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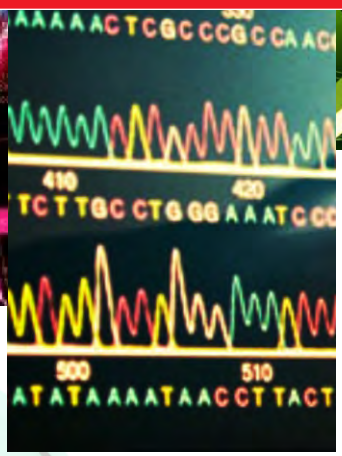

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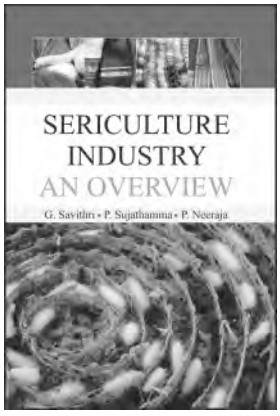

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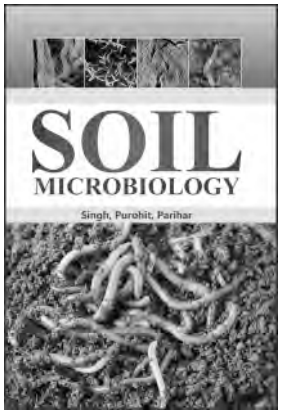

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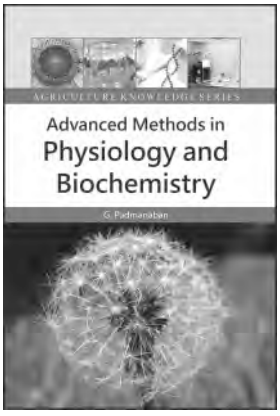

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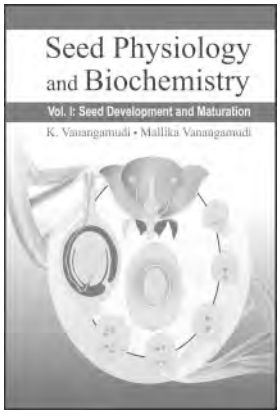

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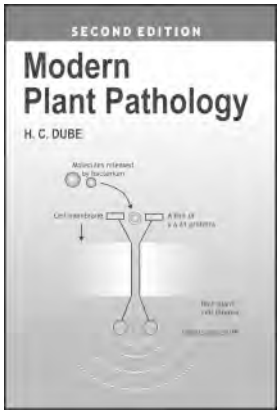

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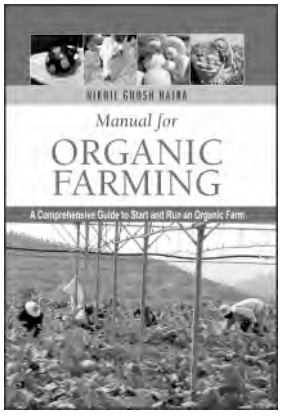

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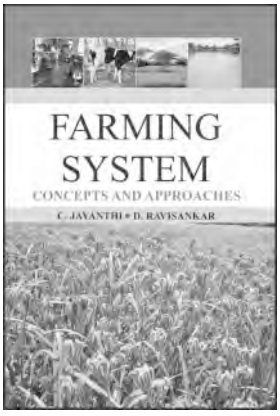

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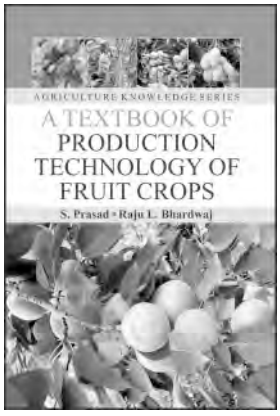

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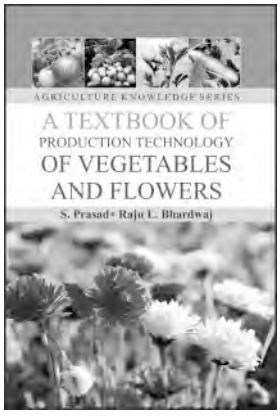

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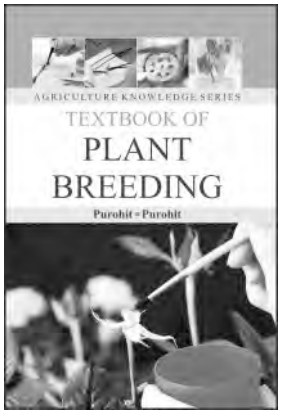

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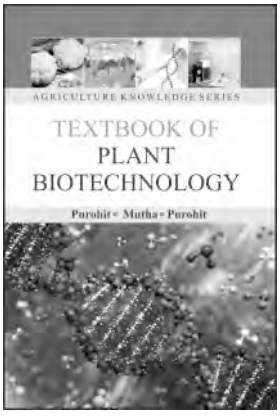

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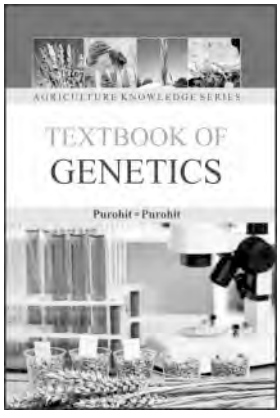

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1. BIOTECHNOLOGY 14650

Growing Media for Protected Cultivation

[1]Vivek Kumar Kurrey [1]Omesh Thakur 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 Email: vivekkumar.kurrey@gmail.com*

In the greenhouse cultivation, after the construction of green house, selection of root medium is the most important aspect. The root media used generally are soil, sand sawdust, coco peat, perlite (sand), polystyrene, peats of many types, sphagnum moss, rock wool etc. These materials are used independently or one or two or three materials are mixed together and used for this purpose. The mixture prepared should be sufficiently heavy to hold the plant and to provide adequate aeration and water holding capacity *i.e.*, after watering 10-20% of the volume of the rooting medium should be occupied by air. Many established green houses in the regions of poor soil to take advantage of the availability of other factors such as transportation, labour supply and utilities. They have also found it expedient to use soil-less media. The root medium has got many functions to perform:

1. Root media support good plant growth.
2. It serves as a reservoir for plant nutrients.
3. It holds water in a way that is available to plants.
4. It facilitates the exchange of gases between roots and the atmosphere above the medium.
5. It provides anchorage or support for the plants.

Selection of a root media type is made on the basis of economics and physical situation in which it must serve.

Sphagnum Peat: Sphagnum peat is commonly used for peat purposes. The N varies from 0.6 to 1.4% and decomposes slowly. It has the highest water holding capacity, holding upto 60% of its volume in water. It is the most acid peat with a pH level of 3 to 4 requiring 14-15 lbs of finely ground limestone/m3 (9-20 kg/m3) to bring pH to desired level for most crops.

Sawdust: Sawdust should be partially composted because the rate of decomposition and nitrogen tie-up is excessive in the fresh state and it may contain toxic substances such as resins, tannins or turpentine. Even after composting sawdust decomposes at a faster rate due to wider C : N ratio (1000:1). Sawdust composted for one month to the stage for use in root media is acidic and requires limestone to neutralize. At this stage, this is granular and dark brown in colour.

Vermiculite: Vermiculite is mined as a mineral and the expanded volume can be as much as 16 times the volume of the original. The important properties are:

1. Vermiculite is a very desirable component of soil-less root media because of its high nutrient and water retention, good aeration and low bulk density. It is commonly included in soil-less media.
2. It has numerous negative changes on its surface.
3. Each vermiculite platelet gives rise to CEC of 19-22 me/100g.
4. It contains potassium, magnesium and calcium nutrients.
5. Vermiculite pH is towards alkaline (may vary up to 9.0) and so its pH level should be adjusted down.
6. Vermiculite is usually not used with soil.

Sand: Sand is used in root media for adding the coarser texture needed to induce proper drainage and aeration. Washed sand should be purchased since it is nearly free of clay, silt and organic matter.

Perlite *(Quartz sand)*: Perlite is a good substitute for sand for providing aeration in root media. It is higher than sand. The important properties of perlite are:

1. Perlite is a sterile and chemically inert material
2. Water adheres to in surface but not absorbed.
3. It is nearly neutral with a pH value of 7.5 and has negligible CEC.
4. It does not appreciably affect the pH level of root media.

Rock Wool: Rock wool is available in granular form for use as a component in formulating root media. The important properties are:

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1. It is granular and has very high available water and aeration properties.
2. It is slightly alkaline but when mixed with peat moss, the pH will come down.
3. It has negligible CEC and cannot hold nutrients. Nutrients can be held by peat moss.
4. It is mixed in equal volume with Sphagnum peat moss to make an excellent mix.

Coco peat *(coir pith):* Coir dust is very similar to peat in appearance. It is light to dark brown in colour and consists primarily of particles in the size range 0.2 – 2.0 mm (75- 90%). Coir dust tends to be high in both sodium and potassium compared to the other peats, but Na is leached readily from the material under irrigation. The high levels of potassium present in coir dust are interesting to note, and may actually prove more a benefit than any detriment to plant growth. The higher pH of coir dust may allow less time to be added to a coir dust based medium. It is noticed that seeds sown in a 1:1 (v : v) mix of coir dust and perlite seem to develop larger root systems than those germinated in 1:2 sphagnum and perlite.

The following qualities of coir dust recommend its use as a peat substitute:

1. High water holding capacity equal or superior to sphagnum peat,
2. Excellent drainage equal to or better than sphagnum peat,
3. Absence of weeds and pathogens,
4. Greater physical resiliency (withstands compression of baling better) than sphagnum peat
5. Renewable resource, no ecological drawbacks to its use.
6. Decomposes more slow than sedge or sphagnum peat,
7. Acceptable pH, cation exchange capacity and electrical conductivity.
8. Easier wettability than peat.

Soil based media: Traditionally, a soil based medium has been composed of equal parts by volume of loam field soil, concentrate grade sand and sphagnum peat moss adjusted to the proper pH level. Depending upon the soil type, minor adjustments in their proportions are made. Sand is used to develop large diameter pores for good aeration. Field soil provides reasonable nutrient and water holding capacities. However, when the amount is reduced, the soil supplying power of nutrients and water holding capacity are reduced but can be increased by introducing sphagnum moss into the medium.

2. BIOTECHNOLOGY 14728

Deciphering the Genetic Code: A Milestone in Genetics Research

Laxmi Kamagond, Savita Kanthi, Ishwar H. Boodi and Guljar Dambal

Regional Agricultural Research Station, Hittinalli Farm Vijayapura-586101, Karnataka, India

INTRODUCTION: The genetic code is the set of rules by which information encoded within genetic material (DNA or mRNA sequences) is translated into proteins by living cells. Codon refers to a set of three nucleotide bases in RNA which codes for a particular amino acid and triplet genetic code was first suggested by Gamov in 1954.

The code defines how sequences of nucleotide triplets, called *codons*, specify which amino acid will be added next during protein synthesis.

The decade of the 1960s-the era of the cracking of the genetic code was one of the most exciting times in the history of biology. Deciphering the genetic code was a difficult and laborious task, and progress came in a series of breakthroughs and these important developments in Cracking the genetic code is a milestone in Genetics research.

There are four methods to decipher the genetic code,

1. **Use of homopolymer:** The first clues to the genetic code came in 1961, from the work of Marshall Nirenberg and Johann Heinrich Matthaei. These investigators created synthetic RNAs by using an enzyme called polynucleotide phosphorylase. The first synthetic mRNAs used by Nirenberg and Matthaei were homopolymer, RNA molecules consisting of a single type of nucleotide.

   For example, by adding polynucleotide phosphorylase to a solution of uracil nucleotides, they generated RNA molecules that consisted entirely of uracil nucleotides and thus contained only UUU codons.

   – These poly (U) RNAs were then added to 20 tubes, each containing the components necessary for translation and all 20 amino acids.
   – A different amino acid was radioactively labeled in each of the 20 tubes. Radioactive protein appeared in only one of the tubes—the one containing labeled

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phenylalanine. This result showed that the codon UUU specifies the amino acid phenylalanine.
- The results of similar experiments using poly(C) and poly (A) RNA demonstrated that CCC encodes proline and AAA encodes lysine.

2. **Use of random copolymers:** To gain information about additional codons, Nirenberg and colleagues created synthetic RNAs containing two or three different bases. Because polynucleotide phosphorylase incorporates nucleotides randomly, these RNAs contained random mixture of the bases and are thus called random copolymers and identified different Amino acids specified by copolymer.
For example, When Adenine (A) and Cytosine(C) nucleotides are mixed with polynucleotide phosphorylase enzyme. RNA molecule produces 8 different codons are AAA, AAC, ACC, ACA, CAA, CCA, CAC, and CCC.
   - This poly (AC) RNAs produced proteins containing six different amino acids: Asparagine, Glutamine, Histidine, Lysine, Proline and Threonine. If a 4:1 ratio of C to A were used in creating the synthetic RNA, P(C) is 4/5 and P(A) is 1/5. Probability of any one of the codon with two Cs and one A should be higher than the Probability of any one of the codon with two As and one C.
   - By comparing the percentage of Amino acids in proteins produced by random copolymers with theoretical frequencies expected for the codon and derive the base composition of codons, Nirenberg and his colleagues could derive information about the base composition of the codons.
   - There are some problems with this method are the theoretical calculations depended on the random incorporation of bases, which did not always occur, and because the genetic code is redundant, sometimes several different codons specify the same aminoacid and also the exact base sequence of codon is not known in this method.

Triplet Binding Assay

To overcome the limitations of random copolymers, Nirenberg and Philip Leder developed another technique in 1964 that used ribosome-bound tRNAs. They found that a very short sequence of mRNA-even one consisting of a single codon-would bind to a ribosome. In a particular mixture only one of the aminoacid is made radioactive (C14 labeled) and others 19 AA not radioactively labeled. The presence or absence of radioactivity on the nitrocellulose membrane will show relationship of codon and AA which was made radioactive.

Repetitive Sequencing Technique

- It is most direct method of confirming genetic code.
- It involves *In vitro* chemical synthesis of short segments of DNA of known base sequence with the help of DNA polymerase.
- The *In vitro* chemical synthesis of long polyribonucleotide of known sequence with the help of RNA polymerase.
- The base sequences of all codons can be known by this method.

3. BIOTECHNOLOGY 15160

Application of Molecular Markers in Fruit Crops

[1]Ravi Kumar Telugu, [2]Mekala Srikanth, [3]Mohammad Shafiqurrahaman

[1&2]Ph.D. Scholar, Department of Vegetable Science, [3]Ph.D. Scholar, Dept. of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar (H.R.)-125004
**Corresponding Author Email: ravikumar.horti@gmail.com*

INTRODUCTION: A genetic marker is a gene or DNA sequence with a known location on a chromosome and associated with a particular gene or trait. It can be described as a variation, which may arise due to mutation or alteration in the genomic loci that can be observed. A genetic marker may be a short DNA sequence, such as a sequence surrounding a single base-pair change (single nucleotide polymorphism, SNP), or a long one, like minisatellites.

Molecular markers have diverse applications in fruit crop improvement, particularly in the areas of-

- Assessment of genetic diversity,
- Identification of QTLs,
- Gene mapping,
- Varietal identification,

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- Diseases diagnosis,
- Marker assisted selection (MAS)
- Hybrid detection,

Assessment of Genetic Diversity

- A number of reports are available on the use for DNA markers to assess genetic diversity among species of several horticultural crops.
- This has significant application, especially for difficult to breed woody perennials.
- The different types of markers that have been used for assessment of genetic diversity are presented as follows- SSR markers in Citrus cultivars, ISSR markers in Passiflora.

Identification of QTLs

- Many important heritable characters are a consequence of the joint action of several genes. Such characters are often referred to as polygenic or quantitative.
- Several characters of plant species, among which are traits of agronomic importance are inherited quantitatively. Eg: Yield, maturity date and drought tolerance.
- The genetic loci for such characters have been referred to as quantitative trait loci (QTLs).
- The essential feature which makes feasible the finding and characterization of a QTL is its linkage with a known marker locus segregating with Mendelian ratios.
- DNA markers provide this opportunity by making it feasible to identify, map and measure the effects of genes underlying quantitative trait.
- In grape QTLs were uses for features such as like Critical Photoperiod, growth cessation or dormancy, bud break (BB) and winter hardiness.

Gene Mapping

- It describes the methods used to identify the locus of a gene and the distances between genes.
- The essence of all genome mapping is to place a collection of molecular markers onto their respective positions on the genome.
- Molecular markers come in all forms. Genes can be viewed as one special type of genetic markers in the construction of genome maps and mapped the same way as any other markers.

Varietal Identification

- Varietal identification is nothing but DNA fingerprinting.
- Singly or in groups, molecular markers are capable of producing patterns that are unique for each individual genotype.
- Their patterns, whether they are generated by PCR or by hybridization with single copy, multicopy or repeated sequences are referred to as genetic fingerprinting.
- Few examples of DNA markers used for varietal identification are mentioned in follows-
  - 7 SSR markers used to 129 Sweet Cherry accessions have been genotyped
  - 26 SSR markers used to 50 Sour Cherry accessions have been genotyped

Disease Diagnostics

Molecular markers have made it possible to develop diagnostic techniques to identify pathogen with an unprecedented accuracy and speed and to tap genes from as diverse sources as microbes, plants and animals to enable the researchers to develop plants resistant to diseases

Eg: Apple and Pear scab (caused by *Venturia inaequalis* and *Venturia pirina*)

Strawberry root rot petiole blight (caused by *Gnomonia fragariae*)

Marker Assisted Selection (MAS)

- This is one of the important applications of molecular markers.
- Molecular markers can potentially increase the importance and usefulness of indirect selection in plant breeding.
- MAS permit the breeder to make earlier decisions about the further selections while examining fewer plants.
- An added advantage in breeding for disease resistance behavior is that this could be done in the absence of pathogen once marker information is available.
- Earlier markers were being developed for monogenic traits but present markers are developed for traits governed by multigenes or polygenes Eg: Scab resistance in Apple.

Detection of Hybrids

- The production of interspecific Prunus hybrids, Grape interspecific crosses and progeny screening for hybrid seedlings in Citrus breeding programme.
- At NRC, Grapes, Pune (India), the ambiguity of Dog ridge from two different sources (IIHR, Bangalore and American strain) was solved.

Conclusion

- The markers have immediate applications in supportive research for advanced breeding programs.
- The major application of markers lies in the strategic research for rapid understanding of basic genetic mechanisms and genome organization at molecular level.
- The success of DNA marker technology for bringing genetic improvement in fruit crops would depend on close interaction between

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plant breeders and biotechnologists, availability of skilled man power and substantial financial investment on research.

4. BIOTECHNOLOGY 15208

Secondary Metabolites: A Potential Production through Plant Cell Culture

Devendra V. Rasam[1] and Saurabh S. Kadam[2]

[1,2]College of Agricultural Biotechnology, Kharawate-Dahiwali

Medicinal plants are the most exclusive source of life saving drugs for the majority of the world's population. Bioactive compounds currently extracted from plants are used as food additives, pigments, dyes, insecticides, cosmetics and perfumes and fine chemicals. These compounds belong to a group collectively known as secondary metabolites. The molecules are known to play a major role in the adaptation of plants to their environment, but also represent an important source of pharmaceuticals. In recent years, traditional system of medicine has become a topic of global importance.

Advances in biotechnology particularly methods for culturing plant cell cultures, should provide new means for the commercial processing of even rare plants and the chemicals they provide. These new technologies will extend and enhance the usefulness of plants as renewable resources of valuable chemicals. There has been considerable interest in plant cell cultures as a potential alternative to traditional agriculture for the industrial production of secondary metabolites. Plant cell culture technologies were introduced at the end of 1960s as a possible tool for both studying and producing plant secondary metabolites. Different strategies using cell cultures systems have been extensively studied with the objective of improving the production of bioactive secondary metabolites. Cell culture systems could be used for the large scale culturing of plant cells from which secondary metabolites can be extracted. The advantage of this method is that it can ultimately provide a continuous, reliable source of natural products.

The major advantages of cell cultures include;

1. Synthesis of bioactive secondary metabolites is running in controlled environment, independently from climatic and soil conditions;
2. Negative biological influences that affect secondary metabolites production in the nature are eliminated (microorganisms and insects);
3. It is possible to select cultivars with higher production of secondary metabolites;
4. Automatización of cell growth control and metabolic processes regulation, cost price can decrease and production increase.

Although the production of pharmaceuticals using plant cell cultures have been highlighted, other uses have also been suggested as new route for synthesis, for products from plants difficult to grow, or in short supply, as a source of novel chemicals and as biotransformation systems. Recent research results indicate that plant cell suspension cells can be used for recombinant protein production under controlled conditions.

The production of pharmaceuticals by plant tissue culture offers a number of advantages such as:

- Control of supply of product independent of the availability of plant itself.
- Cultivation under controlled and optimized conditions.
- Strain improvements with programs analogous to those used for microbial systems.
- No need of the use of harmful herbicides and pesticides.
- Possibility of synthesizing novel compounds, not present in nature, by feeding of compounds analogous to natural substrates.
- No dependence on climate, and geographical location etc.

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5. BIOTECHNOLOGY 15226

Basic Techniques of Map Based Cloning

Thombare Devidas,[1] and Shinde Vishwajeet[2]

Department of Plant Molecular Biology and Biotechnology, IGKV, Raipur. (C.G.)

INTRODUCTION: Most important eukaryotic gene, for example, disease resistance gene, is known by their phenotype and not by their biochemical effects. Traditional cloning strategies have been ineffective with these genes. The concept behind map based cloning is to find a DNA marker linked to a gene of interest and then walk to the gene via overlapping clones.

Map-based cloning or positional cloning also known as reverses genetics. It is a strategy which does not require prior knowledge about the gene or its products. Instead, this cloning strategy requires knowledge about chromosomal location of the gene. Map-based cloning strategies use the fact that, as distances between the gene of interest and the analyzed markers decrease, so does the frequency of recombination.

