail millets are a common prescription by the doctor to the diabetic patients, to curb their blood sugar level. The foxtail millets are known to bring down blood glucose, by a degree of 70%. Foxtail millets have the potential to positively bring down triglycerides, LDL (Low density Lipoprotein) and VLDL (very-LDL). These three components severely increase the rate of diabetes in a human body. On the other hand, foxtail millets are known to increase the HDL (High Density Lipoproteins), which significantly lowers the level of blood sugar.

Reducing Heart Attack Risk: As the foxtail millets have the power to regulate and lowering the blood sugar of the body, it reduces the chances of coronary blockage that results in cardiac arrest and fatalities. Heart attacks take place since the arterial walls of the heart becomes blocked and damaged. Low sugar count in the blood reduces such an eventuality. Foxtail millets reduce the level of triglycerides in our body, which automatically controls the reins of heart diseases.

Moreover, the foxtail millets are known to be least reactive to the C-reactive proteins, which roughly indicate the possibilities of ruptures or inflammation within the wall of the artery. Therefore, using foxtail millets would result in a strong deterrence to cardiovascular diseases.

High in Anti-Oxidants: The millets family has a long history of possessing phenols in them, in varying amount. Foxtail millets, hence, is not an exception. It contains a fair amount of phenolic, which is a strong antioxidant, used to get rid of the toxins that go rampant inside the body. A toxin free body is obviously a healthy one.

Traditional Uses

- The grain of Foxtail millet is used in China as an astringent and emollient in choleric affections and diarrhea.
- The seeds are used in India as a diuretic, to strengthen virility, treat indigestion, dyspepsia and rheumatism.
- It helps to treat food stagnancy.
- The seeds (green) help to reinforce virility.
- The white seeds are useful for fever and cholera.
- In Pakistan, the crushed seeds are combined with ghee and consumed for the sexual vigor or potency.
- The decoction made from Setaria oil and bark of Acacia modesta is used as a tonic or to raise fertility in females and males.
- It is used in India to enhance vigor and treat bone fractures.
- The cooked grains are used in Chhattisgarh as a cure for diarrhea.
- The paste is externally used as a cure for swellings.
- It is combined with other herbs to cure dysuria.
- In Aurangabad, the decoction made from the whole plant is used internally for rheumatism and reduce the pains caused due to parturition.
- The seeds are used to treat diabetes.
- In Western Himalaya, it is combined with cow's curd in order to treat measles.

92. FOODS AND NUTRITION 15839

A Review on Relationship of Menarche Age with Anthropometric Profiles

Kirti M. Tripathi

Krishi Vigyan Kendra, Bulandshahr, SVPUA&T, Meerut

Menarche (first menstrual period) and menopause (end of menstruation) are the two major components in the reproductive life of women. Since the interval between two events determines the natural reproductive period during which female can procreate. As these two biological traits have important cultural, social and epidemiological implications. Increasing attention has been recently devoted by scientists to understanding the causes of age variations in the timing of these events (Thomas *et al.,* 2001).

Studies shows earlier menarche is associated with attaining the critical weight more quickly. Conversely, a late menarche is associated with body weight growth that is slower prenatally, postnatal or both. (Hardy *et al.,* 2000; Akohoshi *et al.,* 2002).

The landmark of pubertal events in girls is the onset of puberty, Peak Height Velocity (PHV) and menarche. Menarche is a rather late event in puberty and usually occurs after PHV is achieved (Hardy *et al.,* 2000). The menarche age is often investigated for various reasons it is the one of the major index of the menopause. There have been studies on role of height, weight and body structure on the menarche age; however there is a disagreement on the role of these factors. Pejhan *et al.,* (2011) considered that some body fat is necessary in female adolescents and an optimal weight is required for onset the menstruation.

Karaponou, 2010 estimated that throughout most of the 20th century the average age at menarche has been falling by around three months each decade. In the 19th century the average age at menarche was between 17 and 18 years, by the 1990's this had dropped to between 12 and 13 year and now it is uncommon for girls as young as 8 to have menarche (Berenjy *et al.,* 2008). According to Sachan (2012) and Bagga (2000) overall mean age at menarche was 12.84 years.

Menstruation is considered a sign of sexual health during the adolescence and fertility age of women. Historically, it has been celebrated as the gift of puberty in many human societies. Puberty is the result of hormonal changes in the hypothalamus-pituitary-gonad axis. This axis is stimulated weakly by placental hormones in the female fetus and it leads to secretion of gonadotropin releasing hormone (GnRH) in the neonatal period. This hormone decreases and remains minimal up to adolescence when the occurrence of first menstruation marks it rapid increase (Bayat *et al.,* 2012).