Basic Technique involved in Map Based Cloning

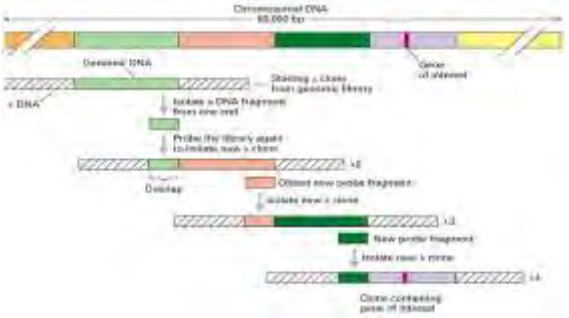
- Identify a marker tightly linked to your gene in a "large" mapping population.
- Find a YAC or BAC clone to which the marker probe hybridizes.
- Create new markers from the large-insert clone and determine if they co-segregate with your gene.
- If necessary, re-screen the large-insert genomic library for other clones and search for co-segregating markers.
- Identify a candidate gene from large-inset clone whose markers co-segregate with the gene.
- Perform genetic complementation (transformation) to rescue the wild-type phenotype.
- Sequence the gene and determine if the function is known.

Methodology

- Initially, selection of parent should be done that is P1 and P2 and crossing of both parent gives F1.
- These F1 is self-crossed to produce F2 segregating population.
- Selective phenotyping is performed for bulk segregation analysis.
- In bulk segregation analysis two bulks (resistant bulk, susceptible bulk) were prepared and 10 plants from each bulk were pooled out.
- DNA extraction from 10 plants from each bulk were isolated and mixed up all DNA in tube.
- PCR amplification using SSR marker and electrophoresis were done of PCR product.
- Polymorphism was calculated it means that polymorphic bands are selected for further analysis.
- Then molecular marker map were generated from population. Locate the chromosome number by association mapping.
- After locating the chromosome, clone contigs were generated by screening BAC library.
- Chromosome walking or Chromosome jumping is done to close the target gene of interest.
- Perform genetic complementation (transformation) to rescue the wild-type phenotype. Sub-clone positive YAC clones Sequence the gene and determine if the function is known.

Chromosome Walking/Mapping

Chromosome walking is initiated by the selection of a molecular marker closed to the gene of interest and the use of the clone as a hybridization probe to screen a genomic library for overlapping sequences. Chromosome walking is very difficult in species with large genome and an abundance of dispersed repetitive DNA. Basic steps involve in chromosome walking are as given below:



Chromosome Jumping

When the distance from the closest molecular marker to the gene of interest is large, a technique called chromosome jumping can be used to speed up an otherwise long walk. Chromosome jumping has proven especially useful in work with large genomes such as the human genome. Chromosome jumps played a key role in identifying the human cystic fibrosis gene.

- Genomic DNA is digested partially with EcoRI.

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- Circularize EcoRI fragments.
- Identify restriction enzyme that cleave on both side of the junction and digest circular DNA molecules with these enzymes.
- Isolate junctional DNA fragment and cleave it with restriction enzyme that excises the unique sequence DNA, and use sequence as probe for another jump.

Difficulties in Map-based Cloning

- The enormous size of eukaryotic genome.
- Relationship between genetic distance, as measured by recombination frequency and physical distance is not uniform throughout eukaryotic genome.
- Most eukaryotic genome has significant amount of repetitive DNA, which makes difficult to perform chromosome walking.

Examples of Agriculturally Important Genes isolated from Rice:

Locus or gene	Function	Identification Method
Xa21	Bacterial Resistance	Map-Based Cloning
Sub1	Submergence tolerance	Map-Based Cloning
Moc1	Tillering number control	Map-Based Cloning
Pi9	Fungal resistance	Map-Based Cloning
Gid1, Gid2 or	Gibberellin signalling	Map-Based cloning
Slr1	pathway	
Sd1	Gibberellin Synthesis	Map-Based Cloning
Lsi1	Silicon transport	Map-Based Cloning

Ki-Hong Jung et al., Nature Reviews Genetics | AOP, published online 27 December 2007; doi:10.1038/nrg2286

Applications

- Molecular breeding of agricultural crops
- Gene over expression
- Gene transferring
- Molecular farming
- Gene pyramiding for functional genomic
- Gene interrogations

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6. BIOTECHNOLOGY 15268

Safety Issues and the Ethics of using DNA Technology

P. Jayamma

Assistant Professor, Dept. of Food and Industrial Microbiology, College of Food Science & Technology, Pulivendula, Kadapa

There will always be concern about the safety of any new technology, and genetic modification and biotechnology are certainly no exceptions. One reason for this concern is that it is nearly impossible to prove that something is entirely safe under all conceivable conditions. People worry that the same techniques that can alter a microbe or plant to make them useful to humans could also inadvertently make them pathogenic to humans or otherwise dangerous to living organisms or could create an ecological nightmare. Therefore, laboratories engaged in rDNA research must meet rigorous standards of control to avoid either accidentally releasing genetically modified organisms into the environment or exposing humans to any risk of infection. The reduce risk further; microbiologists engaged in genetic modification often delete from the microbes genomes certain genes that are essential for growth in environments outside the laboratory. Genetically modified organisms intended for use in the environment (in agriculture, for example) may be engineered to contain "suicide genes" – genes that eventually turn on to produce a toxin that kills the microbes, thus ensuring that they will not survive in the environment for very long after they have accomplished their task.

The safety issues in agricultural biotechnology are similar to those concerning chemical pesticide: toxicity to humans and to non pest species. Although not shown to be harmful, genetically modified foods have not been popular with consumers. In 1999, researchers in Ohio noted that humans may develop allergies to *Bacillus thuringiensis* (*Bt*) toxin after working in fields sprayed with the insecticide. And an Iowa study showed that the caterpillar stage of Monarch butterflies could be killed by ingesting windblown Bt-carrying pollen that landed on milkweed, the caterpillars' normal food. Crop plants can be genetically modified for herbicide resistance so that fields can be sprayed to eliminate weeds without killing the desired crop.

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However, if the modified plants pollinate related weed species, weeds could become resistant to herbicides, making it more difficult to control unwanted plants. An unanswered question is whether releasing genetically modified organisms will alter evaluation as genes move to wild species.

7. BIOTECHNOLOGY 15348

Genome Editing: Method for Plant Genome Engineering

Hirdayesh Anuragi

Ph.D. Scholar, Department of Genetics and Plant Breeding, CCS HAU, Hisar
**Corresponding Author Email: heartyanuragi@gmail.com*

INTRODUCTION: Genome editing is a technique used to precisely and efficiently modify DNA within a cell. It involves making cuts at specific DNA sequence with enzymes called 'engineered nucleases'. Genome editing can be used to add, remove, or alter DNA in the genome. By editing the genome the characteristics of a cell or an organism can be changed.

The basic mechanism includes generation targeted double-stranded DNA cuts which can be repaired by the error-prone, non-homologous end joining repair system or via the homologous recombination-based double-strand break repair pathway provided a suitable template is available. These genome editing reagents require components for recognizing a specific DNA target site and for DNA-cleavage that generates the double-stranded break.

Genome Editing Systems

There are several different types of engineered nuclease used in genome editing. They all contain a nuclease part to cut the DNA and a DNA-targeting part to recognize the DNA sequence they cut. They mainly differ in how they recognize the DNA to cut such as ***RNA based*** technique contain a short sequence of RNA that binds to the target DNA to be cut and ***Protein based*** technique contain a protein that recognizes and binds to the target DNA to be cut. Following techniques are most commonly used these days,

1. ***Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR-Cas)*** is the most common, cheap and efficient system used for genome editing. CRISPR/Cas are loci that contain multiple short direct repeats, and provide acquired immunity to bacteria and archaea. CRISPR genome editing systems allow users to design gRNA which target their DNA sequence of interest. When expressed intracellularly in conjunction with a CRISPR associated endonuclease (Cas9), the gRNA directs Cas9 to the target sequence where it unwinds and cleaves the double stranded DNA. The CRISPR genome editing systems are comprised of only 2 to 3 plasmids, expressing the gRNA and the Cas9 nuclease. These systems are easily tuned for targeting specificity by inserting a complementary oligo into the gRNA expression vector. Additionally, various CRISPR systems for genome editing have been developed for use in different cell types.
2. ***Transcription Activator-Like Effector Nucleases (TALENs)*** Transcription activator-like effector nuclease (TALEN) systems are a fusion of TALEs derived from the Xanthomonas spp. to a restriction endonuclease FokI. By modifying the amino acid repeats in the TALEs, users can customize TALEN systems to specifically bind target DNA and induce cleavage by the nuclease between the two distinct TAL array binding sites. A variety of plasmid kits, which include from 12 to 86 plasmids, are available from Addgene and allow for the creation of custom repeat arrays for easy TALEN preparation. The different TALEN tool kits use various cloning techniques and protocols to enable custom TALEN design and preparation.
3. ***Zinc-Finger Nucleases (ZFNs)*** are fusions of the nonspecific DNA cleavage domain from the FokI restriction endonuclease with zinc-finger proteins. ZFN dimers induce targeted DNA DSBs that stimulate DNA damage response pathways. The binding specificity of the designed zinc-finger domain directs the ZFN to a specific genomic site. Zinc finger nuclease (ZFN) technology utilizes a FokI nuclease as the DNA-cleavage domain and binds DNA by engineered Cys2His2 zinc fingers. Specific zinc fingers recognize different nucleotide triplets and dimerize the FokI nuclease. The activated nuclease introduces a double stranded break between the two distinct zinc finger binding sites, which prompts recombination and modification of the genome.

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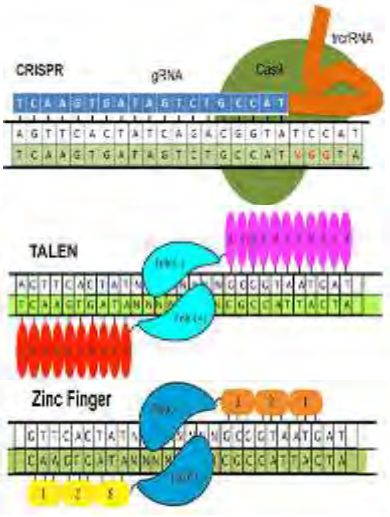

Applications of Genome Editing

Genome editing could be used to edit the genome of any plant. Targeted genome editing has become a powerful genetic tool for studying gene function or for modifying genomes by correcting defective genes or introducing genes. Following are some specific tasks this method can carry out:

- Targeted gene mutation
- Gene therapy
- Creating chromosome rearrangement
- Study gene function with stem cells
- Transgenic plants
- Endogenous gene labeling
- Targeted transgene addition

Concluding Remarks and Future Perspective

Genome editing holds great promise to provide a precise set of tools for counteracting genetic diseases. Recent advances in editing technology have opened the door to application of editing technology to achieving a molecular level cure of many genetic diseases. ZFNs, TALENs, and RNA-guided DNA endonucleases are transformative tools that have the potential to revolutionize biological research. Beside from moral considerations at its present level of development, gene editing technology cannot ethically applied for therapeutically correcting disease genes in pluripotent/germline cells due to our lack of knowledge of detrimental effects that might be attributable to editing procedures.

8. BIOTECHNOLOGY 15385

Potential Role of GM Crops in India

Banoth Vinesh* and Kuduka Madhukar

**Dept. of Genetics and Plant Breeding, College of Agriculture, G.B.P.U.A&T., Pantnagar, Uttarakhand-263145; Dept. of Genetics and Plant Breeding, Inst. of Agril. Sci., B.H.U., Varanasi*

Genetically modified crops (GM crops, or biotech crops) are plants in which the DNA been modified using genetic engineering methods. In most cases, the aim is to introduce a new trait to the plant which does not exist naturally in the species. Examples in food crops include resistance to certain pests, diseases, or environmental conditions, reduction of spoilage, or resistance to chemical treatments (*e.g.* resistance to an herbicide), or improving the nutrient profile of the crop. Examples in non-food crops include production of pharmaceutical agents, biofuels, and other industrially useful goods, as well as for bio-remediation.

In the 21st century, the Indian population will increase at a massive rate. According to the UN World Population Prospects (2015) India's population is expected to exceed China's by 2022. Beside the increase in population, there is increasing industrialization, urbanization and emergence of new pests and diseases coupled with many abiotic stress limiting their capability to enhance production, especially on small land holdings as prevalent in India thus the cropping fertile land area also decrease day by day. In order to meet the feed and nutritional demand of this increasing population, we ought to use arable land to achieve better crop production in that limited area. Farmers in the country currently lose some Rs 50,000 crore ($5 billion) every year to pests and diseases. Droughts, coupled with the lack of irrigation facilities, are exacerbating the problem.

In the current scenario it is very difficult to achieve much yielding by sustainable agricultural methods. From 18th century many biotechnology tools and methods for betterment of crop improvement especially molecular markers are played important role in crop improvement. To save people from outright starvation and die of malnourishment, India need to develop GM (Genetically Modified) crop or allow their use. Genetically engineered crops have genes added or removed using genetic engineering techniques viz., gene guns, electroporation, microinjection and agrobacterium. But advanced techniques like CRISPR and TALEN coming in to existence in recent times offered much more precise and convenient editing tools. GM crops most prominently grown worldwide are Maize,

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Soybean, Cotton, Canola, Sugarbeet, Alfalfa, Papaya and Squash. Countries like U.S., Brazil, Argentina, Canada, India and some Asian countries are growing the GM crops. Especially U.S., Canada and Brazil are the more producer of the GM crops. In India only cotton (*Bt*) was grown from 2002, and it successful in India across all states. According to the International Service for the Acquisition of Agri-Biotech Applications, "India has the world's largest hectare of cotton, and accounts for 46% of the total biotech cotton area planted globally. Genetically modified organisms, or GMOs, grow in an estimated 97% of India's cotton fields and have helped India by some measures become the fiber's top global producer. Recently, in 2017 GEAC has approved the 1st GM food crop *i.e.,* mustard GM (Dhara Mustard Hybrid-11 (DMH-11)) variety. But we need to welcome many other food crop to protect the next generation without any malnutrition deficiency and avoid many hungers driven deaths. Because of many wrong myths among many critics, they oppose the GM food in India. But knowingly or unknown we taken many a mixture of genes every day. For over 20 years, humans have eaten GM foods in billions of meals, and not one ill effect has ever been identified.

The Reasons to choose the GM Crops in India

GM food being imported into the country (including corn, baby food and breakfast cereal, which have been introduced without adherence to relevant labeling laws).

GM crops are one way of improving agricultural output in India. The achievement is possible in the following ways:

1. For improving crop yield (by imparting tolerance to drought, floods, salinity, herbicides or disease)
2. By increasing the shelf-life of the produce after harvest
3. By increasing the nutritional and vitamin content of the food
4. By ways to be more environmentally friendly by reducing pesticide use as with *Bt* crops. This allows farmers to be safer in their fields. Genetically-modified foods have the potential to solve many of the world's hunger and malnutrition problems, and to help, protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides.

Scientists in the U.S. and across the globe are firm that GM food can resolve the hunger challenge in the developing world.

There is a scientific agreement that currently available food derived from GM crops poses no greater risk to human health than conventional food, but that each GM food needs to be tested on a case-by-case basis before introduction. Though no State government in India has permitted commercial cultivation of GM food till now, field trials for 21 GM food crops, including GM vegetables and cereals, have been approved by the government.

But some environmentalists and some common people in India have called GM crops "toxic" and hazardous to health and they don't want to approve the release of GM food in India because:

- Unexpected Side-Effects
- Problems with Labeling of GM Food
- Reduced Species Diversity
- Ecological Damage
- Effects on Non-GM Crops
- Over – Use of Herbicides
- The Benefits May Not Be Available to Everyone

In contrast to the above assumptions of hazardous effects of GMOs, many International Organizations and researchers have a positive say on them. "GM foods currently available on the international market have passed safety valuations and are not likely to present risks for human health," the WHO guidelines note. "In addition, no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved," the guidelines say.

It is need of the hour to allow GMOs in India by ignoring the myths of hazardous effects and it has positive impact. But it is essential to strengthen regulatory framework so that there should not be any delay in commercialization after research. Gene of *Bt Cry1Ab/1Ac* shows that they are not persistent in the soil more than two months, trials for golden rice also to be safe and there was no contamination reported with other rice. Similarly 'Flavor Saver' tomato and brinjal also found no noticeable negative effects on human health therefore, we need to strengthen the regulatory framework and push hard at various levels in India to promote GMOs.

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9. BIOCHEMISTRY 15059

Ribosome Inactivating Protein

Mayur R. Wallalwar*, Datta P. Kakade, and Jyoti Singh

Ph.D. Scholar, Department of Plant Molecular Biology and Biotechnology, College of Agriculture, IGKV, Raipur- 492012
**Corresponding Author Email: mayurwallalwar103@gmail.com*

INTRODUCTION: Ribosome-inactivating proteins (RIPs) are a group of proteins that share the property of damaging ribosomes in an irreversible manner, acting catalytically, *i.e.*, enzymatically. The scientific history of RIPs dates back to 1888 when Stillmark published his dissertation about ricin a toxic ferment from the seeds of *Ricinus communis* L. and some other Euphorbiaceae species. The discovery of ricin was a landmark in plant biochemistry because it was the first plant protein to which a well-defined biological activity could be described. Soon after the discovery of ricin similar toxic substances were identified in the seeds of *Croton tiglium* (crotin), *Abrus precatorius* (abrin) and in the early 1920s in the roots of *Adenia digitata* (modeccin). Thus RIPs were discovered long before they were recognized as inhibitors of protein synthesis. Most plants and bacterial RIPs exert their toxic effects through binding to the large 60S ribosomal subunit and block protein translation. RIPs are widely distributed in nature but are found predominantly in plants, bacteria and fungi. Besides their activity on rRNA, certain RIPs display a variety of antimicrobial activities in vitro, such as antifungal, antibacterial, and broad-spectrum anti-viral activities against both human and animal viruses, including the human immunodeficiency virus, HIV.

Types of RIP

Type 1 RIPs

Type I RIPs were discovered in 1925 when Duggar and Armstrong (Duggar and Armstrong 1925) observed the *Phytolacca americana* antiviral protein (PAP) inhibits the transmission of Tobacco Mosaic Virus (TMV) in plants. Type 1 RIPs are the most widely studied basic proteins. They are monomeric enzymes with a molecular weight of 30 kDa and their main function is translation inhibition. It is capable of depurating artificial polynucleotides loops which are not substrate for ricin. Type 1 RIP, release more than one molecule of adenine from each ribosome. Saporin-L1 is capable of depurinating a variety of polynucleotides and some other RIP depurinate both ribosomal and non-ribosomal substrates (Stirpe, F. and L. Barbieri. 1986).

Type 2 RIPs

They are heterodimeric enzymes with two different polypeptides, the A chain (N-glycosidase) and the B chain (lectin binding activity). The molecular weight of each chain is 30 kDa. They are found to be highly toxic and animals are mostly susceptible to type 2 RIPs. Type 2 RIPs, the first ones to be known, were considered to be highly toxic because their B chain binds to galactosyl-terminated receptors on the cell surface, thus allowing the entry of the A chain into the cytoplasm where it exerts its enzymatic activity on ribosomes, inhibiting cell protein synthesis (Stirpe, 2004). Recently, *Sambucus* species have been found to contain a complex mixture of type 1 and a special type 2 RIPs. Type 2 RIPs are useful for endocytosis studies and intracellular transport in mammalian cells.

Type 3 RIPs

Only a few reports are present on Type 3 RIPs as they are not much prevalent. The molecular weight of type 3 RIPs has been found to be 60 kDa. They are acidic proteins with N-glycosidase activity and are synthesized mostly in an inactive form. JIP60 is the identified type 3 RIP, isolated from maize. Plant tissues treated with methyl jasmonate or exposed to stressors that induce *in planta* jasmonate accumulation synthesize high levels of polypeptides designated jasmonate induced proteins (JIPs) (Hause et al. 1996). Concomitantly, these tissues reduce or even shut-down the synthesis of most proteins that were present before methyl jasmonate or stress treatment. Under, in vitro it specifically cleaves polysomes from longterm methyl jasmonate-treated or stressed barley leaf tissues, but not from untreated or non-stressed plant material, into their ribosomal subunits. In addition, JIP60 reduces the rate of in vitro translation of plant mRNAs in rabbit reticulocyte lysates, suggesting that this protein is also active in animal systems. It is thought that the methyl jasmonate induced RIP in barley might have a dual function in plant defense and in stress reactions. At a later stage, referred to as the terminal stage of the stress response, during which a massive loss of all metabolic functions occurs, it may also be involved in the degradation of "self" ribosomes that are marked specifically for this destination.

Mechanism of Action

RIPs have N-glycosidase activity. They cleave the

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nucleotide N-C bond between the adenine and the pentose sugar. They inactivate ribosomes through a site-specific deadenylation of the large ribosomal subunit. Adenine lies within the 14-nucleotide region known as the a-sarcin loop which is found to be conserved in large rRNAs from bacteria to humans. The first adenine residue of the GAGA sequence is the substrate of RIP. The irreversible modification of 'A' residue blocks the elongation factor, EF-1 and EF-2-dependent GTPase activities and renders the ribosome unable to bind EF-2, thereby blocking translation and protein synthesis. This deadenylation process occurs not only in ribosomes but it is also specific to rRNA, another substrate for RIP activity. It also has the potential to deadenylate different polynucleotides which implies that it also can carry out polynucleotide: adenosine glycosidase activity (PAG).

Applications of RIP

1. Antiviral activity
2. Antitumor activity
3. Antibacterial and antifungal activity
4. Insecticidal activity
5. Immunological effects (immunogenicity, allergenicity, and immunosuppression)

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10. BIOCHEMISTRY 15367

Glycine Betaine: A Miraculous Stress Relieving Compound

Praveen Kumar*, Naresh Kumar and Raghvendra Midathala

Ph.D. Scholars, Dept. of Chemistry and Biochemistry, CCSHAU Hisar – 125004
**Corresponding Author Email: praveenhau@gmail.com*

INTRODUCTION: Plant growth and productivity are adversely affected by nature's wrath in the form of various abiotic stress factors. Plants are frequently exposed to a plethora of stress conditions such as drought, flooding, salt, low temperature, heat, oxidative stress and heavy metal toxicity. When plants are exposed to stress factors, their cells protect themselves from high concentrations of intracellular salts by accumulating a variety of small organic metabolites that are collectively referred to as compatible solutes. Compatible solutes are very soluble in water and non-toxic even at higher concentrations. These metabolites allow cells to retain water and help in avoiding disturbances in their normal functions when exposed to abiotic stresses. Compatible solutes include sugars, polyols, amino acids, proline and related compounds. One of the most- studied compatible solute is glycine betaine (*N,N,N*-tri-methyl glycine, abbreviated as GB). GB is a zwitterionic, fully *N*-methyl-substituted derivative of glycine. It is found in a large variety of microorganisms, animals and higher plants. It is dipolar but electrically neutral at physiological pH. GB is synthesized at elevated rates in response to abiotic stresses. Levels of accumulated GB are generally correlated with the extent of increased tolerance by plants. Many taxonomically distant plant species normally contain low levels of GB (these plants are known as natural accumulators of GB), but can also accumulate larger amounts of GB when subjected to abiotic stress. In many other species, GB has not been detected under normal or stressful conditions (natural non-accumulators) (Chen and Murata 2011). GB effectively stabilizes the quaternary structures of enzymes and complex proteins and protects various components of the photosynthetic machinery, such as ribulose-1,5-biphosphate carboxylase/oxygenase (Rubisco) and the oxygen evolving photosystem II (PSII) and maintains highly ordered state of membranes at non-physiological temperatures and high salt concentrations. Both the exogenous application of GB and also the introduction, via transgenes, of the GB-biosynthetic pathway into naturally non-accumulators increase the tolerance of such plants to various types of abiotic stress. This increased tolerance to abiotic stress provides useful systems for investigating the mechanism by which GB protects plants against abiotic stress.

Biosynthesis of Glycine Betaine

GB is synthesized via two distinct pathways from two different substrates such as choline and glycine (**Fig. 1**). The biosynthesis of GB from choline has been studied in majority of biological systems, including animals, plants and microorganisms. This pathway involves one or

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two enzymes, depending on the mode of oxidation of choline. GB is synthesized as a result of the two-step oxidation of choline via betaine aldehyde, a toxic intermediate. The first step is catalyzed by choline monooxygenase (CMO) in higher plants, whereas the same step is catalyzed by choline dehydrogenase (CDH) in *Escherichia coli* and animals. The second oxidation step is catalyzed by NAD^+-dependent betaine aldehyde dehydrogenase (BADH). In contrast, GB is synthesized from choline by a single enzyme, choline oxidase (COD) in soil bacterium *Arthrobacter* sp. The biosynthesis of GB is stress-inducible and the concentration of GB *in vivo* varies among plant species, ranging from 40 to 400 mol g^{-1} (DW) in natural accumulators under stress condition.

FIG. 1: Biosynthetic pathways of glycine betaine

Accumulation of Glycine Betaine

Site of Glycine Betaine Accumulation

The tolerance of plants to abiotic stress is influenced by two main factors that are the concentration and the localization of GB in cells. There are many reports of the engineered accumulation of GB in plants in which GB-biosynthetic enzymes have been targeted to chloroplasts. However, there are few studies shows that the enzymes have been targeted to either cytosol or mitochondria, or to both cytosol and chloroplasts simultaneously. These observations lead to conclusion that the accumulation of GB in chloroplasts is more effective than the accumulation of GB in the cytosol for the protection of plants against abiotic stress.

Exogenous Application of Glycine Betaine

Due to limitation in production of GB in high quantities in transgenic plants, exogenous application of GB is being successfully used which enhanced internal GB level in numerous low-accumulating or non-accumulating plant species and may help in reducing the adverse effects of abiotic stress and subsequently it can also improve growth and yield. When GB applied to leaves of plants, it is readily taken up by leaf tissues. When GB applied, most of the GB is taken up by the leaves is localized in the cytosol and only a small fractions of the cytosolic GB is translocated to chloroplasts while large amounts of foliar-applied GB were translocated to meristem containing tissues, including the flower buds and shoot apices. It was demonstrated that GB was translocated to actively growing and expanding portions, the long distance translocation of GB being mediated by the phloem. GB was also found effective to relive other stresses as- **Drought, Salinity, Low temperature, Heavy metal and oxidative stress**

Heavy Metal and Glycine Betaine

Heavy metals are important environmental pollutants and many of them are toxic even at very low concentrations. Heavy metals like As, Cd, Co, Cu, Cr, Ni and Zn is phytotoxic either at all concentrations or above a certain threshold level. Heavy metals are present in the environment at concentrations that can be hazardous to the biosphere and are biologically magnified through the food chain. They affect the environment by affecting soil properties like fertility, biomass, crop yields and ultimately human health. Excess production of reactive oxygen species (ROS) due to heavy metals is toxic to plants and cause oxidative damage to cellular constituents but the plants possess several antioxidant defense systems to protect their cells against ROS. GB functioning as osmoprotectants suppresses production of free radicals and ROS. Increased GB content caused a decreased lipid peroxidation and increased the activity of SOD and CAT to mitigate the detrimental effects of Cd stress. GB exhibits similar effects on the activity of ascorbate peroxidase (APX) in detoxifying H_2O_2, generated by Cd stress. Priyanka (2011) reported that GB (50 mM) counteracted the oxidative stress in Cu-stressed mustard plants by elevating the level of proline and of antioxidant enzymes like CAT, POX, SOD which manifested in terms of improved growth and biological yield.

Oxidative Stress and Glycine Betaine

When plants are growing even under non-stress conditions, ROS are regularly generated as metabolic byproducts. The ROS such as superoxide, hydrogen peroxide, hydroxyl radical and singlet oxygen are produced when electrons from electron transport chain in mitochondria and chloroplasts are leaked and react with molecular O_2 in the absence of other electron acceptors. Excessive levels of ROS result in oxidative damage to plants (*e.g.*, nucleic acid, proteins and/or lipids) and causes degradation of chlorophyll pigments. Therefore, ROS generation should remain within plant compatible limits. Under non -stress/ normal conditions these ROS are scavenged by antioxidant defense compounds such as superoxide dismutase (SOD), catalase (CAT), and peroxidase (POX) and prevent ROS from reaching toxic levels. All forms of abiotic stresses, including drought, salinity, high temperature, chilling, freezing and heavy metals, cause an oxidative burst in plant cells. An intricate network of defense and repair

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mechanisms counteracts these oxidation reactions. Any imbalance between ROS generation and safe detoxification represents a metabolic state that is referred as oxidative stress. Therefore, understanding of oxidative stress, antioxidant defense mechanisms and alleviation of oxidative damage are important for protecting plants under stress conditions. The accumulation of GB in plants is very important for protection against oxidative stress, induced by abiotic factors. In addition to their osmo-protective roles, GB also enhances antioxidant defense mechanisms against stress damage.

Mechanism and Protective Role of Glycine Betaine

Protection of Photosynthetic Machinery

The actions of various types of abiotic stress producing ROS inhibit the repair of PSII. It is very likely that CO_2 limitation, low temperature, moderate heat, salinity, and heavy metals generate ROS by suppressing the fixation of CO_2 and decreasing levels of 3-phosphoglyceric acid. The suppression of photosynthetic fixation of CO_2 leads to decline in the level of $NADP^+$. Due to the absence of the major acceptor of electrons ($NADP^+$) in photosystem I (PSI) accelerates the transport of electrons to molecular oxygen with the generation of H $_2O_2$ via O_2^- production. These ROS, in turn, inhibit protein synthesis and, thus, the repair of PSII.

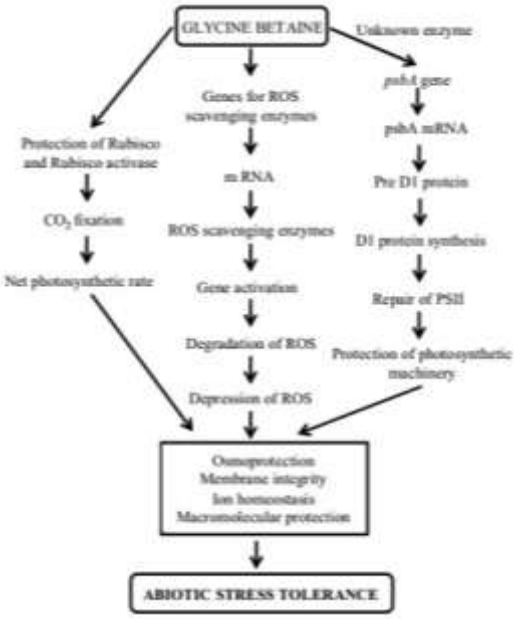

FIG. 2: A hypothetical scheme shows the mechanism and protective roles of glycine betaine directly or indirectly via ROS scavenging system.

Thus, ROS increase the extent of photo inhibition by inhibiting the repair of PSII. The photo damage to PSII is characterized by photochemical damage to a constituent of the PSII reaction center *i.e.*, D1 protein, whereas the repair of the PSII complex involves several steps that ensure the removal and replacement of damaged D1 protein.

GB enhances the tolerance of the photosynthetic machinery to photo inhibition under various stress conditions by several segmental biochemical processes

1. removal of the photo damaged D1 protein from the PSII complex;
2. transcription of the *psbA* gene in chloroplast, which encodes the precursor to the D1 protein, and translation;
3. insertion of the precursor polypeptide into the PSII complex;
4. Removal, by cleavage, of the carboxyl-terminal extension of the precursor to generate the mature D1 protein, and reconstitution of the fully functional PSII complex.

The step(s) at which GB acts specifically to promote the restoration of active PSII complexes and the way in which it does this remain to be determined. In addition, when the photosynthetic fixation of CO_2 is depressed under abiotic stress, excess electrons from PSI are converted to ROS, which inhibit the repair of photo-damaged PSII by inhibiting the synthesis of the pre-D1 protein at the translation step. GB might protect the CO_2-fixing enzymes (Rubisco and Rubisco activase) under abiotic stress, thereby sustaining the fixation of CO_2, which, in turn, depresses the production of ROS. Furthermore, GB activates the expression of genes for ROS-scavenging enzymes, which degrade ROS and decrease the levels of ROS in cells, with resultant mitigation of the effects of the abiotic stress on the photosynthetic machinery (Chen and Murata 2011).

Further studies are necessary for a full understanding of the mechanisms responsible for the effects of various kinds of environmental stresses on photo inhibition and photosynthesis.

Protection of Transcriptional and Translational Machinery

The proposed mechanisms for GB-mediated abiotic stress tolerance include stabilization of native structure of proteins and enzymes, osmoregulation, membrane integrity, protection of photosynthesis and detoxification of reactive oxygen radicals produced during stress (Fig. 3). Thus, GB and functions of their products synthesized in transgenic plants, seems to be capable of activating specific genes might help in understanding of GB-enhanced stress tolerance in plants.

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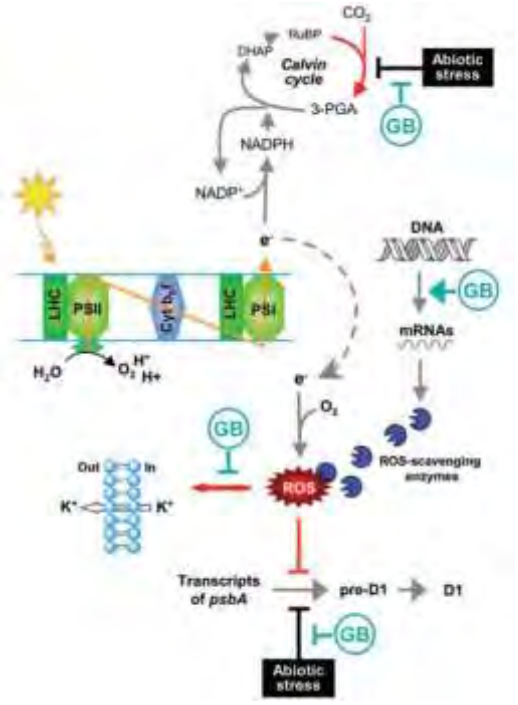

FIG. 3: The roles of GB in the protection of plants against abiotic stress. When the photosynthetic fixation of CO_2 is depressed under abiotic stress, excess electrons from PSI are converted to ROS, which inhibit the repair of photo GB might protect the CO_2-fixing enzymes (Rubisco and Rubisco activase) under abiotic stress, thereby sustaining the fixation of CO_2, which, in turn, depresses the production of ROS. In addition, GB activates the expression of genes for ROS-scavenging enzymes, which degrade ROS and decrease the levels of ROS in cells, with resultant mitigation of the effects of the abiotic stress on the photosynthetic machinery. GB might also directly protect the translational machinery against abiotic stress and limit the efflux of K+ ions, caused by ROS, either by protecting membrane integrity or by a channel-blocking function.

Conclusion

Exogenous applications of GB and transgenic approaches have shed some light on the ways in which GB protects plants against abiotic stresses. Current research efforts are focused on the elucidation of the mechanisms by which GB protects the cellular machinery *in vivo* and how, as a result, it enhances the tolerance of whole plants to abiotic stress. The proposed mechanisms for GB -mediated abiotic stress tolerance include osmo protection, protection of membrane integrity and subcellular structures and ROS detoxification. Given the low levels of accumulation of GB in transgenic plants, these mechanisms may not explain observed stress tolerance in transgenic plants completely. Further identification of GB-inducible genes and the functions of their products could advance our understanding of GB-mediated stress tolerance in plants.

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11. NANOTECHNOLOGY 14767

Role of Nanotechnology in Agriculture

Himaj S. Deshmukh

Ph.D. Scholar, Dept. of Agril. Botany, MPKV, Rahuri (M.S.)
**Corresponding Author Email: hdhsdeshmukh1@gmail.com*

INTRODUCTION: The current global population is nearly 7 billion with 50% living in Asia. A large proportion of those living in developing countries face daily food shortages as a result of environmental impacts or political instability, while in the developed world there is a food surplus. For developing countries the drive is to develop drought and pest resistant crops, which also maximize yield. In developed countries, the food industry is driven by consumer demand which is currently for fresher and healthier foodstuffs. This is big business, for example the food industry in the UK is booming with an annual growth rate of 5.2% and the demand for fresh food has increased by 10% in the last few years.

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The potential of nanotechnology to revolutionize the health care, textile, materials, Information and communication technology, and energy sectors has been well-publicized. In fact several products enabled by nanotechnology are already in the market, such as antibacterial dressings, transparent sunscreen lotions, stain-resistant fabrics, scratch free paints for cars, and self-cleaning windows. The application of nanotechnology to the agricultural and food industries was first addressed by a United States Department of Agriculture roadmap published in September 2003. The prediction is that nanotechnology will transform the entire food industry, changing the way food is produced, processed, packaged, transported, and consumed. This short report will review the key aspects of these transformations, highlighting current research in the agri-food industry and what future impacts these may have.

Nanotechnology and Agriculture

The EU's vision is of a "knowledge-based economy" and as part of this, it plans to maximize the potential of biotechnology for the benefit of EU economy, society and the environment. There are new challenges in this sector including a growing demand for healthy, safe food; an increasing risk of disease; and threats to agricultural and fishery production from changing weather patterns. However, creating a bio economy is a challenging and complex process involving the convergence of different branches of science. Nanotechnology has the potential to revolutionize the agricultural and food industry with new tools for the molecular treatment of diseases, rapid disease detection, enhancing the ability of plants to absorb nutrients etc. Smart sensors and smart delivery systems will help the agricultural industry combat viruses and other crop pathogens.

In the near future nano-structured catalysts will be available which will increase the efficiency of pesticides and herbicides, allowing lower doses to be used. Nanotechnology will also protect the environment indirectly through the use of alternative (renewable) energy supplies, and filters or catalysts to reduce pollution and clean-up existing pollutants. An agricultural methodology widely used in the USA, Europe and Japan, which efficiently utilizes modern technology for crop management, is called Controlled Environment Agriculture (CEA). CEA is an advanced and intensive form of hydroponically-based agriculture. Plants are grown within a controlled environment so that horticultural practices can be optimized.

The computerized system monitors and regulates localised environments such as fields of crops. CEA technology, as it exists today, provides an excellent platform for the introduction of nanotechnology to agriculture. With many of the monitoring and control systems already in place, nano-technological devices for CEA that provide "scouting" capabilities could tremendously improve the grower's ability to determine the best time of harvest for the crop, the vitality of the crop, and food security issues, such as microbial or chemical contamination.

Globally, many countries have identified the potential of nanotechnology in the agri-food sector and are investing a significant amount in it. The United States Department of Agriculture (USDA) has set out ambitious plans to be achieved in the short, medium and long term, and aims to discover novel phenomena, processes and tools to address challenges faced by the agricultural sector. Equal importance has been given to the societal issues associated with nanotechnology and to improve public awareness.

The UK's Food Standards Agency (FSA) has commissioned studies to assess new and potential applications of nanotechnology in food, especially on packaging. At the same time more money has been given by other Government departments towards research and development which includes the development of functional food, nutrient delivery systems and methods for optimizing food appearance, such as colour, flavour and consistency. This R&D is not just restricted to developed countries. Developing countries such as Iran have adopted their own nanotechnology programmes with a specific focus on agricultural applications.

The Iranian Agricultural ministry is supporting a consortium of 35 laboratories working on a project to expand the use of nanotechnology in agro sector. The ministry is also planning to hold training programs to develop specialized human resources in the field. They have already produced their first commercial nanotechnology product 'Nanocid', a powerful antibacterial product which has potential applications in the food industry. The product has also widespread applications in the production of various kinds of detergents, paints, ceramics, air conditioning systems, vacuum cleaners, home appliances, shoes and garments. India has allocated 22.6 million USD in its 2006 budget to the Punjab Agricultural University in Ludhiana, in acknowledgement of its pioneering contribution to the Green Revolution. Its research on high-yielding crop varieties helped boost food production in the 1960s and new projects include the development of new tools and techniques for the agriculture industry. This need will strengthen the adoption of nanotechnology in sensing applications, which will ensure food safety and security, as well as

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technology which alerts customers and shopkeepers when a food is nearing the end of its shelf-life. New antimicrobial coatings and dirt repellent plastic bags are a remarkable improvement in ensuring the safety and security of packaged food. However, there is concern over the use of nano-particles in food and its manipulation using nanotechnologies, which has the potential to elicit the same issues raised in the GM debate.

In this context, a recent report from the Institute of Food Science and Technology in the UK, argues that more safety data is required before nano-particles can be included in food. The report points out that current legislation does not force companies to label food items containing nanoparticles; and so consumers are unlikely to be aware of such applications in food items. It calls for an appropriate pre-market safety evaluation focusing on the effects of particle size as well as composition. The ETC group has gone further and has called for a moratorium on nanotechnology for agrifood. It has also accused major companies and high tech universities of seeking patents on new food items which may shut out innovative companies in less developed countries. Finally, it may be possible one day to manufacture food from component atoms and molecules, so-called "Molecular Food Manufacturing". Already some research groups are exploring this, but still from a top-down approach, using cells rather than molecules. Although the practical application of such technology is far into the future, it is expected that this could allow a more efficient and sustainable food production process to be developed where less raw materials are consumed and food of a higher nutritional quality is obtained.

12. NANOTECHNOLOGY 15349

Silver Nanoparticles: Green Synthesis, Characterization Techniques and its Advantages in Plant Sciences

Mounil Mankad[1], Pooja Mankad[2] and Armi Patel[3]

[1&3]Research Associate, Centre for Advanced Research in Plant Tissue Culture, [2]Senior Research Fellow, Department of Animal Breeding and Genetics, Anand Agricultural University, Anand, Gujarat

INTRODUCTION: Nanotechnology refers to the understanding and control of matter at nanoscale (1 to approximately 100 nm) range, where a unique phenomenon enables novel applications. Nanoscience and technology have immense possibilities to directly impact all the aspects globally in the 21st century. Nanotechnology holds great promise as far as agriculture is concerned. The product formulation following nanoscience principles can provide newly improved agrochemicals which include fertilizers, pesticides, herbicides etc. Increased in surface area at the nanoscale has tremendous application in reducing dosage and as well as applications of pesticides and herbicides. The direct impact of dosage reduction leads to improvement of the socio-economic status of farmers of the country.

Among inert elements, silver holds a unique position and applications in all the sciences. Silver is the preferred choice by the Greeks, Romans, Persians and Egyptians for storing food products. Antimicrobial property of silver is known to mankind since ages and therefore utilized in making utensils for drinking, eating and storing purposes. Silver is the most preferred metals against various microbes till the break-through discovery of antibiotics by Alexzander Flemming. Looking to the evolution of drug-resistant microbes in recent past, scientists and researchers have started exploring possibilities for development of new improved anti-microbial agents. Among various metallic nanoparticles, a huge amount of literature is available for silver nanoparticles (AgNPs) which clearly suggest that these particles can be utilized for manufacturing antimicrobial agents for drug-resistant microbes.

Green Synthesis of AgNPs

The basic component required for AgNPs synthesis is silver metal ion solution generally silver nitrate in a range of 0.1 to 1M and a reducing biological agent which includes microbes, plants and their parts, polymers etc. However, as far as plants mediated green synthesis is concerned, various biomolecules present in the cells acts as stabilizing and capping agents, which completely eliminates incorporation of stabilizing and/or capping agents for the stability of bio-synthesized nanoparticles.