The age at menarche (first menstruation) is clinically valuable, since it forms a basis for diagnosing delayed puberty and pathologic and hormonal disorders. The age of first menstruation is different among various ethnicities. In the United States, the average age at menarche has shifted from 12.75 to 12.54 years over a period of 25 years. The age at menarche is reportedly 12.9 years in Europe, 12.5-12.9 in different regions of India, and 13.3 years in Africa (Anderson *et al.,* 2003; Bektas, 2008).

Data showing later onset of menarche among girls of parents with lower educational level, which may be a menarche tends to be earlier with urbanization. Age of menarche is also affected by ethnicity, social class differences, number of siblings, and secular trends (Gharravi *et al.,* 2008).

Higher subcutaneous fat level and BMI pre pubertal ages are associated with increased likelihood of early menarche (Pourarom *et al.,* 2003). Menarche occurred earlier in girls who were taller girls and girls with more body fat have earlier menarche. Girls who were heavier at 7 year had earlier menarche, found delayed maturation among girls who were stunted during the preschool years. Higher BMI and longer sum of skin folds were strongly associated with earlier menarche (Gharravi *et al.,* 2008; Onland-Moret *et al.,* 2005).

Firsch (1974) believes that in order to short menstruation girls need to achieve a minimum weight of 47.8 kg and more importantly, their body fat should amount to 23.7 % (from 16%) therefore, the puberty starts earlier in medium obese girls (with 20-30% overweight than normal) than in girls with normal weight, in contrast, girls with malnutrition will experience a delay in menstruation (Pejhan *et al.,* 2011; Thomas *et al.,* 2001; Frisch *et al.,* 1974; Norgan *et al.,* 1997). There is a vast amount of literature at a later age will eventually grow taller compared with women who reach their menarche at an earlier age (Onland-Moret *et al.,* 2005).

The girls who achieved menarche earlier (between 9-11 years) showed the maximum mean body weight (46 kg) among the three age groups, being 5 kg more than the mean weight of the girls in ideal age group. The late menarche group of girls showed the least mean body weight (37 kg) which was about 4.5 kg less than that of the ideal group. A similar trend was observed for maximum mean body height (154.84 cm) which was shown by girls who attained early menarche (between 9-11 years). Minimum height was observed for the girls in the late menarche age group (Pejhan *et al.,* 2011). Less extensive training or weight loss may result in anovulatory menstrual cycle, or a shortened luteal phase. These disruptions of reproductive ability are due to hypothalamic dysfunction, which is correlated with weight loss or excessive leanness. It is proposed that these associations are causal and that the high percentage of body fat (26-28%) in the mature human female may influence the reproduction. (Akahoshi *et al.,* 2002).

Conclusion: The mean age at menarche is decreasing continuously from 20 years in ethnic groups. Although the main timing of puberty changes is the genetic factors, other factors such as geographical location, general health status, nutrition and socioeconomic status affect the onset of menstruation and its progression. Implementing educational plans to enhance the knowledge of the adolescent girls on their habits of nutrition and providing them with appropriate eating patterns is recommended, to change their lifestyle, so that implications resulting from lowered menarche age (such as preterm labor, sexually transmitted disease, cultural hassles, etc) are prevented to a large extent. Educational program implemented in schools can play a significant role in the preliminary prevention of nutritional disorders. The obesity problem in the adolescents may be solved through the cooperation of school officials, families and adolescents themselves.

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93. BOTANY 15366

Root System Architecture

Anil Kumar, Reena Rani, Sunayana and Sukhdeep Singh Sivia

Ph.D. Scholar, Department of Genetics and Plant Breeding, CCSHAU, Hisar-125004

Introduction: It is easy to think of plants purely in terms of the clearly visible, above-ground parts of plants, such as leaves, flowers, fruits and stems; however, this is only half the story. Plants also demonstrate a considerable degree of variability in the less visible underground elements: root systems. Root system architecture (RSA) varies between species, and also within species, subject to genotype and environment (Lynch, 1995). Roots are important to plants for a wide variety of processes, including nutrient and water uptake, anchoring and mechanical support.

Root architecture has traditionally been largely ignored by plant breeders in terms of potential yield increases, and was not a major selection criterion as part of the crop development programmes of the 1960s' green revolution (Waines and Ehdaie, 2007). Understanding the development and architecture of roots thus holds potential for the exploitation and manipulation of root characteristics to both increase plant yield and optimize agricultural land use.

Why Root System Architecture?

Achieving grain supply security with limited arable land will present a major challenge in the twenty first century, owing to the growing world population and changing climate. The global population is expected to reach nine billion by 2050 representing an additional two billion people to feed. About one-third of the earth's land surface is arid, and there are very few areas, even in the humid tropics, that are not subject to periodic drought of sufficient duration to inhibit plant growth. Nutrient limitations are less well appreciated but may be equally important. Suboptimal availability of N and P is nearly universal, and acidity, salinity, and base imbalances are common in native soils.