Plants Metabolites as a Reducing Agent

Plants and their parts are the most important raw materials heavily utilized for the synthesis of various metallic nanoparticles like silver, zinc, iron, palladium, gold etc. Conversion of bulk to nano scale of metals requires chemicals molecules which can facilitate reduction of the metal ion. Plants possess a huge amount of diverse biomolecules which possess free radical

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scavenging capacity which includes phenolic and nitrogenous compounds, vitamins, reducing sugars, terpenoids and various other metabolites which possess antioxidant activity. In general, any plants could be utilized for the synthesis of metallic nanoparticles, however, till date most of the plants or their parts which have medicinal properties. Some of these plants and their parts used for the synthesis of AgNPs are listed below:

Sr. No.	Name of the plant	Plant Part	Nanoparticle Size (nm)	Reference
1	*Abutilon indicum*	Leaf extract	7-17 nm	Ashok Kumar *et al.* (2015)
2	*Pistacia atlantica*	Seed Powder	10-50 nm	Sadeghi *et al*. (2015)
3	*Delphinium denudatum*	Root powder	<85	Suresh *et al*. (2014)
4	*Boerhaavia diffusa*	Whole plant powder	25	Vijay Kumar *et al*. (2014)
5	*Couroupita guianensis*	Leaf and fruit	10-45	Vimala *et al.* (2015)

Characterization Techniques for Nanoparticles

Nanoparticles are generally characterized by their size, shape, surface area and dispersity. The common techniques to evaluate nanoparticles characteristics can be classified into two main groups namely; quantitative and qualitative. A brief description of each technique is given below:

Sr. No.	Characterization technique	Information obtained	Limitation
	Qualitative techniques		
1	FTIR	Biomolecules responsible for reduction, capping and efficient stabilization	Water dispersed nanoparticle solution could not be used as pellets are usually prepared using KBr.
2	UV Spectroscopy	Formation and stability of AgNPs in aqueous solution and 400 to 450 nm is used to characterize AgNPs	Quartz cuvette upon repeated usage tends to become blackish in color.
3	XRD	Surface, crystallographic and calculate the crystalline nanoparticle size	Larger crystalline samples (>1mg) required
4	SEM	Surface, Size; shape morphology	the sample must be conductive or sputter coated,
5	Color change	Distinct color change of the silver nitrate the solution from colorless to gray color after reduction process indicates the formation of AgNPs	Highly sensitive to: (i) Green synthesis method (ii) Reducing agent (iii) Substrate concentration (iv) Time / duration
	Quantitative techniques		
1	TEM	Surface, Size; shape morphology, crystallographic composition, elemental composition, electrical conductivity	Sample preparation process is tedious compared to SEM
2	DLS	Particle size, poly-dispersity index	Data generated in three different forms *i.e.* intensity, number and volume based.
3	XPS	The chemical state identification of one or more of the elements in the sample. The binding energy of one or more and density of electronic states.	Considerable errors in analyzing chemically heterogeneous surfaces; degradation during analysis; the method requires high vacuum
4	ICP MS	Isotopic analysis; multi-element analysis	ICP-MS cannot differentiate NPs or dissolved form unless a physical separation is previously done.
5	NTA	Size, zeta potential, particles per ml	Higher particle count will reduce the sensitivity of the instrument.

Advantages of NPs

Different nanomaterials have diverse applications in agriculture and allied field. Applications of nanomaterials in target-specific delivery can (i) decreased applications of plant-protection products (ii) enhanced nutrient use efficiency (iii) increased in yield through

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optimized nutrient management. Targeted delivery of nanoformulations could be achievable by designing smart formulations which can (i) release the nutrient/pesticide on demand or on command; (ii) target specific delivery (iii) reduced phytotoxicity and (iv) enhanced water retention capacity. The usage of silver nanoparticles is largely confined to antimicrobial studies especially in establishing of axenic cultures of various plants.

13. MICROBIOLOGY 14639

Demonetization: Can Reduce the Microbial Load in India?

K. Damodara Chari

Ph.D. Scholar, College of Agriculture,
Professor Jayashankar Telangana State Agriculture University, Hyderabad-500030.

The demonetization of Rs. 500 and Rs. 1,000 banknotes was a policy enacted by the Government of India on 8 November 2016, ceasing the usage of all Rs. 500 (US$7.40) and Rs. 1,000 (US$15) banknotes of the Mahatma Gandhi Series as legal tender in India from 9 November 2016. The announcement was made by the Prime Minister of India Narendra Modi in an unscheduled live televised address at 20:15 Indian Standard Time (IST) on 8 November. In the announcement, Modi declared that use of all Rs. 500 and Rs. 1,000 banknotes of the Mahatma Gandhi Series would be invalid after midnight of that day, and announced the issuance of new Rs. 500 and Rs. 2,000 banknotes of the Mahatma Gandhi New Series in exchange for the old banknotes. However, the banknote denominations of Rs. 100, Rs. 50, Rs. 20, Rs. 10 and Rs. 5 of the Mahatma Gandhi Series and Rs. 2 and Rs. 1 remained legal tender and were unaffected by the policy.

Paper currency note is widely exchanged for goods and services in countries worldwide and it was first developed in China. An individual living in unhygienic conditions having unhygienic habits will contaminate the notes with bacteria and these notes will act as a vehicle delivering bacteria to contaminate the hands of the next user. improper hand washing after using the toilet, counting paper notes using saliva, coughing and sneezing on hands then exchanging money, and placement or storage of paper notes on dirty surfaces leads to the contamination and these notes will act as a vehicle delivering bacteria to contaminate the hands of the next user.

The money makes for easy transfer of microorganisms and thus cross contamination. Paper notes of currency which is handled by a large number of people, under a variety of personal and environmental conditions thus increase the possibility of acting as environmental vehicle for the transmission of potential pathogenic microorganisms. Accumulated data obtained over the last 20 years on the microbial status and survival of pathogen on currency notes indicate that this could represent a potential cause of sporadic cases of food borne illness. The lower the index values of the money, the higher the microbial contamination of the currency. They further showed that the age of the notes and the material that was used to produce the notes influence the number of microbial contamination. Lower denomination notes harbor the greatest bulk of infectious agents since they are exchanged more than higher denomination notes. Several studies have reported bacterial contamination from 60% to as much as 100% on tested paper currencies.

Study conducted on India rupee, Bangladesh Teka, Iraqi and Ghanaian Currency Notes were contaminated with 100% by pathogenic or potentially pathogenic bacteria. Eighty eight percent of the Saudi one Riyal paper note, 96.25% of Palestine banknote, 69% of Mexico, 91.1% Colombian bills, 90% of South African banknotes were contaminated with pathogenic or potentially pathogenic bacteria with mixed bacterial growth. Currency notes in circulation are contaminated with various microbial agents of which most are resistant to commonly used antibiotics and therefore represents risks and public health hazards to the community and individuals handling currency notes.

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Research has shown that paper currency serves as an ideal breeding ground for microorganisms for several reasons. First, the paper bills offer a large surface area for organisms and organic debris to collect. Secondly, folds and/or deliberate depressions or projections specifically engineered into the bills' design as ant counterfeiting methods serve as settling sites for both organisms and debris, which allow the microorganisms to live longer. Lastly, banknotes weave their way through the population for many years before they come to rest. Studies indicate that the age and denomination of a bill have a direct correlation with the contamination observed

A recent review reported that many Gram positive bacteria, such as Enterococcus spp., S. aureus and Streptococcus pyogenes, and Gram negative bacteria, such as Acinetobacter spp., Escherichia coli, Klebsiella spp., Pseudomonas aeruginosa, Serratia marcescens and Shigella spp., can survive for months on surfaces. In addition, mycobacteria and Clostridium difficile can survive for months, while other pathogens, such as *Bordetella pertussis*, *Haemophilus influenzae*, *Proteus vulgaris* or, *Vibrio cholera*, persist only for days. Candida albicans can survive for up to 4 months on surfaces, whereas respiratory tract viruses, such as Coronavirus, Coxsackievirus, Influenza virus, severe acute respiratory syndrome associated virus or Rhinovirus, can persist on surfaces for a few days. Noroviruses are environmentally stable, able to survive both freezing and heating (although not thorough cooking), and resistant to many common chemical disinfectants, and can persist on surfaces for up to 2 weeks. Herpes viruses persist for only a few hours to 7 days, and viruses of the GI tract, such as Astrovirus, HAV, Poliovirus and Rotavirus, persist for approximately 2 months

What's the solution? Disinfection of the currencies in banks with UV light, supersonic or chemical means, producing bank notes from materials which inhibit bacterial growth or material with antimicrobial activity as well as replacement of traditional methods of trading with electronic money transactions, have all been proposed.

It is also recommended that plastic currency should be introduced, which can be washed and cleaned easily. There should be regular disinfection of currency deposited in banks and post offices by using ultraviolet light or by fumigation. In addition to this, there should be regular withdrawal of damaged and worn-out notes by the concerned authorities. Money handling machines like ATM should be made to sanitize money by destroying the microbes by heat or short exposure to antimicrobials. The paper or coatings used for currency notes should be with antimicrobial properties. Banks and business organizations should be advised to make use of machines made for the purpose of counting money and they should avoid using saliva for wetting the notes. Even they should not use water pads for counting paper notes as it moistens the notes and encourages the growth and establishment of a micro habitat for microbes. There should be public awareness of the fact that currency notes could be a source of infection and can be dangerous to health. Therefore, public education on proper handling and care of currency should be advocated in order to reduce currency contamination. Moreover, public enlightenment campaigns on good money handling practices should be done and lastly more similar studies should be carried on a regular basis in order to build a global information network on money hygiene bearing in mind the public health implications of contaminated currency notes.

Present amended **demonetization of old big paper currency notes by** Narendra Modi government, definitely reduce the large amount of harmful microflora from environment.

14. MICROBIOLOGY 15256

Role of Endophytic Bacteria in Plants

[1]Reena Patel and [2]Tushar Geveriya

[1&2] Department of Plant Pathology, N. M. College of Agriculture, Navsari Agriculture University, Navsari-396450
**Corresponding Author Email: rinapatel111993@gmail.com*

Endophytic Bacteria

Endophytic bacteria are defined as bacteria detected inside surface-sterilized plants or extracted from inside plants and having no visibly harmful effects on the plants.

An endophyte is an endosymbiont, often a bacterium or fungus that lives within a plant for at least part of its life cycle without causing apparent disease. Endophytes are ubiquitous and have been found in all species of plants. Some endophytes may enhance host growth, nutrient acquisition and may improve the plant's ability to tolerate abiotic stresses, such as drought, and enhance resistance to insects, plant pathogens and herbivores. As often with other organisms

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associated with plants such as mycorrhizal fungus, endophytes gain carbon from their association with the plant host. The most common genera of bacterial endophytes reported in the literature include *Pantoea, Pseudomonas* and *Bacillus*.

The term endophyte refers to interior colonization of plants by bacterial or fungal microorganisms. Endophytic microorganisms, microorganisms that grow in the intercellular spaces of higher plants, are recognized as one of the most chemically promising groups of microorganisms in terms of diversity and pharmaceutical potential. Furthermore, the endophytic microorganisms are not considered as saprophytes since they are associated with living tissues, and may in some way contribute to the well-being of the plant. It seems that other microbial forms, *e.g.*, mycoplasmas and archaebacteria, most certainly exist in plants as endophytes, but no evidence for them has yet been presented. The most frequently isolated endophytes are the fungi. Endophytic bacteria colonize an ecological niche similar to that colonized by plant pathogens but do not cause damage to their hosts. It turns out that the vast majority of plants have not been studied for their endophytes. Thus, enormous opportunities exist for the recovery of novel fungal forms, taxa, and biotypes. As more evidence accumulates, estimates keep rising as to the actual number of fungal species. It seems obvious that endophytes are a rich and reliable source of genetic diversity and novel, undescribed species. The endophytes that we are most concerned with are the ones growing inside a turfgrass plant.

Plants host distinct microorganism communities on and inside various of their compartments; the diversity of microbes associated with healthy plants is enormous, fungal and other eukaryotic species can be found but a critical importance is attributed to the remarkable richness of beneficial bacteria. In particular, endophytes colonize the internal parts of plants and can be isolated from various surface-sterilized plant portions.

Advantage

Plant-microbe interactions can positively influence plant growth through a variety of mechanisms, including fixation of atmospheric nitrogen by different classes of proteobacteria.

It increased biotic and abiotic stress tolerance imparted by the presence of endophytic microbes, direct and indirect advantages conferred by plant growth–promoting rhizobacteria, by the production of phyto-hormones or by enhancing availability of minerals or translocating those directly from soil to plant, as the case of mycorrhizal fungi.

Plant growth stimulation is largely due to increased availability of highly unavailable nutrients such as phosphorus, iron and other mineral nutrients, fixed nitrogen, production of plant growth regulators, phosphate solubilisation, production of siderophore molecules for iron uptake and ammonia release.

It can improve plant health acting as biocontrol agents: they protect host plants by synthetizing a large spectrum of diverse molecules that could be harnessed for potential use in agriculture, industry or medicine.

15. MICROBIOLOGY 15375

Pink Pigmented Facultative Methylotrops (PPFM)

Dr. Pasupuleti Reddypriya*

Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore - 641003
**Corresponding Author Email: reddypriyap@yahoo.com*

INTRODUCTION: Excessive use of chemical fertilizers to increase production from available land has resulted in deterioration of soil quality. To achieve a sustainable agricultural system with maximum crop yield, it is essential to incorporate fertilizers with plant growth-promoting microbes. Biofertilizers help make agriculture more sustainable by the improvement of soil fertility, resilience against pests, and crop yield. The methylotrophic bacteria are important bioinoculants. The use of methylotrophic bacteria that have the ability to colonize different habitats, including soil, sediment, water, and both epiphytes and endophytes as host plants, has been suggested for sustainable agriculture. Methylotrophic bacteria are known to play a significant role in the biogeochemical cycle in soil ecosystems, ultimately fortifying plants and sustaining agriculture. Methylotrophs also improve air quality by using volatile organic compounds such as dichloromethane, formaldehyde, methanol, and formic acid. Additionally, methylotrophs are involved in phosphorous, nitrogen, and carbon cycling and can help reduce global warming. Hence, different aspects of the interaction between methylotrophs and host plants are discussed, including the role of methylotrophs in phosphorus acquisition, nitrogen fixation, phytohormone production, iron chelation, and plant growth promotion, and co-inoculation of these bacteria as biofertilizers for viable agriculture practices.

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Methylobacterium - Plant Interaction

Methylobacterium is a plant-associated bacterium, popularly called Pink-Pigmented Facultative Methylotrophs (PPFMs) present in the phyllosphere and rhizosphere of most of the crop plants. The association of *Methylobacterium* species with plants seems to rely on a symbiotic relationship between the bacterium and host plants. These bacteria often live in environments containing diverse substrates. These methylotrophic bacteria belong to the genus *Methylobacterium* and are known to metabolize methanol but also a limited number of alternative carbon substrates, such as organic acids and alcohols.

In dense and diverse communities like those found in the phyllosphere and rhizosphere, this enables them to utilize nutrients other bacteria cannot, enhancing their competitive ability. One of such habitat is the phyllosphere, where facultative methylotrophic bacteria are found to be ubiquitous and abundant. Plant leaf surfaces release diverse carbon sources, mainly sugars and organic acids, at low amounts (μM range), and these sources are heterogeneously located and result of leaching through the cuticle. In addition to these substrates, volatile carbon substrates, particularly the plant cell wall metabolism byproduct methanol, are released via the stomata. Methanol emission peaks in the morning, when the stomata first open. There is evidence that methanol is consumed by *Methylobacterium* and contributes to the epiphytic fitness of the organism. However, in addition to the peak of methanol emission in the morning, *Methylobacterium* should adapt its metabolism to use additional carbon sources during the rest of the day when methanol emission is low or during the night when stomata are closed and methanol is consequently no longer available.

Most common niche for synergism between *Methylobacterium* and plant is the phyllosphere, where they utilize methanol evolved from leaves as the sole source of carbon and energy and in response, methylo-bacteria produce phytohormones like cytokinin and auxins. The use of leaf impressions on a methanol-agar medium has demonstrated the presence of pink-pigmented facultative methylotrophs in over 70 plant species. These PPFMs are especially abundant on leaves of field-grown crops averaged about10^6 cfu of PPFMs per leaflet, and typically >80% of the viable bacteria recovered from leaves were PPFMs. The occurrence of soil methylotrophs is probably related to the abundance of plant lignin and pectin in soils; these polymers are major potential sources of methanol. Hence, this plant associated beneficial bacteria was test verified as bioinoculant in several crops proved to enhance the crop growth and yield.

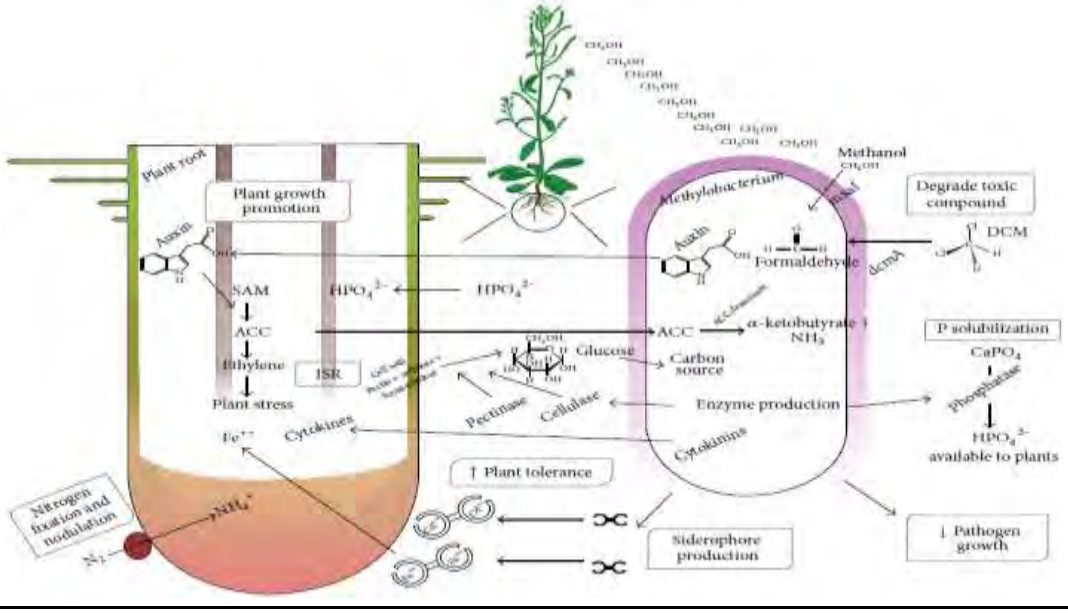

FIG. 1: Mechanisms of PPFM for plant growth promotion

Methylobacterium Biofertilizer

Commonly abbreviated to PPFMs, these bacteria are members of the genus *Methylobacterium* and are commonly found in soil, dust, various fresh water supplies and on plant surfaces. PPFMs are aerobic, Gram-negative bacteria and, although they are able to grow on a wide range of multi carbon substrates, they are characterized by the capability to grow on one-carbon compounds such as formate, formaldehyde, and methanol as their sole carbon and energy source. They are easily isolated on a methanol based mineral

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medium. Although gram negative, Methylo-bacteria often stain gram variable and do not grow on Mac Conkey agar. Research has suggested that PPFMs can benefit host plants in a variety of ways such as promoting germination, growth and yield of sugarcane, and accumulation of vitamin B in lettuce. Their pigmentation, which is frequently pink but may also be yellow or orange, is thought to provide protection from solar UV radiation which damages the DNA of bacteria at low doses because of their small cell size. The metabolism of PPFMs is unusual because, as their name suggests, they are able to utilize C1 compounds such as formaldehyde, methanol and methylamine. One of the best-characterized methylotrophs used as biofertilizer, both genetically and physiologically, is the methanol utilizing organism *Methylobacterium extorquens* AM1.

Beneficial effect on Plant

- Fasten seed germination and seedling growth
- Accelerate vegetative growth
- Increase leaf area index and chlorophyll content
- Earliness in flowering, fruit set and maturation
- Improves fruit quality, color and seed weight
- Yield increase by 10%
- Mitigate drought

Method of Application

- Seed treatment – Imbibe seed in 1.0 % volume for 5-10min (depending on seed)
- Foliar Spray of 1% PPFM
- Spray during morning or evening
- Recommended for all crops
- Spray at critical stage of crop growth (or) 30days interval.

Precaution: Do not mix with pesticide / fungicide

16. AGRONOMY 14705

Flowering Tobacco

[1]Shivaprasad S. G. and [2]Latha S.

[1]M.Sc. (Horticulture) Dept. of Floriculture, [2]Ph.D. Scholar, Dept. of Horticulture; [1]College of Horticulture, University of Agricultural and Horticultural Sciences, Shimoga, [2]College of Agriculture, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India

Flowering tobacco is scientifically called as ***Nicotiana alata*** belongs to the family **Solanaceae.** It is a South American ornamental perennial having nocturnally fragrant greenish-white flowers. *Nicotiana* or flowering tobacco, is an annual flower related to the tobacco plants of commerce, and bred for its ornamental value.

This plant produces a low rosette of large, flat, velvety leaves supports the tall flowering stems covered with many star-shaped flowers. Flower colors include white, pink, maroon, lavender, green, red, and yellow, blue. The plants can grow up to three feet tall, but dwarf forms are also popular. It's a perennial species but is treated as an annual. The plants are about 60cm tall, vigorous branching with large, coarse and velvety-hairy foliage. The blooms usually opens in the evenings but now, day-blooming varieties are also available. The plants are very free flowering.

Nicotiana is a plant that can give much-needed height to beds and borders. Group it in clusters for more impact. Avoid planting it in dusty places. Its most suitable for beds, borders, pots and for growing in groups in the shrubbery and as accents. Planting flowering tobacco (*Nicotiana alata*) in your garden is one habit you won't want to break. Nicotiana's lovely tubular blooms attract hummingbirds with their colors and gardeners with their evening fragrance. Its undemanding nature is always appreciated and flowering tobacco has become a favorite annual for flower beds, planters and window boxes. It is an easy-to-grow summer blooming plant that is appropriate for many themed gardens such as butterfly or hummingbird, scented, and cutting flowers.

Nicotiana grows best in fertile, humus-rich, moist, well-drained soil in partial shade or full sun in cooler areas. They are tough plants that will tolerate high temperatures. They can be grown successfully in a sunny or semi-shaded situation. When grown under the shade of trees, its flowers remain open in the day.

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It is propagated through dividing rhizomes, tubers, corms or bulbs (including offsets), herbaceous stem cuttings and seeds.

Seed propagation: Seeds may be sown directly in the main field but later thinning with proper spacing should be done. The seeds are sown eight weeks prior to planting out. Seeds germinate in 10 to 20 days at 70 degrees Fahrenheit. Don't cover seeds; they need light to germinate. The seeds are sown in September-October in the plains and in March-April in the hills. Later the seedlings are transplanted into permanent beds. Transplant to the garden when all danger of frost has passed.