The importance of root architecture in plant productivity stems from the fact that many soil resources are unevenly distributed, or are subject to localized depletion, so that the spatial deployment of the root system will in large measure determine the ability of a plant to exploit those resources.

What is Root System Architecture?

Root system architecture (RSA) is the what, when, and where of root growth. RSA on a macroscale describes the organization of the primary and lateral roots, and also accessory roots (including other root types found in cereals) where they are present, and is a key determinant of nutrient and water-use efficiency in plants. On a microscale, this includes root hairs that increase the surface area, aiding with uptake of water and nutrients. The structure of a plant root system can be defined by what classes of roots are present, their angles of growth, how often they branch, and their diameters, among many other traits. In RSA functional-structural modelling, this information is used to recreate realistic plant root systems.

Strategies for Root System Architecture

Root architecture, the spatial arrangement of a root system, has been shown to be important in agricultural systems and natural systems for nutrient acquisition, plant interactions, and nutrient cycling. Understanding the contribution of specific root traits, or phenes, to root system function is critical for crop improvement because it allows identification of traits that contribute desired functions.

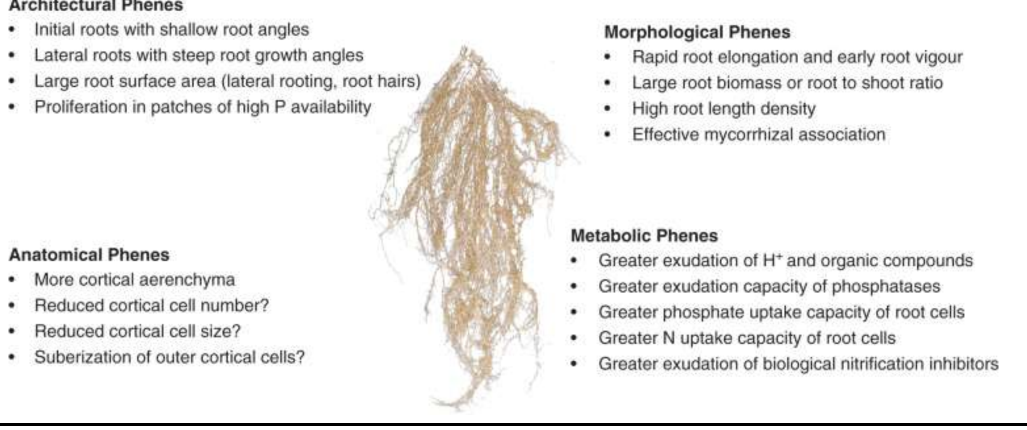
Phenes can be classified in numerous ways. A mechanistic classification of root phenes can be made on the basis of whether they primarily affect resource acquisition or resource utilization. The novel modelling of root hair development indicates that the greatest gains in P-uptake efficiency are likely to be made through increased length and longevity of root hairs rather than by increasing their density. Root traits associated with maintaining plant productivity under drought include small fine root diameters, long specific root length, and considerable root length density, especially at depths in soil with available water (Lynch, 2007).

Classification of Root Phenes. (York *et al.,* 2013)

Root phenes	Mechanism	Foraging	Economy
Axial root growth angle	Acquisition	Exploration	Neutral
Root growth rate	Acquisition	Exploration	Influencing
Number of axial roots	Acquisition	Exploration	Influencing
Lateral root branching	Acquisition	Exploitation (N)	Influencing
Root hair density	Acquisition	Exploitation (P)	Neutral
Root hair length	Acquisition	Exploitation (P)	Neutral
Rhizosphere modification	Acquisition	Exploitation (P)	Influencing
Aerenchyma	Utilization		Influencing
Root etiolation	Utilization		Influencing

Combining a number of root architectural, morphological, anatomical and metabolic phenes for improved adaptation to soils with low fertility and drought tolerance will require multidisciplinary approaches. Collaboration between breeders and physiologists contributes to defining appropriate root phenes that can serve as selection criteria for breeding, and to help design selection schemes and methods to address major soil constraints.

Root Adaptations to Infertile Soils



Rao *et al.,* 2016

Root observation and phenotyping is often an important and a required part of abiotic stress research, especially in breeding and selection. The available information on methods of root research is very large, scattered and often difficult to resolve towards one's work. High-throughput root phenotyping is an important tool in this context as it permits the profiling of the extent, magnitude, and distribution of root traits in crop germplasm, and because phenotyping is limiting progress in crop breeding. Advances in high-throughput phenotyping of roots will enable focused efforts to improve crop nutrient acquisition by selection for root ideotypes and to understand the influence of inter-and-intraspecific root system variation on community structure and ecosystem function. Several software packages have been developed for imaging roots and extracting quantitative data from captured root images. A few examples of these software tools include RootScan, RootNav, DART, GiARoots, IJ Rhizo, RootSystemAnalyzer, RootReader, RootReader3D and RooTrak.