It needs average Water. Water regularly; do not overwater. It grows upto the height of 36-48 in. (90-120 cm), the foliage is evergreen and smooth textured. All parts of plant are poisonous if ingested.

Flowering: The plants flower after 3 to 3 ½ months of sowing.

Bloom Time: Mid-Summer, Late Summer/Early Fall, Blooms repeatedly.

Collection of seeds: Allow pods to dry on plant; break open to collect seeds. Properly cleaned, seed can be successfully stored

17. AGRONOMY 14782

Importance of Cover Crops in Eroded Lands

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

Regional Agriculture Research Station Vijayapura-586101

INTRODUCTION: A cover crop is a crop planted primarily to manage soil erosion, soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agroecosystem (Lu *et al.* 2000), an ecological system managed and largely shaped by humans across a range of intensities to produce food, feed, or fiber. Currently, not many countries are known for using the cover crop method.

Cover crops are of interest in sustainable agriculture as many of them improve the sustainability of agroecosystem attributes and may also indirectly improve qualities of neighboring natural ecosystems. Farmers choose to grow and manage specific cover crop types based on their own needs and goals, influenced by the biological, environmental, social, cultural, and economic factors of the food system in which farmers operate (Snapp *et al.* 2005). The farming practice of cover crops has been recognized as climate-smart agriculture by the White House.

Cover crops are used as ground cover, mulches, green manure, nurse crops, smother crops, and forage and food for animals or humans. Cover crops can be annual or perennial species, including certain legumes, grasses, and non-leguminous dicots.

Cover crops are gaining popularity as more farmers realize their economic and environmental benefits. A cover crop is a rapidly growing crop, used either between other crops, during fallow years, or as a companion crop. Cover crops can be harvested, but their primary uses are for soil improvement, for protecting natural resources, and for reducing soil erosion. They also can help reduce the amount of water that drains off a field, protecting waterways and downstream ecosystems. And because each root creates pores in the soil, they help allow water to filter deep into the ground. Thus they help conserve water in several ways. Cover crops are also called "green manure" and "living mulches." They're called "green manure" because they provide nutrients to the soil much like manure does, and as "living mulches," cover crops prevent soil erosion.

Cover crops are an important part of sustainable agriculture since they add fertility to the soil without chemical fertilizers via biological nitrogen fixation. They are also a natural way to reduce soil compaction, manage soil moisture, reduce overall energy use, and provide additional forage for livestock.

Cover crops grown in summer are often used to fill in space during crop rotations, help amend soil, or suppress weed (living mulch). Winter cover crops help hold soil in place over the winter and provide ground cover. They can fix nitrogen at the same time.

DEFINITION: A cover crop is a type of plant grown primarily to suppress weeds, manage soil erosion, help build and improve soil fertility and quality, and control diseases and pests.

They are usually grasses or legumes, but may be other green plants.

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Important Cover Crops

Leguminous crops are often very good cover crops. Summer annual legumes, usually grown only during the summer, include soybeans, peas, and beans. Winter annual legumes that are normally planted in the fall and counted on to overwinter include Austrian winter field peas, crimson clover, hairy vetch, and subterranean clover. Some, like crimson clover and field peas, can overwinter only in regions with mild frost. Berseem clover will overwinter only in hardiness. Hairy vetch is able to withstand fairly severe winter weather. Biennials and perennials include red clover, white clover, sweet clover, and alfalfa. Crops usually used as winter annuals can sometimes be grown as summer annuals in cold, short-season regions. Also, summer annuals that are easily damaged by frost, such as cowpeas, can be grown as a winter annual in the deep southern United States.

Benefits of Cover Crops

The benefits vary by farm, situation, and season, the crop rotation, time of year, geographic location and input costs are all critical aspects to consider before choosing a cover crop. Farmers must have a clear idea of what benefit they hope to achieve with the cover crop, and a timely plan for removal.

Scavenging Nutrients

Some cover crops are very good at converting "left over" soil nutrients into organic matter. Rye and most cereal grains are good at taking up nitrogen left after the primary crop and holding it until worked back into the soil in the spring. Since nitrogen is very mobile, especially with heavy rain, this is a good way to preserve valuable nutrients. (Cereal grains)

Nitrogen Fixation: Very few plants are capable of creating their own nitrogen. The family of plants known as legumes is the most important, and can work well as cover crops for this purpose. Clovers, alfalfa, trefoil, and vetch are all legumes and potential cover crops (Legumes).

Reduced Erosion: All farmers should minimize the amount of time that soil remains bare to reduce erosion. Cover crops are an ideal way to prevent water and wind erosion in between crops. A solid seeded cover crop can decrease runoff, increase water retention and reduce loss of crucial nutrients.

Weed Suppression: Solid seeded cover crops can suppress weeds through direct competition and by shading the soil. Weeds that are often a problem in row crops can be reduced by using a cover crop in between crops or as a companion crop growing between rows or underneath the primary crop. Certain cover crops, like rye, release allelopathic compounds that suppress the germination of weeds. (Cereal grains, buckwheat, sorghum Sudan)

Loosening Compacted Soils: Certain deep-rooted cover crops can help break up soil compaction. Their deep tap roots penetrate down into the subsoil, which in turn allows better water infiltration, more effective tillage and better overall soil tilth. (Alfalfa, tillage radish)

Improved Soil Tilth: Tilth refers to the physical condition of the soil and its suitability to grow a crop. It includes many properties such as water retention, stability, aeration and drainage. Cover crops can improve all aspects of soil tilth and are also an excellent way to increase organic matter both immediately and over time. Increasing soil organic matter is a proven way to improve all aspects of soil tilth and fertility.

Beneficial Insect and Animal Habitat: All crop pests have natural enemies. Cover crops encourage these beneficial animals by providing habitat and food. Flowering cover crops are especially useful for attracting beneficial animals and insects. Flowering cover crops also attract pollinators, which will improve pollination rates of other crops in the field. (Clovers, legumes, buckwheat)

Disadvantages of Cover Crops

- Additional costs
- Interference with primary crop
- Pest problems
- High management systems

18. AGRONOMY 15058

Precision Farming

Tulika Kumari, Binita Kumari and Priyanka Lal

ICAR-National Dairy Research Institute

Agriculture is the main occupation of Indian population. About 70 per cent rural people depend on farming for their livelihood. Agriculture means cultivation or production of crop plants, it is synonymous with farming. It is an interaction of various inputs viz; seed, soil, water and agro-chemicals and provide different food and non-food produce to farmers. Since, the inputs are limited but the demand for food is increasing over the years due to increase in population, therefore, there is need of increasing productivity. The focus on increasing

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productivity during green revolution coupled with total disregard of proper management of inputs which results in environmental degradation. Therefore, there is need of such technique which enhances the productivity without any adverse effect on environment. For this type of sustainable production, precision farming is one of the best technologies for increasing productivity in small area. Now question comes, what is precision farming?

Precision Farming is defined as the information and technology based farm management system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of the land resources. This concept is sometimes called precision agriculture, prescription farming, or site-specific management. The idea is to know the soil and crop characteristics unique to each part of the field, and to optimize the production inputs within small portions of the field. The philosophy behind precision agriculture is that production inputs (seed, fertilizer, chemicals, etc.) should be applied only as needed and where needed for the most economic production.

The Need for Precision Farming

A farmer's mental information database about how to treat different areas in a field required years of observation and implementation through trial and error. Today, that level of knowledge of field conditions is difficult to maintain because of the larger farm sizes and changes in areas farmed due to annual shifts in leasing arrangements. Precision farming offers the potential to automate and simplify collection and analysis of information. It allows management decisions to be made and quickly implemented on small areas within larger fields. Precision farming techniques can improve the economic and environmental sustainability of crop production. It could be visualized through reduced use of water, fertilizers, herbicides and pesticides besides the farm equipment. Precision farming uses information technologies to segment a field into smaller units and determine each unit's individual characteristics. In this way, the producer can apply production inputs in the precise location and quantity they are needed for maximum economic yield.

Importance

1. Improve Crop Yield.
2. Provide information to make better management decisions.
3. Reduce chemical and fertilizer costs through more efficient application.
4. Provide more accurate farm records.
5. Increase profit margin.
6. Reduce pollution.

Tools of Precision Farming

1. **Global Positioning System (GPS):** GPS is heart of precision farming. It is important to find out the exact location in the field to assess the spatial variability and site specific application of inputs.
2. **Geographic Information System (GIS):** It is a computer based management system used for computation, storage, analysis and display of spatial data in the form of a map. The GIS is the key to extracting value from information on variability.
3. **Remote Sensing:** Remote sensing is collection of data from distance. Remotely sensed data provide a tool for evaluating crop health. Plant stress related to moisture, nutrients, compaction, crop diseases and other plant health concern are easily detected in overhead images.
4. **Variable Rate Technology (VRT):** VRT consists of farm field equipment with the ability to precisely control the rate of application of crop inputs that can be varied in their application.
5. **Yield monitoring and mapping:** Yield monitor are crop yield measuring devices installed in harvesting equipment. The yield data from the monitor is recorded and stored at regular interval along with positional data revised from the GIS unit. GIS software takes the yield data and produce yield map.

Application

1. Water management
2. Surface covered cultivation
3. Controlled environment structure
4. Organic farming
5. Micro propagation / tissue culture
6. Integrated Pest Management and Integrated Nutrient Management (IPM/INM)

Constraints

1. Small farm size,
2. Lack of success stories,
3. Lack of local technical expertise,
4. Knowledge and technical gap,
5. High cost of obtaining site specific data.

Conclusion: The precision farming system is an innovative approach for responding to the diminishing resources, economic pressure and increased environmental degradation in agriculture. This system helps farmers to use more effectively farm inputs, such as fertilizers, insecticides, fungicides, herbicides and irrigation water, in order to achieve increased productivity, efficiency, profits and environmental protection. With the help of precision farming farmers are able to use crop inputs more effectively, which means greater crop yield and quality without polluting the environment. The philosophy behind precision agriculture is that production

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inputs (seed, fertilizer, chemicals, etc.) should be applied only as needed and where needed for the most economic production. Thus, the precision farming system is one of the most important technologies for improving crop yield with the limited resources, without deteriorating environmental quality.

19. AGRONOMY 15250

Significance of Gossypol Content in Cotton

Sunayana*, Anil Kumar, Reena Rani and Sukhdeep Singh Sivia

Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar-125 004
**Corresponding Author Email: nainapunia@gmail.com*

Cotton, one of the world's most important cash crops, is grown in more than 80 countries across the world. While cotton is cultivated for its fibre, the fact remains that the plant produces approximately 1.6 times more seeds than lint, on a weight basis. Cottonseed is rich in oil (approximately 21%) and protein (approximately 23%) that are of relatively high quality. However, due to the presence of toxic gossypol, a cardio- and hepatotoxic terpenoid, cottonseed is unfit for consumption. Gossypol is a phenolic compound produced by pigment glands in cotton stems, leaves, seeds, and flower buds (Gossypium spp.). It is a phenolic aldehyde that permeates cells and acts as an inhibitor for several dehydrogenase enzymes. The seeds of Gossypium species vary widely in gossypol content, with levels ranging from 0.13% to 6.6%. Cottonseed may contain concentrations greater than 14,000mg/kg of total gossypol and 7,000mg/kg of free gossypol. Gossypol is a terpenoid aldehyde which is formed metabolically through acetate via the isoprenoid pathway. Its chemical formula is $C_{30}H_{30}O_8$ having molar mass 518.56 g/mol. Melting and boiling point of Gossypol is 177 to 182 °C and 707 °C respectively. Cottonseed meal is a by-product of cotton that is used for animal feeding because it is rich in oil and proteins. However, free gossypol can be released from the bound form during digestion. In cotton, gossypol plays a dual role. On one hand, it confers resistance to insect pests and diseases while on the other hand its high concentration in seed is undesirable when used for human or animal consumption in different forms. It plays an important role in conferring resistance against certain insect pests and diseases. It has antiviral activity and confers resistance in cotton against tobacco budworm, cotton bollworm, spiny bollworm (*Earias insulana*) and cotton leaf worm (*Spodoptera litura*). It also confers resistance against root knot nematode (*Meloidogyne incognita*) and fungi *Verticillium dahliae* and *Fusarium oxysporum*. Gossypol confers resistance against insect pests by way of antibiosis. In other words, it imparts antibiosis type of resistance mechanism to the host plant. Cotton seed oil contributes about 10% to the global production of edible vegetable oils. Its quality is superior to soybean oil in terms of stability, flavour and range of uses. The major disadvantage of oil obtained is the dark colour derived from gossypol pigments. Gossypol reacts with essential amino acid lysine and reduces its availability. However, presence of gossypol in the seed makes the seed cake and protein unfit for human consumption as well limits cottonseed use in animal feed. High concentrations of free gossypol may be responsible for acute clinical signs of gossypol poisoning which include respiratory distress, impaired body weight gain, anorexia, weakness, apathy, and death after several days. However, the most common toxic effects are the impairment of male and female reproduction. Another important toxic effect of gossypol is its interference with immune function, reducing an animal's resistance to infections and impairing the efficiency of vaccines. Ruminants can ingest more cottonseed meal containing gossypol than monogastric animals, because the free gossypol is detoxified in the rumen cottonseed meal is mainly used to augment animal feed as a substitute, at least in part, for soybean meal. Reduction of gossypol content in cotton to develop cottonseed and cotton meal with the potential to feed a wide spectrum of animals, including humans, has long been a goal for cotton breeders; there is need to develop varieties which have high gossypol in vegetative and floral parts and gossypol free seeds.

One alternative is the selection and use of cotton varieties containing a relatively high to low gossypol enantiomer ratio. The other preventive procedures involve the treatment of cottonseed products to decrease the concentration of free gossypol through heat treatment, roasting, extrusion, irradiation, fungal fermentation, nutritional supplementation with ferric sulfate and sodium selenite. While it is possible to remove glands/gossypol using physical/chemical means, the processing steps are cost prohibitive.

Based on the presence or absence of gossypol glands, cotton genotypes are of two types, viz. glanded and glandless. Gossypol can

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be removed by liquid cyclone process, from the oil but not from the cake or meal. Glandless cotton refers to those genotypes which are devoid of gossypol glands. Glandless cottons open new areas for enhancing the utility of cotton seed as they are potential source of good quality vegetable oil and protein for human consumption. By selecting for two major genes, plant breeders can produce gossypol free cotton genotypes as glandless condition is governed by two pairs of recessive genes (g12and g13 with some modifiers (g14and g15). Substitution of mutant alleles for active alleles at both loci produce cottons that are devoid of glands and gossypol. The presence of gossypol glands in leaf, stem and flower buds but their absence in the seed is referred to as delayed plant morphogenesis. The delayed morphogenesis of gossypol glands in embryo, is found in three wild species viz. *Gossypium bickii, G. australe* and *G. sturtianum*. These sources should be used to develop glanded plants with glandless seeds for imparting insect resistance and ensuring clean seed oil. By using conventional breeding techniques; the glandless varieties were commercially unviable because of the increased susceptibility of the plant to insect pests due to the systemic absence of glands that contain gossypol and other protective terpenoids. Thus, the promise of cottonseed in contributing to the food requirements of the burgeoning world population remained unfulfilled.

More recently, a genetic engineering strategy has been implemented to reduce gossypol levels specifically in cottonseed. Transgenic cotton that harbored the seed-specific promoter-delta-cadinene synthase RNAi construct exhibited reduced seed gossypol levels. Reduction in gossypol was restricted to the seed. It reduced cottonseed-gossypol levels in a stable and heritable manner and this trait was stable throughout multiple generations. Results from enzyme activity and molecular analyses on developing transgenic embryos were consistent with the observed phenotype in the mature seeds. Most relevant, the levels of gossypol and related terpenoids in the foliage and floral parts were not diminished, and thus their potential function in plant defense against insects and diseases remained untouched. Ultra-low gossypol cottonseed (ULGCS) lines were developed using RNAi knockdown of d-cadinene synthase gene(s) having significantly higher (4%–8%) oil content compared with the seeds from the nontransgenic parent. A targeted genetic modification, applied to an underutilized agricultural byproduct, provides a mechanism to open up a new source of nutrition. Additional insights into the cotton genome may be used to develop modified strategies to further reduce gossypol levels in cottonseed or to improve the nutritional content. Production of cottonseed that is acceptable for human consumption could conceivably produce enough protein to feed half a billion people annually.

20. AGRONOMY 15384

Allelopathy in Cropping System

Bavajigudi Shobha Rathod[1] and S. Kavitha[2]

[1]Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu and [2]Department of Agricultural Extension, PJTSAU, Rajendranagar, Hyderabad, Telangana, India.

INTRODUCTION: Weed control and soil fertility are the most important constrain that interfere the growth and development of crop and cause higher yield loss. Weed control is major pre-requisite for improve crop productivity and production. Indiscriminate use of chemical fertilizers and pesticides in agricultural production systems has started manifesting a decline in the productivity and impact on soil and human health. Allelopathy holds promise for the environmentally friendly weed management that reduces dependence on herbicide, weeding and simultaneously decrease cost of production and increase yield.

Molisch in 1937, introduced the term allelopathy and is was derived from the Greek words *allelon* 'of each other' and pathos 'to suffer' and mean the injurious effect of one upon the other. Allelopathy is the detrimental effects of chemicals or exudates produced by one (living) plant species on the germination, growth or development of another plant species (or even microorganisms) sharing the same habitat. Allelopathy does not form any aspect of crop-weed competition, rather, it causes Crop-Weed interference.

Types of Allelopathy

1. **True allelopathy:** The direct or indirect harmful effect on the other crops through the release of toxic substance as such from the plant.
2. **Functional allelopathy:** When precursor is released which is converted into active substances by some microorganisms is categorized under functional allelopathy.

Allelopathy is observed in two ways

1. **Allo-inhibition:** The chemical substances

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released by one species may inhibit species of plants other than one releasing it.

2. **Auto-inhibition:** The toxins may inhibit more strongly plants of the producer species itself.

Allelochemicals in Weed Management

Chemicals released from plants and imposing allelopathic influences are termed allelochemicals or allelochemics. For weed management we are interested in the inhibition of one plant (the weed or weeds) by another (usually the crop) through the production of allelochemicals. These allelochemicals may be actively produced by a growing plant or arise from the residues after death. Allelo chemicals are produced by plants as end products, by-products and metabolites liberalised from the plants. They belong to phenolic acids, flavanoides, and other aromatic compounds viz., terpenoids, steroids, alkaloids and organic cyanides.

Application of Allelopathy to Farming

Allelopathic interactions between plants have been studied in both managed and natural ecosystems. In agricultural systems allelopathy can be part of the interference between crops and between crops and weeds and may therefore affect the economical outcome of the plant production. Recently, several papers have suggested that allelopathy holds great prospects for finding alternative strategies for weed management. Thereby, the reliance on traditional herbicides in crop production can be reduced. Today, the allelopathic activity of some crops, for example rye, is to some extent used in weed management.

Use of Allelopathic Crops

Allelopathic crops can be used to control weeds by:

1. Use of crop cultivars with allelopathic properties
2. Application of residues and straw of allelopathic crops as mulches
3. Use of an allelopathic crop in a rotational sequence where the allelopathic crop can function as a smother crop or where residues are left to interfere with the weed population of the next Crop.

Allelopathic Activity of Selected Crops

Rice (*Oryza sativa*): In recent years, extensive screening programmes have been carried out in the search for rice accessions with an enhanced allelopathic activity. In field tests, 412 rice accessions out of 12000 were allelopathic against *Heteranthera limosa* and 145 out of 5000 were allelopathic against purple Ammannia when the allelopathic activity was evaluated as a weed free zone around rice plants. Sixteen rice accessions inhibited both weed species. In another field experiment, 1000 accessions were screened for allelopathic activity against the two weedy species, *Echinochloa crus galli* and *Cyperus difformis*. Of these 45 accessions showed allelopathic, activity against one of the weeds and five accessions inhibited both species. These experiments showing selectivity in weed control among accessions of rice, indicate that several chemical compounds, with selective mode of action against particular weeds are involved in rice allelopathy.

Wheat (*Triticum aestivum*): The allelopathic effect of wheat has mainly been studied in relation to its use as green manure/straw. Wheat residues suppress weeds due to the physical effect and to the production of allelochemicals. Phytotoxic phenolic acids and simple acids have been identified in wheat residues. The content of total phenolics has been measured in water extracts of dried residues of 38 different wheat cultivars. The allelopathic activity of the extracts was evaluated for effects against *Lolium rigidum* by an laboratory seed germination bioassay. The allelopathic effect was positively correlated with the total phenolic content in the tissue of the wheat cultivars. Hydroxamic acids have also been identified in shoot and root tissue of wheat. The most abundant of these acids in wheat tissues is DIMBOA. When the content of hydroxamic acids was examined in wheat seedling during 7 days of germination, DIBOA was also found in roots and leaves of the three cultivars examined. Hydroxamic acids were not detected within the seeds. High concentrations, up to 6 mmol/kg fw, of hydroxamic acids have been recorded in roots of some wheat cultivars and has been suggested to be valuable in the allelopathic control of weeds.

Effects on Soil Properties and Nutrient Availability

Apart from the direct toxic effect on other plants, some allelochemicals are supposed to influence the availability of nutrients in the soil. It has been hypothesized that allelopathic plants in addition to qualitative and quantitative changes in the soil content of allelochemicals also may cause changes in soil chemical characteristics. Phenolic acids can form complexes with nutrients and thereby influence the nutrient availability and nutrients in soil. In addition, some allelochemicals to their direct effects on other plants may also interfere via altered nutrient availability.

Conclusion: Several researchers have suggested improvement of allelopathic properties of crop cultivars by traditional breeding or by genetic manipulation. So far, no crop with strong allelopathic activity has apparently been developed, but research in this area is receiving attention. In rice, the search for the genes

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involved in rice allelopathy has started. Further more research is required for knowing the allelopathic properties on control of weeds at different stages of the plant and their residual effects in cropping system.