Conclusion: Plants depend on their root systems to acquire the water and nutrients necessary for their survival in nature, and for their yield and nutritional quality in agriculture. Root systems are complex and a variety of root phenes have been identified as contributors to adaptation to soils with low fertility and drought tolerance. Phenotypic characterization of root adaptations to infertile soils is enabling plant breeders to develop improved cultivars that not only yield more, but also contribute to yield stability and nutritional security in the face of climate variability.

Advanced root phenotyping tools will allow dissection of root responses into specific root phenes that will aid both conventional and molecular breeders to develop superior cultivars. These new cultivars will play a key role in sustainable intensification of crop–livestock systems, particularly in smallholder systems of the tropics. Development of these new cultivars adapted to soils with low fertility and drought tolerance is needed to improve global food and nutritional security and environmental sustainability.

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94. ENVIRONMENTAL SCIENCE 15784

Climate Change: Impacts and Adaptation Strategies for Smallholder Farmers

Himani Bisht and Shaloo

Water Technology Centre, ICAR-IARI, New Delhi-110012

Climate change refers to a change in the state of the climate by changes in the mean and/or the variability of its properties that persists for an extended period of time. It is caused by many factors such as variations in solar radiation, volcanic eruptions and emission of Greenhouse gases (GHSs) affecting the temperature, rainfall, crop evapo-transpiration etc. Global temperature rise, results in warming of oceans, shrinking ice sheets affecting the changes in hydrologic cycle. The global-scale precipitation is projected to gradually increase in the 21st century but many subtropical arid and semi-arid regions are likely to experience less precipitation. The model predictions indicated that the runoff may increase in Northern latitudes and decrease in Southern regions (IPCC, 2014). The potential future effects of global climate change include more frequent extreme events such as wildfires; increase in frequency, duration and intensity of droughts and floods, tropical cyclones (IPCC, 2007).

Vulnerability of Smallholder Farmers to Climate Change

Indian agriculture is facing challenges due to climate change and increasing climatic variability such as droughts, floods, tropical cyclones, heat waves are known to negatively impact agricultural production and livelihood of farmers. Although climate change affects the agricultural sectors in different ways, but smallholders whose main source of livelihood derives from agriculture are most vulnerable. With no access to advanced infrastructure and resources, even small changes in climate can have disastrous impacts on their livelihoods. Reduction of crop yields, water logging of soils, increased livestock disease and mortality and salinization of water can all be expected to affect the productivity and food security of smallholder farmers especially in developing countries. Helping these small farmers to adapt to the climate change can have a big impact on creating sustainable food security.

Impacts of Climate Change on Crop Production

Climate change has been and will continue to be a critical factor affecting the agriculture sector due to the dependence of agricultural sectors on optimal climatic conditions and water availability. Crop production is sensitive to temperature, increasing carbon dioxide concentration as well as change in precipitation. It has been projected by the recent report of the IPCC and a few other global studies that unless we adapt, there is a probability of 10–40% loss in crop production in India by 2080–2100 due to global warming **(IPCC, 2007)**, despite beneficial aspects of increased CO_2. Projections indicate the possibility of loss of 4–5 million tonnes in wheat production with every rise of 1°C temperature throughout the growing period with current land use **(Agarwal, 2008)**. A study at the International Rice Research Institute (IRRI) observed that for every 1°C increase in mean night time temperature, rice yields declined by 10%. Increasing rate of evaporation and transpiration due to higher surface temperature also reduces availability and quality of water for agricultural as well as human consumption **(ADB 2009)**. With per

1°C increase in temperature will cause reduction in rice production by 4% - 20%, maize production by 32% - 50% and wheat production by 5% - 20% (**Kumar *et al.*, 2011**). Global warming would cause more rainfall in some areas, which would lead to an increase of atmospheric humidity and the duration of the wet seasons. Combined with higher temperatures, these could favour the development of fungal diseases and could increase pressure from insects and disease vectors. Fruit trees are severely affected by fluctuations in temperature and rainfall, which caused massive flower abortion, fruit dropping, reduction in fruit development and a massive attack of insects and aphids.

Adaptation to climate change: Adaptation can be the most efficient way for farmers to reduce the negative impacts of climate change. This can be achieved through:

1. Identify and promote faster-maturing varieties that are drought, heat, pest, virus, disease, and saline tolerant.
2. Change in cropping pattern by introduction of new crops and varieties to add to or replace existing crops and varieties. Crop diversification which allows farmers to change crops in future if required according to the longer-term temperature and precipitation changes. Changing cropping techniques/calendar is another common adaptation to climate variability at the farm level, which largely involves altering the timing of farm activities according to variations in climatic.
3. Optimize land-use systems, such as shifting from yield per hectare to 'crop-per-drop' systems.
4. Increase availability and efficient use of water for agriculture production through integrated water resource management practices, reduced reliance on erratic rainfall patterns, improved recharge of groundwater for irrigation and by adopting a range of water harvesting techniques, such as low-cost groundwater recharge methods, efficient irrigation systems and rainwater harvesting.
5. Protected production technologies such as greenhouses, polyhouses which protects from extreme weather events; reduced water usage from reduced evapo-transpiration, increases income through higher productivity and improved quality and reduced chemical input costs with pest barriers should be promoted.
6. Planting herbaceous and woody plants along farm contours and establishment of waste weirs to protect the soil from erosion caused by variations of rainfall and to conserve soil fertility. These practices are also coupled with mixed cropping and multi cropping can be an effort to reduce the negative impacts of climatic variability, and to increase crop yields as well as farm income.
7. Low tillage or no tillage practices to reduce soil erosion during heavy rainfall and for improving water holding capacity of soil.
8. Expanding the network of remote weather stations for improved pest and disease forecasting and control, early warning and climate change modeling.
9. Strengthen expertise in agricultural research, advisory and extension services on climate risk management and adaptation.
10. Establish robust seed, food and forage storage to protect farm products from extreme weather events.
11. Community-based adaptation by forming community organizations which encourage small farmers to harness their own knowledge and skills to enhance their resilience to climate change and variability.

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95. POULTRY SCIENCE 15842

Probiotic in Poultry Nutrition

Khwairakpam Ratika[1] and Rajkumar James singh[2]

[1]*Division of Dairy Cattle Nutrition, National Dairy Research Institute, Karnal-132001*

[2]*Division of Veterinary Biotechnology, Indian Veterinary Research Institute, Izatnagar, Bareilly-243122*

Feed accounts for about 70% of total poultry production cost. Economical poultry production largely depends on optimum utilization of feed, improved body weight, absence of disease and low mortality. Reaching to the highest body weight or maximum egg production in return for each unit of feed intake is the aim of commercial poultries. The poultry industry used antibiotic feed additives for disease prevention, growth and enhancing poultry production. Use of in-feed-antibiotics not only increases the cost of production but also leads to residues in meat and eggs and develops antibiotic resistance in human being consuming the poultry meat or egg. Thus, many countries have banned use of antibiotics in poultry industry. Alternatively, probiotics are used as feed additives for better production in poultry.

Probiotic, which means "for life" has been defined as "a live microbial feed supplement which beneficially affects the host animal by improving its intestinal balance". Probiotics are a dietary supplement that increase the population of microflora which are required in the intestinal tract in order to process feed properly, strengthen the immune system and help chickens to digest their feed more efficiently and helping remain healthy and gain weight faster in chickens. Most commonly used probiotics in poultry are *Lactobacillus*, *Bifidobacterium, Leuconostoccus, Enterococcus, Lactococcus, Bacillus, Saccharomyces, Aspergillus* and *Pediococcus species.*

Desirable Characteristics of Probiotics

- Be of host origin
- Non-pathogenic
- Withstand processing and storage
- Resist gastric acid and bile
- Adhere to epithelium or mucus
- Persist in the intestinal tract
- Produce inhibitory compounds
- Modulate immune response
- Alter microbial activities

Mode of Probiotic Action

- Modification of the microbial population of the gastrointestinal tract, promoting growth of favourable microflora.
- Increase in digestion and absorption of nutrients.
- Some probiotics produce antimicrobial substances that may inhibit growth of pathogenic micro-organisms in the intestine.
- Diets containing probiotics could modulate the host immune response.

Probiotics in Poultry Nutrition

Probiotics can improve broiler chicken growth rates. Supplementation of probiotic increased digestibility of feed resulting in improved feed use efficiency which could be one reason for improved growth rate. Also, the improvement in performance may be due to a change in microbial populations in the GIT resulting immuno-modulation. Probiotics in poultry diets can affect the histology of the intestinal mucosa. The villus height and the villus : crypt ratio in the intestinal mucosa are increased. Increased villus height increases absorption of nutrients from the intestine. Generally, increase in villus height and villus height : crypt ratio increases the absorption of nutrients due to a larger surface area.

The public health risk from zoonotic pathogens of poultry like Salmonella and antibiotic resistance is increasing with intensification of the poultry industry in developing countries. In addition, other enteric diseases of poultry, like necrotic enteritis and coccidiosis, cause huge economic losses to the industry. Probiotics could be a potential alternative to antibiotic feed additives to manage the enteric pathogen load in poultry, by reducing intestinal colonization and spread of common zoonotic and other enteric pathogens. Some probiotics produce short chain fatty acids (SCFA) in the caeca in sufficient amounts to inhibit *Salmonella spp*. Coccidiosis is the most important protozoan parasitic disease of poultry caused by different species of Eimeria protozoa that colonize different sections of the GIT. The probiotics were thought to maintain intestinal health in infected birds and reduced the shedding of oocysts from infected birds, thereby reducing the spread of disease.