21. CROP ECOLOGY AND ENVIRONMENT 14367

Agricultural Implications of Net Radiation

Mundhe S. G.[1*], Khazi G. S.[2] and D. A. Sonawane[3]

[1] M.Sc. Scholar, Department of Agril. Meteorology, [3]Associate Professor, Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra

[2]Ph.D. Scholar, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parhani (MS) – 431 402

**Corresponding Author Email: mundhe.sachin5@gmail.com*

Net Radiation and Water Requirements of Crops.

The concept of Potential Crop Transpiration, PCT (Smith *et al*; 1992) provides a very useful tool for (i) determining peak water needs of crops (ii) for unification of apparently diverse data on water needs of crops (iii) pin-pointing crop and soil factors that influence crop water needs and (iv) agro meteorological scheduling of irrigation for a given crop and location. Net Radiation is a vital component in determination of PCT.

Crop and Radiation-Related Relationships in Photosynthesis.

Crop yield is ultimately a question of photosynthetic production and respiratory consumption of dry matter and apportioning of the net accumulated dry matter to the economic yield-component of the crop. Photosynthesis is better when sun's rays are slanted. The more the photoperiod the more is the photosynthesis. Because of the above there are differences in the yields of crops across latitudes with better yields at higher latitudes.

The principal environmental factors concerned with photosynthesis are solar radiation, CO_2 and temperature while" respiratory depletion is mainly governed by temperature. In environmental relations of photosynthesis the term light intensity instead of solar radiation is used. Other terms used are Foot Candle, Saturation light Intensity, Light Compensation Point and CO_2 Compensation point.

In terms of energy, one calorie/cm^2/minute is equal to 7000 foot candles. Intensity of sunlight at noon in summer in tropics will be about 100~0 foot candles. Saturation Light Intensity is the minimum light-intensity at which rate of photosynthesis reaches the maximum value° Temperature, Light and CO: Compensation points refer respectively to minimum values of temperature, light intensity and CO~ level at which the respiration rate equals the photosynthetic rate. The value of each of the above parameters relating to temperature, light intensity and temperature is dependent on and vary with the level of other parameter as depicted in Figure I and gives rise to the concept of Limiting Factors.

The response of crops to a given environmental factor is affected by crop physiology. The above feature accounts for the wide differences observed amongst crops in their responses when exposed to the same weather. The same holds good for photosynthesis also. Maize and Sorghum, Tobacco and Soybean are the most efficient. Least efficient and average sers of sunlight respectively. Similarly wheat is a more efficient user of CO_2 than rice while maize is the least efficient user of CO_2. While reduced solar radiation in the vegetative phase of rice has little influence on yield except under excessively cloudy conditions (Stansel.1975), solar radiation from panicle initiation to maturity is linearly related to yield of rice (Islam and Morison, 1992).

Crops differ in the method of fixation of CO_2. Those following the. Calvin cycle produce a 3 - carbon compound as a precursor and are called C_3 plants. Those following the Hatch-Slack pathway produce a 4-carbon compound as a precursor and are called C4 plants. A very minor group of plants follow the Crassulacean Acid Metabolism and are called CAM crops. Barley, Beans, Beets, Cotton, Groundnut, Oats, Peas, Potato, Rice, Soyabean, Spinach, Sunflower, and Wheat are C_3 plants. Maize, Millets, Sorghum and Sugarcane areC4plants. Members of Crassulaceae are CAM plants.

The C3 plants have significant Photorespiration *i.e.,* have high rates of respiration in light. There are indications that even amongst the C_3 and C_4 crops the maintenance respiration as a fraction of photosynthesis and its Q10 value *i.e.,* the degree of rise for every 10 degrees Centigrade rise in temperature will vary widely. The C_3 pathway is less efficient than the 'C_4 pathway in production of photosynthesis. The CAM plants fix up CO_2 at night. C4 plants have no light saturation point and their photosynthesis is little affected in the

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temperature range of 20 to 30 degrees Centigrade. The C3 plants get light saturated in the range of 2500 to 5000 foot candles. The CO_2 compensation point is high for C_3 plants, about 5 to 10 times greater than C4 plants. Current levels of CO_2 is a limiting factor in photosynthesis of C_3 plants (Pearcy and Bjorkman, 1983). Thus global warming associated with increase in levels of CO_2 will benefit C_3 plants more than C4 types. Higher temperatures for maximal photosynthesis are required by C_4 plants compared to C_3 crops. Thus C_4 crops are more efficient under hot and bright weather conditions.

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22. CROP PHYSIOLOGY 15167

The Importance of Sulphur as a Plant Nutrient

M. D. Jadhav and A. N. Alekar

Assistant Professor, Department of Plant Physiology, Sadguru College of Agriculture, Mirajgaon, Ahmednagar (M.S.)-414401

**Corresponding Author Email: meenajadhav10@rediffmail.com*

Importance of Sulphur Element

Sulphur is an important nutrient for optimal plant growth. It often accumulates in areas with volcanic activity, and mostly found in organic form in soils. It is one of the key macro elements essential for plant growth. Sulphur is taken up from the soil solution by the plant in the sulphate form (SO_4^{2-}). Crop require as much sulphur as they do phosphorus and it can therefore be rightly called fourth major nutrient in Indian agriculture.

Sulphur compound have a stimulating effect on the activities of legume bacteria and help in maintaining of soil fertility. Because three amino acid cysteine (26%), cystine (27%) and methionine (21%) content sulphur, it is essential for protein production. It also boots the oil content and nitrogen metabolism in plants. Sulphur plays an essential part in formation of chlorophyll, increases root growth, helps in activation of enzymes, and acts as part of co-enzyme A and pyrophosphate. Sulphur is also a constituent of Sulphur-glycosides, Coenzymes A, Vitamin Biotin, Thiamine (B1) and also iron sulphur protein called ferredoxins. Like nitrogen, phosphorus and potassium, sulphur is one of the essential plant nutrients. It contributes to an increase in crop yields in three different ways:

1. It provides a direct nutritive value,
2. It provides indirect nutritive value as soil amendment, especially for calcareous and saline alkali soils,
3. It improves the use efficiency of other essential plant nutrients, particularly nitrogen and phosphorus.

In general, sulphur has similar functions in plant growth nutrition as nitrogen.

Sulphur Fertilizer Types

Most sulphur containing fertilizer materials generally can be divided into four groups:

1. Fertilizers containing sulphate
2. Fertilizers containing elemental sulphate
3. Fertilizers containing a combination of sulphate and elemental sulphur, and
4. Liquid sulphur fertilizers.

Factors affecting Sulphur Availability in Soils

Availability of sulphur in soils is strongly influenced by the soil organic moiety and other soils properties. A few of these are discussed as follows:

1. **Soil texture:** Sandy soils owing to its low organic matter content and low water holding capacity sulphate-S is leached with irrigation water to deeper soil layers. So this type of soils found to be deficient in sulphur.
2. **Soil organic matter content:** Organic matter is the major reservoir for S as a higher fraction of S is associated with organic

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matter. However, the availability of S depends upon the mineralization immobilization turnover (MIT) of the soils rather than the organic matter content of the soil.

3. **Soil temperature:** The conversion of various forms of S to the sulphate-S form is a microbial process which depends upon the soil temperature. Temperature in the mesophilic range (25-35ºc) is beneficial while low soil temperature slow this process.
4. **Drainage:** Microbial conversion of organic S to sulphate-S free oxygen and aeration. The process slows down when the soil is saturated with water.

Deficiency Symptoms in Oilseed Crops

When plants have inadequate sulphur first they suffer from hidden hunger. When its deficiency become severe, the plant shows typical deficiency symptoms. Sulphur deficiency symptoms in many ways resembles to those of nitrogen deficiency *i.e.*, the leaves become pale-yellow or light green. Unlike nitrogen, sulphur deficiency symptoms first appear on younger leaves. Plants deficient in sulphur are small and with short and slender stalks, their growth is retarded. Typical symptoms of sulphur deficiency have also been identified for different oilseed crops which are depicted in table 1.

How to Correct Sulphur Deficiency?

There are many excellent sources of S that can be used to supplement the soil supply. Most commonly used are as follows-

- Gypsum (16-18%): Calcium sulphate ($CaSO_4.2H_2O$) is only slightly soluble in water and mainly used as soil ameliorant.
- Single Superphosphate (11-12%): Widely used fertilizer. Commonly used as because it adds to soils sulphur as well as phosphorus.
- Ammonium Sulphate (24%): $[(NH_4)^2SO_4]$ is a commonly used fertilizer to supply both N and S.
- Elemental Sulphur (99%): Elemental S is an excellent source of S, but it is insoluble and requires microbial oxidation to SO_4^{--} before plant uptake.

TABLE 1: Typical symptoms of sulphur deficiency in oilseed crops.

Crops	Deficiency Symptoms
Sunflower	Yellowing spreads from the base to the apex. Growth of plants is reduced. The size of capitulum is severely restricted. Inflorescence may remain covered within the bracts. Maturity of flowers is often delayed.
Groundnut	Stunted growth, and general yellowing of plants. Acute sulphur deficiency causes the entire plant to turn yellow.
Sesame	Produce smaller new leaflets with yellow and erect petioles than the normal plant growth.

How to Apply Sulphur Fertilizer?

Broadcast and subsequent incorporation, band placement, seed placement are the methods of applications of sulphur fertilizers in soils.

23. CROP PHYSIOLOGY 15220

The Physiology of Flowering in Strawberry (*Fragaria* × *ananassa* Duch.)

Anuradha and Mahantesh Kamatyanatti

Ph.D. Scholar, Dept. of Horticulture, CCS Haryana Agricultural University, Hisar, 125004
**Corresponding Author Email: anuradha2917@gmail.com*

The strawberry is a perennial plant that is usually described as herbaceous, although it is true woody plant, evidenced by production of secondary xylem in roots and crowns (Darrow, 1966; Esau, 1977). The plant body is comprised of a compressed stem, or crown, from which arise leaves, runners, roots, axillary crowns and inflorescences. The strawberry inflorescences is a modified stem terminated by primary flower. Arising laterally from this stem are usually two secondary flowers, from which four tertiary flowers may arise, followed by eight quaternary flowers. The flower of strawberry occur in cluster. Individual flowers are typically comprised of ten sepals, five petals, twenty to thirty stamens and sixty to six hundred pistils, depending on the flower order (Hancock, 1999). The type of infloresence and branching may vary among different cultivars and even within cultivars. Two type of flowers viz, hermaphrodite and pistillate flowers, occur in the cultivated strawberry. On the other hand, three types of flowers viz, staminate, hermaphrodite and pistillate flowers are found in wild hexaploid and octoploid species. (Chattopadhyay, T.K. 2013). The number of pistils is the highest and the female tendency is the strongest in the primary flowers. The number of pistils and female tendency decreases successively in the secondary, tertiary and quaternary flowers. The pistil sterility is uncommon in the strawberry. However formation of mis-shaped fruit from the

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later flowers of inflorescence indicated occurrence of pistil sterility in these flowers (Guttridge, 1979).

Flower induction is the event that initiates the transition of a vegetative apex to a floral apex in response to an environmental or developmental cue. Induction is usually determined after the fact, by documenting the beginning of floral initiation, which is the first anatomical change observed in the apex undergoing transition. Because of difficulty in separating induction from initiation, these words are often synonymously (Darnell *et al*, 2003). Flower induction is sensitive to thermo-photoperiod and to several agronomic and nutritional factors (Savini *et al*.2005).

Research into the physiology of flower initiation and development in strawberry has been conducted for many years. Photoperiod and temperature are considered the two most important environmental factors controlling the transition from vegetative to floral growth. All three photoperiodic types, short day (SD), long day (LD), and day-neutral (DN) exist in *Fragaria*, although most of the commercial octoploid cultivars grown are either SD or DN (Hancock, 1999). Greatly differing threshold photoperiods (11–16 h) and temperatures (9–21 ^{0}C) have been reported in various studies (Larson, 1994). The strong interaction between photoperiod and temperature on flower induction shows that a lower temperature is required to achieve successful induction at longer photoperiods. Moreover, each cultivar has its own particular photoperiod x temperature interaction response curve for flower induction (Taylor, 2002). The number of short-day (SD) cycles required for flower induction at different temperatures in different cultivars has been investigated in several studies (Guttridge, 1985). Sønsteby and Nes (1998) reported a critical number of 16 short days for the cultivar Korona. Most flowers were developed after 24 short days at temperature of 15 ^{0}C. Day-length treatment can also enhance crown branching, as recently shown by Hytonen *et al*. (2004). Jonkers (1965) stated that the sensitivity of the strawberry plant to photoperiod and/or temperature varies with the size or age of the plant. However, little is known about the age at which plants are sensitive to short-day treatment. Moreover, effects of plant age and their interactions with photoperiod, temperature and the number of short day cycles are poorly quantified. These effects are probably cultivar dependent. Strawberry appears to have a minimum plant size that has to be exceeded before flower induction can take place (Jahn and Dana, 1970). Flowering was delayed with increasing plant age. Leaves of any age could inhibit floral initiation and that the presence of young leaves reduced the inhibitory effect of mature leaves, possibly due to the young leaves acting as sinks, thus diverting both assimilates and the inhibitor from the meristem.

The numbers of inflorescences and flowers increase almost linearly with the duration of short-day treatment. The number of flowers per plant not only depends on the duration of the short-day treatment, but also on the age of the plants and the temperature during short-day treatment. A longer period of short-day treatment increases the number of inflorescences per plant, but decreases the number of flowers per inflorescence (Verheul *et al*. 2007).

Flowering of strawberry may also be modified by the plant's water regime and nutrient status, especially nitrogen (N) status. In some short days cultivar there is particular timing of fertilizer application, which stimulates flowering. Nitrogen fertilization immediately after commencement of SD exposure enhanced the floral induction effect of SD in June-bearing strawberries (Sønsteby *et al*., 2009). Flowering time in the field was mainly determined by thermal relations in the spring and early summer, and accordingly, it was strongly delayed with increasing latitude and altitude of the location. In addition, late floral initiation in autumn also delayed flowering in the spring.

Flower emergence and development in strawberry can be accurately controlled by adjusting photoperiod, temperature, the duration of short-day treatment and plant age under greenhouse conditions. The acquired knowledge on significant interactions between environmental conditions and flower and inflorescence emergence may be used to produce high quality plants. More research is needed to define the critical night-temperature for flower emergence, and the critical photoperiod for flower induction in important greenhouse cultivars of strawberry. In addition, environmental effects on flower differentiation should be clarified in order to obtain optimal yield and fruit quality.

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24. CROP PHYSIOLOGY 15370

Drought Stress and Present Scenario

Sumit Jangra, Disha Kamboj, Priti, Aditi, and Rahul Kumar Meena

Department of Molecular Biology, Biotechnology and Bioinformatics, CCS Haryana Agricultural University, Hisar-125004
**Corresponding Author Email: sumit.jangra712@gmail.com*

Stress is an altered physiological condition caused by factors that tend to disrupt the equilibrium. Strain is any physical and chemical change produced by a stress. Stress is used with various meanings, the physiological definition and appropriate term as responses in different environmental situations. If a factor deviates from its optimum does not necessarily results in stress. Stress is a constraint or unpredictable change imposed on regular metabolic patterns of growth results in injury, disease or aberrant physiology. Plants are mainly exposed to stresses such as drought, precipitation, salt, flooding, heat, oxidative stress and heavy metal toxicity.

Drought can be defined as unavailability of water due to inadequate rainfall or irrigation for a time being sufficient to exhaust soil moisture and injure plants. When the plants ability to absorb water is less than transpirational loss this results in drought stress. A definition of drought generally accepted by plant breeders is: "a shortfall of water availability sufficient to cause loss in yield" or "a period of no rainfall or irrigation that affects crop growth". Various biotic and abiotic stress severely affects pant growth and productivity. Water deficit is one of the major limiting factor which adversely effects plant growth and yield. In other words, drought is a complex, slow-onset phenomenon of ecological challenges that affects people more than other natural hazards causing serious economic, social and environmental losses.

Abiotic stresses, such as drought, salinity, extreme temperatures, chemical toxicity and oxidative stress are serious threats to agriculture and result in the deterioration of the environment. Abiotic stress is the primary cause of crop loss worldwide, reducing average yields for most major crop plants by more than 50%. Drought and salinity are becoming particularly widespread in many regions, and may cause serious salinization of more than 50% of all arable lands by the year 2050. In 2014-15, India had a 12% deficit in rainfall, followed by a 14% shortfall in 2015-16. El Nino was the main reason this great deficiency in rainfall during this time period. As per the response filed by the Ministry of Agriculture and Farmer's Welfare on 29th April 2016, 266 districts across 11 states were officially declared drought affected. In backdrop of the 2015-16 drought, the Supreme Court of India, in land mark judgment, directed the Union government to revise the Drought Management Manual before the end of 2016, giving due weightage to the four indicators of drought with fixed determinants. These indicators were rainfall, shortage of water level in reservoirs, surface water and ground water levels and sowing and crop conditions. India suffers US $ 100 bln losses due to drought. Experts say the 100 bln dollar loss to the economy is just a tip of the iceberg. The subsidies which government will have to hand out to its poor, will have a massive impact on its current account deficit. And that remains a big issue for a country that is aiming to become an economic powerhouse. India has been through 23 major droughts since 1871-2015, 68% of the sown area is subjected to a varying degree of drought every year, 50 million people are affected by drought every year and the average annual rainfall is 750-1,125 mm in most drought prone area.

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Moisture deficit is a significant challenge to the future of crop production. Severe drought in parts of the U.S., Australia, and Africa in recent years drastically reduced crop yields and disrupted regional economies. Even in average years, however, many agricultural regions, including the U.S. Great Plains, suffer from chronic moisture deficits. Cereal crops typically attain only about 25% of their potential yield due to the effects of environmental stress, with moisture stress the most important cause. Two major trends will likely increase the frequency and severity of crop moisture deficits:

Global Climate Change

Higher temperatures are likely to increase crop water use due to increased transpiration. A warmer atmosphere will also speed up melting of mountain snowpack, resulting in less water available for irrigation. More extreme weather patterns will increase the frequency of drought in some regions.

Competing uses for Limited Water Supplies

Increased demand from municipal and industrial users will further reduce the amount of water available for irrigated crops. Although changes in tillage and irrigation practices can improve production by conserving water, enhancing the genetic tolerance of crops to drought stress is considered an essential strategy for addressing moisture deficits.

One of the recent study found that climate change could derive an 11% decrease in crop yields and a 20% increase in price by 2050 if countries do not stem their greenhouse gas emission. And while developed countries have the resources to adapt, their poor counterparts are often hard hit when extreme weathers events. This year El Nino, for instance has left millions in need of food assistance in places like Ethiopia where majority of population depends on agriculture to make ends meet. Funding for efforts to adapt to climate change, including by preparing farmers, has been a key focus of groups focused on the issue.

Plant Physiology Traits Defection by Drought Stress

- A plant responds to a lack of water by halting growth and reducing photosynthesis and other plant processes in order to reduce water use. As water loss progresses, leaves of some species may appear to change color—usually to blue-green.
- Foliage begins to wilt and, if the plant is not irrigated, leaves will fall off and the plant will eventually die.
- Drought lowers the water potential of a plant's root and, upon extended exposure, abscisic acid is accumulated and eventually stomatal closure occurs. This reduces a plant's leaf relative water content. The time required for drought stress to occur depends on the water-holding capacity of the soil, environmental conditions, stage of plant growth, and plant species.
- Plants growing in sandy soils with low water-holding capacity are more susceptible to drought stress than plants growing in clay soils. A limited root system will accelerate the rate at which drought stress develops. A root system may be limited by the presence of competing root systems, by site conditions such as compacted soils or high-water tables, or by container size (if growing in a container).
- A plant with a large mass of leaves in relation to the root system is prone to drought stress because the leaves may lose water faster than the roots can supply it.
- Newly installed plants and poorly established plants may be especially susceptible to drought stress because of the limited root system or the large mass of stems and leaves in comparison to roots

25. WATER MANAGEMENT 15232

Water Harvesting Techniques

Manoj Kumar Dev and Sumit Biswas

College of Agriculture, Ambagarh Chowki, Raj Nandgoan
**Corresponding Author Email: mkdev1111@gmail.com*

INTRODUCTION: Water harvesting term was firstly used in Australia by H.J. Geddes. Water harvesting is the process of runoff collection during periods of peak rainfall in storage tanks, ponds etc. It is a process of collection of runoff water from treated or untreated land surfaces or catchments or roof tops and storing in an open farm pond or closed water tanks or reservoirs or in the soil itself (in situ moisture storage) for irrigation or drinking purposes. This harvested water can be used for various productive purposes such as domestic water supply, creating stock for water and irrigation of the crops, trees and also for fish farming.

All water harvesting systems have three components viz.,

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1. **The catchment area-** It is the part of the land that contributes the rain water.
2. **The storage facility-** It is a place where the runoff water is stored from the time or it is collected until it is used.
3. **The command area-**The command area is where water is used.

Water Harvesting Technique

1. Water harvesting technique includes a wide range of methods, which are based on the following three basic points:
   a) source of water available
   b) Required storage duration
   c) Intended use of harvested water
1. On the basis of above listed points, the harvesting techniques are classified as under:
   a) Roof harvesting
   b) Runoff harvesting
      i) Short term storage
      ii) Long term storage
      iii) Flood water harvesting

Roof Harvesting: Roof water harvesting technique is storing of rain water from building roof for purpose of recharge of ground water, to maintain ecological balance and to make proper use of rain water for irrigation.