Eggs production has been in relation to probiotic application. A combined mixed culture of *Lactobacillus acidophilus, Lactobacillus casei, Bifidobacterium thermophiles and Enterococcus faecium* enhanced egg size and lowered feed cost in laying hens.

Bifidobacterium thermophiles and Enterococcus faecium improved egg production and quality. Supplementation of probiotics increased egg shell weight, shell thickness and decreased broken egg ratio in layer. Probiotic has a role in improvement of meat quality of broilers.

96. VETERINARY 15783

Maternal Behaviour of Animals: A Way of Raising their Offspring

Sunil Kumar[1*] and Kuladip Prakash Shinde[2]

[1]Animal Physiology Division, ICAR-National Dairy Research Institute, Karnal, Haryana, INDIA
[2]Livestock Production Management Division, ICAR-National Dairy Research Institute, Karnal
*Corresponding Author E. Mail: dr.sunil8507@gmail.com

INTRODUCTION: Maternal behaviour is the bonding process in which animals learns to recognize her new calf and commits to caring them. These behaviors allow the animal to bond with her calf, protect and provide it with nourishment and ultimately break down this bond at weaning. It is a complex blend of hormonal induced and learned behaviour. Maternal behaviour is influenced by hereditary, experiential and hormonal factors. Primiparous females are most likely to neglect or attack their offspring. Mature animals that have had calves before are more apt to quickly mother their offspring than first time heifers. Changes in progesterone and estrogen levels initiate the birth process, while rising levels of oxytocin trigger maternal behaviour. Oxytocin is released not only from the posterior pituitary into the bloodstream, but also from the terminals of cells bodies lie in the periventricular area of the hypothalamus, the axon of which stimulate the neural mechanism underlying maternal activities in other parts of the brain. Brain oxytocin levels increases at parturition, at suckling and when the vagina stimulated and increasing oxytocin in the cerebrospinal fluid stimulate maternal behaviour. Its presence in the olfactory bulb of the brain plays role in smell and importance of odour in the bonding process, with the help of those animals recognizing their own calf. Cervical stimulation is crucial for proper hormonal trigger. Release of oxytocin is caused by stretching/stimulation of cervix *i.e.* gradual dilation of the cervix as fetus passes through birth canal with each uterine contraction. Hormonal priming by estrogen and progestrogene, plus vaginocervical stimulation, is necessary in order to reduce aggression towards, or withdrawal from, alien lambs by ewe. Experience is also necessary for full expression of maternal behaviour because only multiparous ewes would show positive maternal behaviour licking, sniffing and low pitched bleating after the combination of hormonal and vaginocervical stimulation.

The offspring may take somewhat longer to recognize its mother than the mother to recognize it. Litter bearing animals such as pigs, cats, and dogs are not as exclusive in their bonds. Nest building occurs in pigs and to a lesser degree in dogs and cats. Nursing is less frequent in hider species such as cattle and goats than in followers such as horses and sheep. Cows are social (gregarious) animals the maternal behaviour starts when they choose the nesting spot and leaves the rest of the group. Maternal behaviour divided into two parts: (i) care giving behaviour and (ii) care seeking behaviour phase. The care giving behaviour starts after parturition. After giving birth cow's sense of smell helps them to recognize their calf. Care giving behaviour evident when the cow starts to lick her calf after parturition in order to help thermoregulation system of calf by drying the coat. The first 5 minutes of grooming helps to motivate the urinal system. The grooming may last up to 30 minutes and grooming tightens the bond between the mother and young. The care giving behaviors of cows start to decline after approximately 120 days of calf life. After that, care seeking behaviour by calves started. Young animals naturally starts vocalize if disturbed, stressed or hungry. The presence of a cow close to the calf reduces their stress. Suckling behaviour begins 2-5 hours after birth and the mother must be standing. The calf vigorously butts the mother's udder with its head while suckling. It is found that heifers which had a difficult birth took longer to stand than animals that had already had several calves. Experienced cows usually stand within one minute of the birth of the calf. The mother licks the young to stimulate breathing, circulation, urination and defecation. Teat sucking by the calf is most intense soon after it stands up and it is common for suckling to occur first from a front teat. The distance maintained between cow and their calf increases gradually with time however they keep in contact by vocalising. Within the first week of life the calf begins to follow the cow and groups of calves will be found lying together for much of the day while the cows are grazing. Understanding of maternal behaviour in animal production system may help in preventing stress of dam or calf during calving or weaning. In most of dairy farm all aspects of maternal behavior discourages except the milk production, but changing consumer interest in organic production of milk will make an understanding of maternal behavior in priority in years to come.