Run Off Harvesting: Runoff harvesting for short and long term is done by constructing the structures, given as under:

Short Term Harvesting Technique

1. **Contour Bund:** This method involves the construction of bunds on contour of the catchment area and holds the flowing surface runoff, through the area into surrounded space of two adjacent bunds. The height of contour bund generally ranges from 0.30 m to 1.0 m. and length from 10 m to few hundred meters and the side slope of the bund is kept in an optimum limit.
2. **Semi-Circular Hoop:** This type of structure consists of a constructed in the shape of semi-circle. The height of hoop is kept from 0.1 to 0.5 m and radius varies from 5 to 30 m. The excess water is discharged from the point around the tips to the next lower hoop.
3. **Trapezoidal Bund:** The layout of the trapezoidal bunds is the same as the semi-circular hoop, but they unusually cover a large area. The height of the trapezoidal bund ranges from 0.3-0.6 m and width across the tip varies from 40 m to 160 m. It is suitable for that area where rainfall intensity is too high and causing surface flow at peak rate which damage the contour bunds.
4. **Graded Bund:** Graded bunds are also referred as off contour bund. They consist in which has the slope ranges from 0.5 to 2.0 per cent. They are used as an option where rainfall intensity and soils are such that the runoff water discharged from the field can be easily intercepted. The excess water is divided in to the next field through a channel. The height of the graded bund ranges from 0.3 to 0.6 m. This type of bunds for water harvesting is generally used for irrigating the crops.
5. **Rock Catchment:** The rock catchments are the exposed rock surfaces, used for collecting the runoff water into a part as depressed area. When rainfall occurs on the exposed rock surface, takes the formed so, it is drained towards the lowest point called as storage tank should also be made. The water collected in the tank can be used for domestic stock or irrigation purposes.
6. **Ground Catchment:** The large area of ground is used as catchment for runoff yield and runoff is diverted into storage tank. These channels are again compacted to reduce the seepage or percolation loss. Ground catchment technique is used for collecting the runoff water for supplying the water for irrigation of vegetables etc.

Long Term Harvesting Technique

The long term runoff harvesting is mainly done for building a big water stock for the purpose of irrigation, fish farming, and electricity generation and it is done by constructing the reservoirs and big size ponds in the area.

The most common long term runoff harvesting structures are of two types:

1. **Dugout Pond:** The dugout ponds are constructed by excavating the soil from the ground surface. These ponds may be fed by ground water or surface runoff or both. Construction of these ponds is limited to those areas which have land slope less than 4% and where water table lies within 1.5 to 2.0 meters depth from the ground surface.
2. **Embankment Type Reservoir:** Embankment type's reservoir classified according to purpose for which they meant
   a) Irrigation Dam
   b) Silt Detention Dam
   c) High Level Bund
   d) Farm pond
   e) Water Harvesting Pond
   f) Percolation Tank

Flood Water Harvesting

1. **Diverting to Graded Bund:** The runoff water is diverted to the area cover by graded bunds by constructing the diversion structure such as diversion drain. Widely used in several countries such as Pakistan and Afghanistan.
2. **Check Dam:** Check dams are constructed across the river or depression to check the flow and allowing for infiltration into

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alluvium under the bed and also replenish the aquifer below the bed. This system included various benefits such as less loss of water due to evaporation than the surface water reservoirs, fewer problems of siltation and cheaper construction.

3. **Sand Dam:** It consist of constructing of dam across the valley or depression for the purpose of the reducing the flow velocity of water mixed with sand. Water flowing through the valley is filled into the pore spaces of the sand reservoir and thus creating the water body. It has advantage of less loss of water through evaporation.
4. **Subsurface Dam:** It consists of subsurface vertical barriers which are constructed across the valley, down the bed. The water flow through the valley is stored in subsurface reservoirs, created by barriers. The subsurface dams or barriers are generally constructed with clay, stone, concrete or steel materials etc.
5. **Flood Control Reservoir:** The reservoirs constructed across the suitable sites for controlling the flood are known as 'flood control reservoirs'. They are well equipped with self-operating mechanical outlets for letting out the harvested water into the stream or canal below the reservoirs.

26. WEED SCIENCE 14715

Weedy Rice: A Potential Threat to Rice Cultivation

*Jeetendra Kumar Soni

Ph.D. Scholar, CCS Haryana Agricultural University, Hisar-125004
**Corresponding Author Email: jeetu.soni1991@gmail.com*

Rice is the staple food for the world. It is traditionally grown in Asia by manual transplanting of seedlings into puddled soil. In the recent years, due to the labour and water shortages along with the problem of uncertainty in rainfall in the scenario of climate change, pulled the farmers to shift from transplanting to direct seeded rice (DSR) system. Although there are several advantages of DSR, weeds are the major constraints in DSR production because of the absence of the suppressive effect of standing water on weed growth at crop emergence and the absence of stage difference between the crop and the weeds (Chauhan and Johnson, 2010). Among these weeds, weedy rice is the most problematic one which is difficult to manage causing huge yield loss to rice producers under DSR.

WEEDY RICE: Weedy rice (*Oryza sativa* f. *spontanea*) evolved largely by natural hybridization between wild and cultivated rice, is a potential threat to rice cultivation as it affects crop production, harvest, quality and income. Weedy rice is morphologically and biochemically similar to cultivated and wild counterpart species. It was first documented in USA in 1846. In India, infestation was first reported in 1994 and spreads in West Bengal, Andhra Pradesh, Assam, Bihar, Karnataka, Madhya Pradesh, Orissa, Tamil Nadu and Uttar Pradesh. Heavy infestation of weedy rice in rice fields during the recent years were reported in Kerala, forcing farmers to abandon the crop due to huge reduction in crop yield (around 40-70 per cent) depending on the severity of infestation.

Characteristics of Weedy Rice

Weedy rice at seedling stage, it is difficult to distinguish as they mimic the crop, while it is possible after tillering, due to many morphological differences with the rice varieties *i.e.,* more numerous, longer and more slender tillers, leaves are often hispid on both surfaces, tall plants, pigmentation of several plant parts, grains with awns and red pericarp and shattering of seeds. Seed surface had parallel rows of trichomes which help in dispersal of seeds, give better grip for seeds in soil facilitating germination and prevent wash out during heavy rains (Jose *et al.*, 2013). Unlike the rice crop, weedy rice seeds are unable to germinate in saturated soil and possess variable degree of seed dormancy.

Problems associated with Weedy Rice

Weedy rice is a superior competitor to crop cultivars due to all above characteristics. Reduction in yield is the major problem due to weedy rice which varies depending on the amount of infestation. By infesting rice fields, weedy rice increases production costs and reduces farmers' income by decreasing yield.

Management Options

Prevention Measures: Use of clean and certified seeds, clean farm implements and regular field inspection by farmers can prevent weedy rice

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infestation.

Cultural Methods: Non-chemical means of weed control in rice should be centred on land preparation, varietal selection, water management and fertilizer management. Some of them are following:

1. **Stale Seedbed Technique:** It is an efficient means to manage weedy rice. After seedbed preparation the area is left idle, to allow weedy rice and other weeds to germinate. Rice can then either be drilled or water seeded after the weeds are destroyed by either mechanical (harrows) or chemical (non-selective herbicides) means.
2. **Soil Solarisation:** The effectiveness of soil solarization by using 100 micron transparent polyethylene sheets for 30-45 days during the summer months for getting more than 90 per cent control of weedy rice. This will be useful for the rice nurseries to produce seedlings free of weedy rice seedlings.
3. **Straw and Stubble Burning:** Burning straw and stubble is an effective strategy in reducing weedy rice seed present on the soil surface.
4. **Selection of Cultivars:** Use of tall cultivars, cultivars with early vigour and quick canopy closure are more competitive with weedy rice. Short-duration cultivars mature earlier than weedy rice.
5. **Flooding:** Appropriate timing, duration, and depth of flooding are critical in managing weedy rice and other weeds in direct-seeded rice systems.

Mechanical Control of Weedy Rice

Weed seedlings could be destroyed just before the planting of the rice by blade or rotary harrowing in both dried and flooded soils.

Chemical Methods

Selective herbicides to control weedy rice in conventional rice systems are not available as weedy rice and cultivated rice belong to the same species, posses' similar bio physiological process. Pre-plant application of effective soil active herbicides may help to suppress weedy rice emergence. In Bangladesh, growers apply Pretilachlor (with a safener) before or after tillage operations under standing water to reduce weedy rice infestation. Surface application of oxyflourfen in two inches standing water after land preparation and three days before sowing effectively controls weedy rice in the initial critical period of 12–15 days (Arya and Ameena, 2015).

Integrated Weed Management

Depending on the severity of infestation, effective control of weedy rice in direct seeded puddled rice is possible by integrating the management options like stale seed bed, pre sowing surface application of oxyfluorfen @ 0.2 kg/ha three days before sowing in 2cm of standing water along with selective drying of weedy rice panicles by direct contact application of broad spectrum herbicides at 15 to 20 % concentration using wiper device at 60-65 and/or 70-75 DAS.

Conclusion: With a shift to direct seeding of rice and increasing infestation of weedy rice, the bio similar has emerged as a potential threat to rice cultivation in India as well. That forced the farmers to abandon the crop due to huge reduction in crop yield. Hence weedy rice infestation in the farmer's field required immediate attention. A management programme aimed at local eradication at the field level followed by integrated management strategies should be given prime attention to sustain rice production.

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27. IRRIGATION 14777

Water Management during Critical Stages of Rice

Dileshwari[1], Mansingh Banjare[2] Omesh Thakur[3] and Aradhana Dhruw[4]

Research Scholar Department of Soil and Water Engineering[1], Department of Farm Machinery and Power Engineering[2], Department of Vegetable Science[3], Department of Plant Physiology[4], IGKV Raipur, Chhattisgarh

**Corresponding Author Email: madhukardileshwari@gmail.com*

INTRODUCTION: Water is the life of plant and must be supplied in proper quantity. Most of the soils receive water through the rain and also supplemented by irrigation. The interval between

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two irrigation depends primarily on the rate of soil moisture depletion. Normally the crop should not allow extracting more than 50% available water. The intervals are shorter in sandy soil than heavy soil. When the water supply is very limited, the crops are irrigated only at critical stages.

Crop water requirement is the water required by the plants for its survival, growth, development and to produce economic parts. This requirement is applied either naturally by precipitation or artificially by irrigation.

- Average Water requirement – 1100 mm
- Average Water requirement (SRI) – 700 mm

The daily consumptive use of rice varies from 6-10 mm and total water is ranges from 1100 to 1250 mm depending upon the agro climatic situation, duration of variety and characteristics of the soils.

TABLE 1: Stage-wise water requirement for paddy

Stages of growth	Water requirement (mm)	Percentage of total water requirement
Nursery	40	3.22
Main field preparation	200	16.12
Planting to panicle initiation	458	37.00
Panicle initiation to flowering	417	33.66
Flowering to maturity	125	10.00

Critical Stages of Irrigation: The stage at which the water stress causes severe yield reduction is also known as critical stage of water requirement. It is also known as moisture sensitive period. Critical stages of water requirement in rice are:

- Active tillering
- Panicle initiation
- Booting
- Heading and
- Flowering.

During these stages, the irrigation interval should not exceed the stipulated time so as to cause the depletion of moisture below the saturation level.

Moisture Stress

Moisture stress means the action of excess or deficit of water on plants. However, moisture stress is generally used to imply water deficits.

Water Deficits and Rice Performance: Water deficit occur in the plant whenever transpiration exceeds uptake. The effect of water deficits on growth and yield of rice depend on the stage of crop growth at which the water deficits occur.

Vegetative Growth Stage

- Immediately after transplanting, adequate land submergence (5 cm) is necessary to prevent damage to establishing seedlings from high winds and for root development.
- Following the early rooting stage, a shallow depth of land submergence (2 cm) facilitates tiller production and firm root anchorage in the soil.
- Moisture stress occur at active tillering phase will reduce the yield by 30%.

Reproductive Stage

- Rice crop is most sensitive to water deficit from panicle primordial development to heading.
- Three days of moisture stress at 11 days and at three days before heading results in maximum yield loss due to high percentage of sterility.
- Moisture stress occur at reproductive phase will reduce the yield by 50 - 60%.

Maturity Stage

- This stage (milk to grain maturity) is least sensitive to soil moisture stress.
- After yellowish ripening stage, there is no necessity for standing water.
- Water may be drained from the field about 7-10 days before harvest to facilitate harvesting.

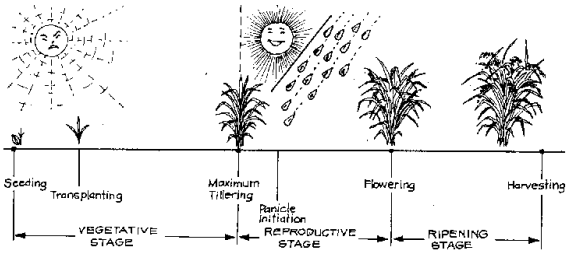

FIGURE 1: In this figure depicted growth stages of Rice

Water Stress Management

- Spray Cycocel @ 1000ppm (1ml of commercial product in one liter of water) under water deficit situations to mitigate ill effects of moisture stress.
- Split application of potassium 50% at basal and 25% each at tillering and panicle initiation stage along with *Azospirillum* (seed inoculation, seedling dipping or soil application) alleviates harmful effects of the soil moisture stress.
- Seed hardening with 1% KCl for 16 hours (seed and KCl solution 1:1) and shade dried to bring to storable moisture. This will enable the crop to withstand early moisture stress.
- Foliar spray of kaolin 3% or KCl 1% to overcome moisture stress at different

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physiological stages of rice.

Excess Water and Crop Performance

- Response of rice crop to excess water conditions is different for different growth stages, varieties and seasons.
- Turbid water greatly damages the crop than clear water.
- Seedling establishment to maximum tillering stage is least sensitive. Excess water during the vegetative phase hinders tillering.
- Flowering to maturity is more sensitive to excess water than the stage from maximum tillering to flowering.
- Fields that is kept flooded beyond the dough stage will mature in a non-homogenous way and harvest will be delayed.

Management of Excess Water

- Leveling of land removes excess water by runoff.
- Drainage removes excess water from the root zone that is harmful for plant growth.
- The best time for drainage in ill drained soils is at late tillering stage.
- Controlled irrigation reduces excess use of water in water-logged area.
- Flood control measures: Construction of bunds may check water flow from the rivers to the cultivable lands.

Continuous Submergence

- Continuous land submergence for rice is, usually, practiced due to the associated major advantages of increase in availability of nutrients and less weed management problems.
- Shallow submergence of water up to 5 cm depth throughout the crop period is optimum for high yield.

TABLE 2: Depth of submergence at different stages

Stages of crop growth	Depth of submergence (cm)
At transplanting	2
After transplanting for 3 days	5
Three days after transplanting up to maximum tillering	2
At maximum tillering (in fertile fields only)	Drain water for three days
Maximum tillering to panicle initiation	2
Panicle initiation to 21 days after flowering	5
Twenty one days after flowering	Withhold irrigation

Intermittent Submergence: Continuous land submergence requires huge quantity of water for rice production, so to minimize the irrigation requirement, the approach of intermittent submergence has been practiced.

- Under high humidity and low evaporative demand, the practice of intermittent submergence *i.e.,* submergence during the critical stages of crop and maintenance of saturation or drying up to hair cracking stage during the rest of the crop stages.
- Intermittent period varied from one to nine days depending on rainfall pattern, depth of water table and soil texture.
- This practice saves about 30% water.

Continuous Flowing Irrigation: Standing water in lowland rice minimize the irrigation needs leading to high water use efficiency compared with continuous flowing irrigation water from field to field.

- Flowing water from field to field increases grain yield of rice by preventing accumulation of harmful salts in the soil.
- However, nitrogen losses will be higher with continuous flowing irrigation water. Flowing irrigation water is ideal for problem soils.

Rotational Irrigation

- Required quantity of irrigation water is applied at regular intervals, such that there may not be any standing water in field between two irrigations.
- Irrigation interval is adjusted in such a way that the crop will not experience water deficits at any period.
- It is usually followed at time of deficit water supplies.
- Major advantage of rotational irrigation is possibly the more effective use of rainfall.
- Shallow submergence is advantageous during critical period of the crop

Conclusion: When the water resources are limited, the land may be submerged at least during the critical stages of growth, viz. tillering and flowering, and maintained only saturated at other stages.

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28. IRRIGATION 14830

Subsurface Drainage Method for Agricultural Lands

Vinodkumar and Md. Majeed Pasha

Department of Agricultural Engineering, UAS, GKVK, Bangalore-560065
**Corresponding Author Email: 786012pasha@gmail.com*

INTRODUCTION: Water logging and salt accumulation are major constraints to sustainable agricultural production in most countries of the world, especially in developing countries (including India). In India, drainage problem is acute in the states of Punjab and Haryana, while it also prevails in the command areas of other states. Waterlogging is a situation of an agricultural land when the root zone gets saturated. Such a condition restricts normal air circulation, reduces the oxygen level and increases carbon dioxide level in the root zone. On the other hand, salt affected soils are those in which the concentration of salts in the root zone adversely affects the normal root activity. Both the waterlogging and salt affected soils produce detrimental effects on crop growth and yield as well as cause environmental degradation. Waterlogging and salinity of agricultural lands are caused due to natural causes or artificial causes (*i.e.*, human interventions). Important natural causes are high rainfall during the rainy season, unfavorable topography, backwater entry from rivers, seawater intrusion, high evaporation during long dry periods, and the salts present in the soil. These problems are prevented with the help of subsurface drainage system. Subsurface drainage is the removal of excess water from the root zone.

Components of Subsurface Drainage System

FIG.1: Inspection chamber.

Pipes: Presently corrugated pipes with perforation were using. This makes transporting and handling the pipes a lot easier and cheaper, and it enables higher installation rates.

Drain Envelopes: When a subsurface drain is installed, some soils may require measures to protect the drain pipe from soil particle entry. Organic material is mostly fibrous, and includes peat, Synthetic materials may be in a granular form (*e.g.*, polystyrene) or in a fibrous form [*e.g.*, nylon, acryl, and polypropylene. Mineral fibers such as glass fiber, glass wool are used.

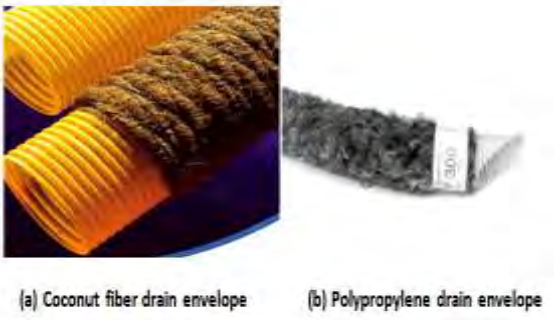

FIG. 2: Envelop with drainage pipe.

FIG. 3: collector outlet.

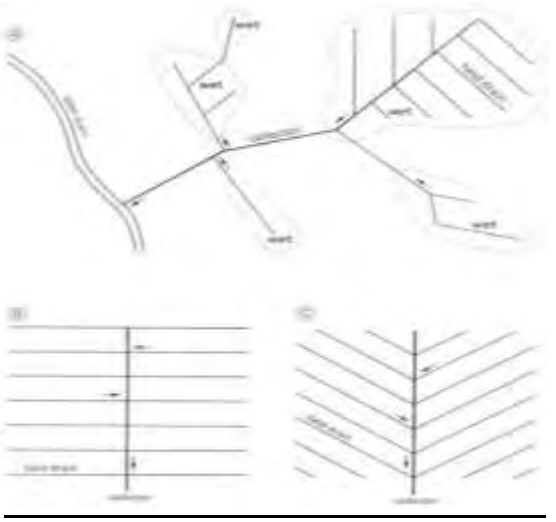

FIG. 4: layouts of pipe drainage systems.

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Inspection chamber: A manhole allows inspection and maintenance of the field drains and the collector. The lid may be either above or below the land surface depending on the need for frequent inspection.

Collector outlet: It is common to build a concrete or masonry structure. In order to avoid problems with the mechanical maintenance of open drains, the outlet structure can be built in a recessed area.

Installation

Uniform grade: the grade should be great enough to prevent silting but flat enough to prevent flow from exceeding the allowable velocity and subjecting the drain to excessive pressure.

Depth: the minimum depth of cover over the drain and the maximum trench depth are influenced by such limiting factors as the type of bedding the nature of the trench bottom the width of the trench bottom, the amount of live load. The depth of the lateral is between 90 to 120 cm.

Blinding: blinding is the placement of the bedding material consisting of loose, soil on the sides and over the top of the drain to a depth of 15 cm. the bedding material will permit water to reach the drain easily, help maintain proper alignment of the tubing, and back filling operation.

Backfilling: place the remaining excavated material into the trench and mound it over the trench to allow for settling the backfilling material is placed in the trench in a manner that displacement of the drain will not occur.

Advantages of Subsurface Drainage

- Aeration of the soil for maximum development of plant roots and desirable soil microorganisms;
- Increased length of growing season because of earlier possible planting dates;
- Decreased possibility of adversely affecting soil tilth through tillage at excessive soil water levels;
- improvement of soil water conditions in relation to the operation of tillage, planting and harvesting machines;
- Removal of toxic substances, such as salts, that in some soils retard plant growth; and
- Greater storage capacity for water, resulting in less runoff and a lower initial water table following rains.
- Adding productive land without extending farm boundaries, increasing yield and quality of crops,
- Permitting good soil management, ensuring that crops may be planted and harvested at optimum dates, and eliminating inefficient machine operation caused by small wet areas in fields

Conclusion: Subsurface drainage method has proven to be successful and highly effective in the removing the excess harmful water from the root zone of the crop. Drainage technologies are being continuously upgraded and we must take the advantage of the updated and improved global information concerning drainage and reclamation of agricultural lands. Such an approach to land and water management is the need of the hour in order to ensure sustainable agricultural production in the country.

29. REMOTE SENSING AND GIS 15324

Remote Sensing and Geographical Information System (GIS) Applications in Agriculture

M. K. Nayak, Anil Kumar and Madho Singh

Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar-125004

Agricultural has always remained an essential activity of any nation. Production of food in sufficient quantity and quality is essential for the well-being of the people anywhere in the world. The Indian Remote Sensing Satellites (IRS, ISRO) system of India is the largest constellation of remote sensing satellites for civilian use in operation today in the world. All these are placed in polar sun-synchronous orbit and provide data in a variety of spatial, spectral and temporal resolutions. LANDSAT of NASA, USA also is the most important program in space imaging.

Geographic Information System

Geographical Information System (GIS) has become an important field in academics, public utility and industries. GIS is one of the fastest growing sectors along with the computer industry. Geographic Information is basically dealing with the issues of space and time.