Elements of Maternal Behaviour

Separation from the Herd and Preparation of the Nest Site: The onset of maternal behaviour begins when animals isolates themselves from herd mates and chooses a nesting site before calving. A cow becomes restless 1-2 days before calving. If possible, she will leave the herd shortly before birth, finding a quiet place to calve. They do so that no herd interference can occur at the birth and bonding may be disrupted.

Activity: Immediately before calving cows become more restless, perhaps due to discomfort. From 3 days before calving the number of standing bouts increases by 80% in dairy cows housed indoors. Majority of ungulates give birth in the recumbent position. First few hours after birth cows spend much of their time licking the calf, which is important in stimulating calf activity and also have physiological effects such as stimulating breathing, circulation, urination and defecation. Licking also dries the calf's coat, reducing evaporative heat loss. Cows with previous experience lick their offspring for longer periods than inexperienced primiparous mothers.

Placentophagia: Cows frequently ingest some or the entire placenta once this is expelled 2-6 h after calving. They also lick the amniotic fluid, fetal membranes and any straw or bedding contaminated with these discharges. Most but not all cows show placentophagia. It may be that 'hider' species like cattle, that leave the neonate near the birthing site while the dam forages, benefited by both improving the hygiene of the area and reducing the risk of attracting predators. Amniotic fluids also appear to have some analgesic properties. Cows that ingest these fluids show less sensitivity to pain, perhaps facilitating the expression of maternal behaviour after painful calving.

Vocalizations: Cows are vocal animal and call in response to a range of conditions. Quiet grunting sounds are common in first few hours after calving and these calls are often used in combination with licking. The function of these contact call may play a role in allowing the calf to recognize the cow's voice.

Suckling: Providing milk to the calf is the most important maternal behavior. Cows will typically suckle their calf within the first few hours after birth. Interestingly, this latency to nurse is longer in dairy cows (2–6 h after birth) than it is in beef cows (about 1 h after birth). This difference in latency to nurse may be because the beef breeds are more capable or motivated to express maternal behaviour and also due to anatomical differences in udder and teat. Latency is normally longer in primiparous than multiparous cows because of the difficulties that some primiparous animals have in accepting their calves. In dairy cattle the latency of older cows to first nurse is longer because of their pendulous udders makes difficulties to calf locates a teat. The calf's immunity relies upon absorbing immunoglobulins from colostrum, but its ability to absorb declines rapidly during the first 12 h after birth.

Cross Fostering: Calf rejection represents a failure of the natural bond between cow and calf. Farmers sometimes need to extend this natural bonding by fostering calves onto another cow. Fostering of calves is common, particularly in beef systems when a cow dies and also in some dairying systems where one nurse cow rear several dairy calves.

Weaning: Weaning consists of withdrawal of maternal care when the calf becomes socially and nutritionally independent. In nature weaning is typically a gradual process, with the cow reducing her nursing frequency and milk output over the course of several months. In domestic animals weaning is often imposed by human caregivers, in which it occurs much sooner than would occur in nature. The way calves are weaned is of special interest because this can be a concern for both animal welfare due to distress associated with weaning and animal production in which growth of calves may affected due to stress of early weaning.

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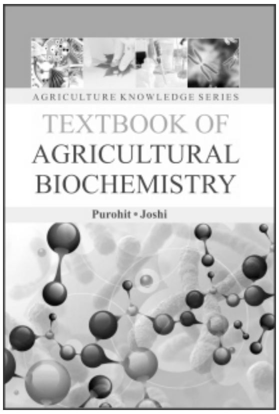

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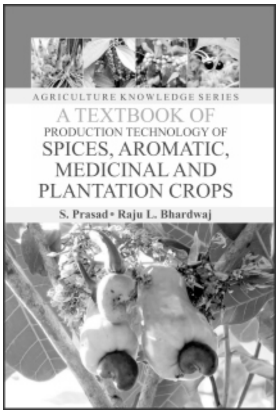

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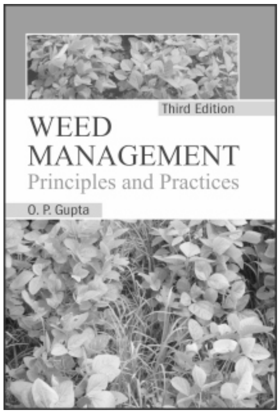

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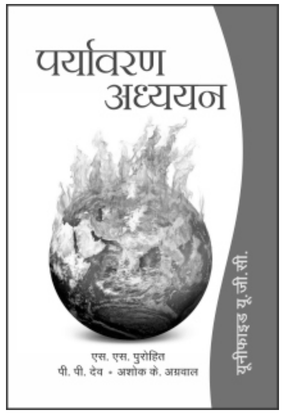

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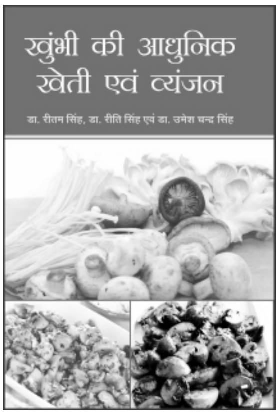

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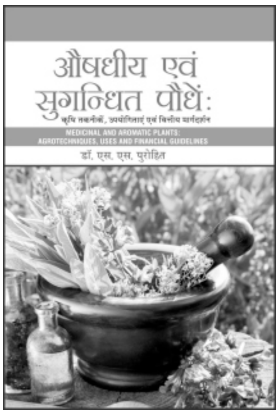

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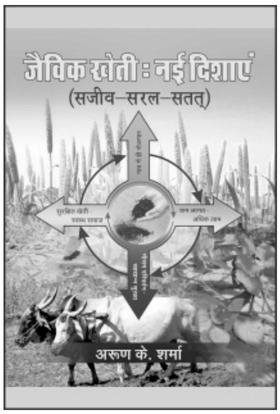

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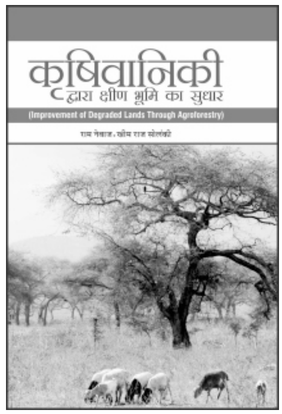

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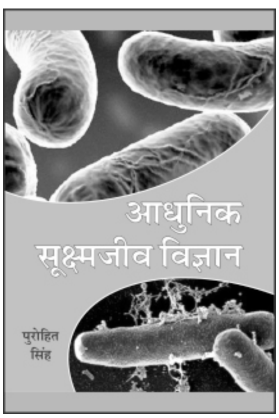

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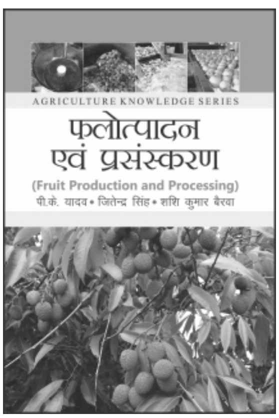

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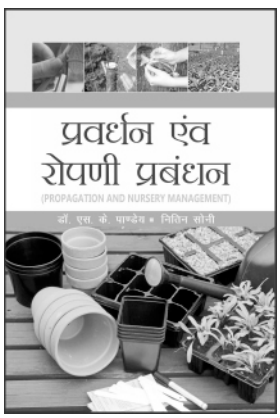

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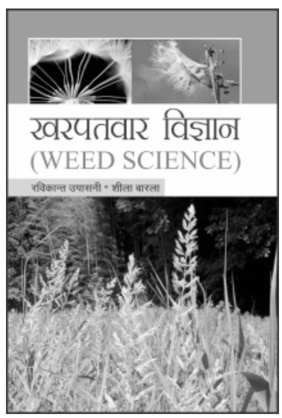

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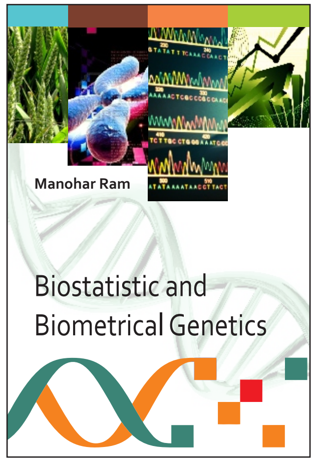
Biostatistic and Biometrical Genetics

Manohar Ram



ABOUT THE BOOK

The book is prepared to serve as a text book for senior undergraduate and post graduate students. The book is written in simple language and even complex terms have been reduced for easy understanding. Biostatistic and Biometrical Genetics provides up-to-date information about almost all basic principles, basic techniques, biometrical Genetic methods and analysis available in the literature. Due importance has been given to both the theoretical and practical aspects of the subject. The book will serve as an in-depth guide to the students of genetics and plant breeding interested in identifying most biomaterial techniques and knowing their role in crop improvement programmes. The book will also be helpful for the statisticians who are working in collaboration with the geneticists and plant breeders.

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APPENDIX

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AGROBIOS (INDIA)
Behind Nasrani Cinema, Chopasani Road, Jodhpur - 342 003
Ph.: +91-291-2643993; 2642319
E.Mail: agrobiosindia@gmail.com; Website: agrobiosonline.com

Visit us at: agrobiosonline.com

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