In brief, a GIS capable to:

- Collect, store and retrieve spatial information
- Display spatial information through shapes and texts
- Query spatial information that meets certain conditions

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- Clarify the relationship between spatial data
- Analyze spatial data to support all kinds of decision-making Geometrical shapes as point, line and polygons are used to store geographical features along with their location (geographical coordinates) in GIS software.

Popular GIS software used in India are:

- Arc GIS (by ESRI) Proprietary format is .shp files
- Super GIS (by Supergeo) Proprietary format is .geo files
- Geomedia (by Intergraph) Proprietary format is .mdb files

Applications Geoinformatics (Remote sensing, GIS and GPS) has vast application in field of agriculture. The ability of RS & GIS to analyze and visualize agricultural environments has proved to be very beneficial to farming community as well as industry.

Geoinformatics use in Agriculture

1. **Crop analysis by Indices:** The most widely used indices is Normalized Difference Vegetation Index (NDVI). It is computed as NDVI = (IR-R)/ (IR+R); Where IR is pixel's value in the near- infrared band and R is pixel's value in the red band. The other indices are, Ratio vegetation index (RVI), calculated as RVI = IR/R; and Difference Vegetation Index (DVI) calculated as DVI = IR-R. 2. Land use and land cover
   Imagery or aerial photographs capture synoptic view of an area, hence nothing can be remained unobserved while in surveys there are ample chances of negligence of some features. Monitoring of surface features or phenomena (floods, deforestation, forest fires etc.) become easy and cost effective.
2. Crop area Estimation
3. Crop specific info and agribusiness
4. Analysis of damaged crops regions
5. Estimating water content from remote sensing
6. Precision agriculture (PA) or satellite farming or site specific crop management (SSCM)
7. Cadastral Data Management System
8. Agrometeorological Applications

Agricultural is always influence by climatic and meteorological phenomena. The meteorological data are collected through a spatial network of point station observation (observatories). The development of satellite meteorology has allowed obtaining frequent and accurate measurements of a number of basic agro-meteorological parameters (*e.g.* surface albedo, surface temperature, evapotranspiration, solar radiation, rainfall etc.).

30. SOIL SCIENCE 15042

Site Specific Nutrient Management in Rice

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-584 104, Karnataka, India
**Corresponding Author Email: dhanalakshmiagri@gmail.com*

Rice (*Oryza sativa* L.) is the staple food crop of more than 60 per cent of the world population. About 90 per cent of rice grown in the world is produced and consumed in the Asian region. In India, rice is the most important and extensively grown food crop, occupying about 43.97 million hectare with the production of 104.32 million tonnes and productivity of 2371 kg ha^{-1} (FAO, 2012). Sustainable high yield agriculture is India's top-most agenda for food security. Soil nutrient supplies, fertilizer efficiency and productivity vary widely across small distances in diverse irrigated rice fields in Asia. Low soil fertility status and poor nutrient management practices result in low yield. In this context, site-specific nutrient management can play a vital role in balancing the soil fertility and plant nutrient supply to an optimum level through the judicious and efficient use of chemical fertilizers. However, blanket fertilizer recommendations are often applied over large areas without taking into an account of wide variability and season-specific crop nutrient requirement. Thus to avoid the ever-increasing problems related to nutrient losses researchers had conducted work on Site Specific Nutrient Management (SSNM) in different countries for rice. Considering soil test results, it helps to supply the nutrients on need basis to rice crop for a target yield and its implementation in field.

Key Scientific Principles used in Developing Practices for Determining 4 R's

1. **Right source:** Apply balanced amount of

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fertilizer, Set realistic yield goals and apply, Nutrients to meet the target yield.

2. **Right rate:** Greater synchrony between crop demand and nutrient supply
3. **Right time:** Determine the critical time for the nutrients. Apply the nutrients when plant needed.
4. **Right place:** Recognize root-soil dynamics. Manage variability within the field to meet site-specific crop needs.

Principle of SSNM

Site Specific Nutrient Management (SSNM) is an approach to feeding rice with nutrients as and when needed. The application and management of nutrients are dynamically adjusted to crop needs of the location and season. The SSNM approach aims to increase farmers profit through - Increased yield of rice per unit of applied fertilizer, higher rice yields, and Reduced disease and insect damage.

How the SSNM is followed..?

- Nutrients required based on target yield & nutrient removal to be computed
- Soil available nutrients status was decided as 'Low' 'Medium' or 'High' based on soil test ratings.
- If soil test rating is:
  - Low: Required nutrients were increased by 20%
  - Medium: No change in the required nutrients
  - High: Required nutrients were decreased by 20%
  - Micronutrients were applied based on critical limits and general uptake pattern

Omission Plot Technique

The nutrient omission plot technique is a tool for determining crop requirements for fertilizer P or K. When farmers use less than the estimated crop requirement for a nutrient, a nutrient addition plot technique can be used by farmers to determine the merit of using more of the nutrient. The nutrient addition plot technique is particularly useful for K and micronutrients. Opportunities exist to use farmers' historical use of fertilizer P and K, farmers' straw management practice, yield targets of farmers, and simple field observations to estimate field-specific fertilizer P and K needs. Simple guidelines are needed for using such information together with existing knowledge on soils to empower farmers in using improved practices for their specific rice fields.

Advantages of SSNM

Site specific nutrient management is a concept that can be applied to any field or any crop, while most often use of computer and satellite technology in the site specific nutrient management does not require special equipment and does not require a large farming operation. The technology tools certainly expand the capabilities for using site specific management.

Wang *et al.* (2007) reported that higher rice yield (6.4 t/ha), higher agronomic efficiency (12.5 kg/ha) of N, higher recovery efficiency of N (29%), lower usage of N (120 kg/ha), P (14.2 kg/ha) and K (51.9 kg/ha) fertilizers was observed in SSNM practice as compared to FFP in double-rice cropping system.

Singh *et al.* (2008) experiments were conducted for 3 years to evaluate the effect of SSNM in rice-wheat cropping and reported that 50% of the increase in productivity on farmers' fields as compared to the increases observed in these on-station experiments, and only 25% area coverage with SSNM, the total annual increase in RWCS production could be 11 Mt for rice and 4.75 Mt for wheat.

Nagegowda *et al.* (2011) reported that higher grain yield (56.7q ha^{-1}) and straw yield (72.27q ha^{-1}) of rice was recorded in SSNM and the increase was to an extent of 30 and 22.2 per cent, respectively, when compared to FFP.

Biradar *et al.* (2012) reported that nutrient application as per SSNM concept resulted in significantly higher grain yields of maize (7.02 t/ha), rice (8.34 t/ha), wheat (3.79 t/ha) and *rabi* jowar (2.56 t/ha) over recommended dose of fertilizers and FFP.

Conclusion: Rice and rice based cropping systems are cultivated widely and intensively in India under diverse soil and agro ecological conditions consuming major proportion of soil and water resources, agro chemicals and fertilizer inputs. SSNM can take into account of all nutrient deficiencies to ensure crop demands and soil fertility to be improved, which in turn ensures higher nutrient use efficiency, crop productivity and economic returns. It suggests feed the crop as per its requirement to harness the productivity potential of the crops. The higher grain yield of rice is obtained with SSNM treatment as compared to farmers practice.

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31. SOIL SCIENCE 15145

Soil Fertility and Productivity

Rohit K. Patidar and Debabrata Nath

Division of Soil Physics, ICAR- Indian Institute of Soil Science, Bhopal

Importance of Soil Fertility

As civilization moves to beginning of the twenty first century and as World's population continues to increase, the importance of a continuing increase in food production is obvious. India alone is contributing more than a Billion people. It means that our crop production must be at least doubled by the end of the century.

There are two options open to us. One way is to increase the area under the plough and the other to increase production per unit area. The scope is limited for the first option. So greater attention will have to be paid to the increasing of the production per unit area, per unit time. The strategy is to maintain soil fertility and proper nutrient management without impairing soil quality (sustainable agriculture).

Soil fertility: Soil fertility is defined as the quality that enables the soil to provide proper nutrient compounds in proper amounts and in proper balance for the growth of specified plants. Soil fertility is also defined as the ability of soil to supply adequately the nutrients normally taken from the soil by plants.

Soil as a Source of Plant Nutrients

Soils are complex natural formations on the surface of the earth and consist of five main components: mineral matter, organic matter, water, air and living organisms. The rocks and minerals on weathering release nutrients into the soil. The most important part of the soil with respect to plant nutrition is the colloidal fraction which consists of inorganic colloids (clay) and organic colloids (humic substances). Most of soil colloids possess electronegative adsorption sites available for attracting cations including calcium, magnesium, potassium, ammonium *etc* as well as H+ arising from the biological activity. Organic matter on decomposition releases nutrients. The cations adsorbed on the surface of the colloids are capable of exchanging rapidly and reversibly with those in soil solution. The principal immediate source of mineral nutrients to plant roots is ions in the soil solution. This nutrient supply is gradually depleted by absorption of nutrient ions by plant roots and continuously replenished by desorption of exchangeable ions on the clay-humus complex and break down of readily decomposable organic debris. The microbes in the soil also help in supplementing nutrients by the way of nutrient transformations. These sources represent the reserves that serve to replace but only at a relatively slow rate. For intensive cultivation of crop plants, however, application of mineral salts to soil is required.

The overall goal of soil fertility research is a more fundamental understanding of chemical and biochemical reactions in soils related to plant growth, sustainability while maintaining soil and environmental quality. Soils are the medium in which crops grow to provide food and cloth to the world. Soil is the major factor that limits the type of vegetation and crops. Under similar climatic conditions, a loose and porous soil that retains little water will support sparse vegetation when compared to deep, fertile loam or clay. The basic need of crop production is to maintain soil fertility and soil productivity

Soil fertility and soil productivity

	Soil Fertility	Soil Productivity
1	It is the inherent capacity of the soil to provide essential chemical elements for plant growth	Soil productivity emphasizes the capacity of soil to produce crops and is expressed in terms of yield.
2	A combination of soil properties and an aspect of soil – plant relationships.	An economic concept and not a property of soil
3	Soil fertility is vital to a productive soil. But a fertile soil is not necessarily be a productive soil. Many factors can limit production, even when fertility is adequate. For example, soils in arid region may be fertile but not productive.	Soil fertility is one factor among all the external factors that control plant growth like air heat (temp.), light, mechanical support, soil fertility and water. Plant depends on soil for all these factors except for light
4	Organic matter in the soil improves soil fertility by mineralization of nutrients	Organic matter also improves soil productivity by improving soil porosity, aggregation and physical condition of soil thus modifying the soil environment for crop growth

Concepts of Soil Fertility and Soil Productivity

- It is evident from the early writing of

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Theophrastus (372 – 287 BC) even before the advent of Christian era, Greek and Romans realised the impact of soil on the growth of plants and made a mention about the application of organic wastes and saltpeter for the plants.

- The first experiment aimed at elucidating the increase in the weight of plant during its growth was reported by **Nicholas** (1401 - 1446).
- **Jan Baptiste van Helmont** (1577-1644) attributed the increase in weight of willow shoot to water.
- But a German chemist, **Glauber** (1604-1668), who attributed the growth of plants to the absorption of saltpeter (KNO3) from the soil.
- **John Woodward** (during the year about 1700) first conducted water culture experiments on spearmint and emphasized that the growth factor is some terrestrial matter but not the water.
- **Jean Baptiste Boussingault** (1802-1882) carried out field plot experiments. He was called as 'father of field plot technique'.
- **Justus von Liebig** (1803-1873) put forth the 'law of minimum' which states that the yield is governed by the limiting nutrient and is directly proportional to the factor which is minimum in the soil.

Factors affecting Soil Fertility – Physical, Chemical and Biological Factors

Physical

- Soil Formation – f (Parent material, Climate, Topography, Time)
- Parent material – Contain adequate in essential elements like apatite (P source), and calcite (calcium) etc.
- Climate - Factors like rainfall modifies fertility. If there is heavy rainfall cations (like ca) present in the soil may be leached down hence the soil become acidic. Soils in low rainfall with high temperatures rich in bases (Ca, Mg, Na) accumulate on surface through water evaporation however heavy rainfall areas are rich in Al and Fe, Hence climate modify soil fertility.
- Topography - Physically nutrients are carried from upper elevated lands to lower lands. Hence more nutrients are seen in valley.
- Soil depth – Deep soils are fertile, roots can extract more nutrients. But, presence of hard pans restricts the utility of nutrients.
- Time - Soils which are aged are fertile and living organisms are present in higher quantity indicated higher fertility and more organic matter.
- Water logged / submerged soils are deficit in Nitrogen. NO_3 are lost under water logged soils leads to yellowing of crop. Therefore leaching losses of nitrogen is common problem.
- Size of clay – More the clay content – higher the soil fertility. More CEC improves nutrient holding capacity and water holding capacity. Among soil colloids, the ratio of 1:1 kaolinite and 2:1 montmorillonite, if 2:1 types are more, CEC and WHC will be more.
- If Soil is rich in more of montmorillonite and vermiculite clay, WHC and NHC will be more.

Clay type	CEC
Kaolinite	3-10
Mica	10-40
Montmorillonite	80-150
Vermiculite	100-150
Organic colloids	>200

Chemical Factors

- Influence the quantity of nutrients available
- The form in which it is available
- Balance of nutrients – Ca in saline and Fe in acidic soils creates imbalance in nutrition. Presence of toxic elements affects mobility of nutrients ions in soils *ex.* nitrate and phosphates. Solubility of salts like Ca, Mg, Na, SO_4, CO_3, NO_3 affects the nutrients availability. If EC is > 4 ds m-1 affects the plant growth.

Biological Factors

- A gram of fertile soil contains billions of microorganisms. (4000 kg m.os/ ha). It constitutes 0.01 to 0.4 % of total soil mass.
- Roots of higher plants are associated with microflora like fungi, bacteria, actinomycetes, algae etc.
- Mycorrhizae associated with roots of several plants helps in nutrients acquisition of few mobile and immobile nutrients through mycelia.
- Protozoa and nematodes are microflora. Their population is separately influenced by types of crops grown influence soil fertility.
- Microbial biomass – associated with particulate and colloidal fraction of soil helps in nutrient acquisition.
- Macro fauna like earthworms associated with mixing of soil and pore formation. They are primary decomposers of the litter
- N fixers- free living or symbiotic organisms, P – solubilizers are involved in nutrient acquisition and mineralization.

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32. SOIL SCIENCE 15236

Soil Compaction in Agricultural Fields

Sridhar N. and Ramachandran S.

Research Scholar, II Ph.D., Dept. of Farm Machinery and Power, AEC & RI, Kumulur, TNAU, Trichy
**Corresponding Author Email: sriphd88@gmail.com*

INTRODUCTION: Agriculture has got a prime role in Indian economy. Though the share of agriculture in national income has come down, still it has a substantial share in GDP. This review was concerns of soil compaction in agricultural fields that used conventional tillage practices with tractors. Soil compaction occurs when soil particles are compressed together especially when the soil is wet - destroying soil structure, reducing porosity, and leading to a more dense soil that is hard for crop roots and water to penetrate as show in Fig.1. Changes in agricultural practices, such as increased number of field operations and larger equipment, have made soil compaction more common on many fields.

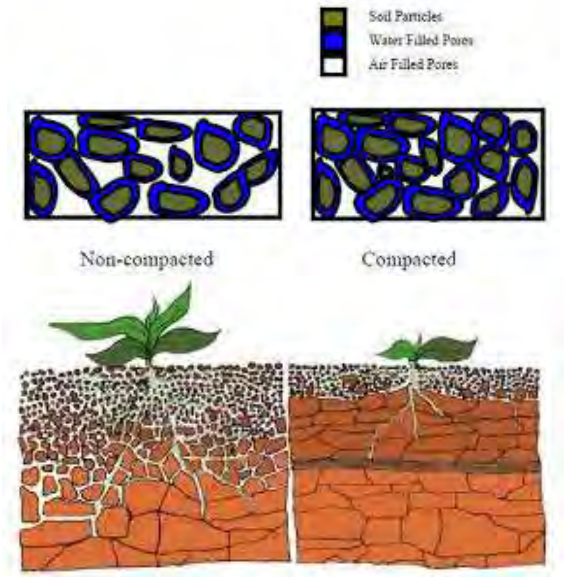

FIG. 1: Effects of compaction on pore space. (Source: Neil Hansen, 2003)

Measurement of Soil Compaction

A common way to detect a compacted layer is by using a soil penetrometer (compaction meter). Penetrometers use a metal probe with a cone-shaped tip to measure the force required to push through the soil as shown in Figure 2. This force may be expressed in megapascals (MPa) or pounds per square inch (psi). A reading of over 300 psi (2 MPa) is regarded as too hard for most agricultural roots to penetrate (Aase *et al.*, 2001). As the soil dries out, the compaction reading normally increases, so it is important to conduct compaction measurements when the soil is at field capacity, *i.e.,* soil moisture level after gravity has drained excess soil water from recent irrigation or precipitation.

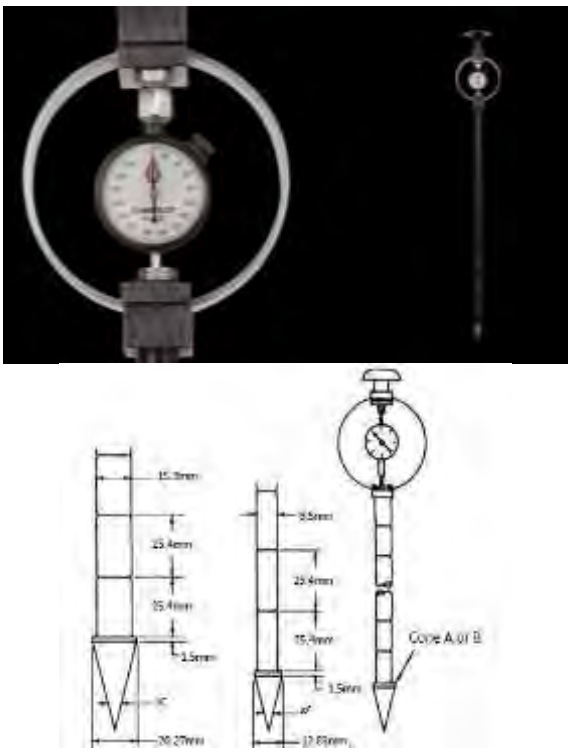

FIG 2: Compaction measuring device soil penetrometer (Source: ASABE 2006 b)

Effects of Soil Compaction

Compaction caused by farm operations has been shown to affect the yield of field crops in several ways (Alblas *et al.*, 1994; Filipovic *et al.*, 2006;).

1. Soil Structure
2. Nutrient Uptake
3. Crop Emergence and Stand
4. Crop Growth and Development
5. Crop Yield
6. Iron Deficiency Chlorosis
7. Overall Crop Energy

Management Strategies of Soil Compaction

Soil compaction is a more common due to modern farming operations that rely on heavy equipment, implements, and tractors. Still, there are several ways to avoid soil compaction under such conditions. Some better management practices that can prevent subsurface soil

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compaction are:

- Avoid soil tillage operations when the soil is wet.
- Practice controlled traffic on the farm.
- Use tractors with the correct type of tires and tire pressures.
- Reduced tillage practices.
- Managing the soil organic matter

Conclusion: Soil compaction can be a great challenge in agricultural fields and can lead to yield reductions depending on the type of crop grown. However, there are many strategies that producers can use to avoid or address soil compaction issues on the farm. Compaction in the topsoil can be avoided by reducing tire pressure, using flotation tires, doubles, radial tires, or tracks, and by employing large-diameter tires. Reducing the number of trips over the field and reducing the total area per acre actually traveled are recommended. Taking measurements with a penetrometer can provide information about the depth and extent of soil compaction, and this can assist in developing management options.

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33. SOIL SCIENCE 15380

Role of Micronutrients for Improving the Yield and Quality of Crops

[1]Aware S. B and [2]Babar A. K.

[1]Assistant Professor, Department of Soil Science and Agril. Chemistry, [2]Assistant Professor, Department of Agronomy, K. K. Wagh College of Agriculture and College of Agriculture Business Management, Nashik

**Corresponding Author Email: awaresulbha@gmail.com*

INTRODUCTION: The word 'Micronutrients' represents some essential nutrients that are required in very small quantity for the growth of plant, these are also called as trace elements. The micronutrient deficiency in soils has been attributed in Indian agriculture due to continual removal of micronutrients from the soil by recently introduced fertilizer responsive varieties of crops particularly cereals which produce high biomass on fertilizer application, use of micronutrient free fertilizer in modern agriculture and minimum use of organic fertilizers.

Deficiency of zinc, iron, copper, manganese, boron, molybdenum has been noticed about 48, 12, 4, 5, 33, 13 % in soils of India, respectively.

Changes in soil pH, $CaCO_3$ content, organic matter content and size fractions (clay and silt) had strong influence on the distribution of micronutrients.

TABLE 1: Guideline for critical, toxic levels of micro nutrients in plant

Element	Critical level	Toxicity level
Fe (mg/kg)	<50	Not toxic
Zn (mg/kg)	15-20	>400
Mn (mg/kg)	10-20	>300
Cu (mg/kg)	3-5	>20
B (mg/kg)	<10.0	>100
Mo (mg/kg)	<0.1	>0.5
Co (mg/kg)	<0.2	>0.5
Cl (%)	<0.2	>2.0

Source: Enhancing nutrient use efficiency in problem soils-Book - CSSRI, Karnal (2009)

Why we Need Micronutrients?

- Increased fertilizer rates resulting in increased yields means a higher removal of micronutrients from soil.
- Improved crop varieties are capable of producing higher yields per acre and consequently remove more micronutrients from the soil.
- Land forming and land leveling with the removal of several inches of topsoil many times results in deficiency of certain micronutrient on the cut areas.
- High phosphorus levels, either natural and

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fertilizer application, have been found in some areas to induce micronutrient deficiency.

- Repeated application of one trace element induces deficiencies of other elements. Reclaimed land often suffers from deficiency of micronutrient especially after few years of cropping.
- Changes in climatic condition such as rain, soil moisture, microflora of soil, plants grown under shade and soil pH will affect the availability of micronutrients.
- Limited source of green manures, compost manures and organic manures, slows down release of micronutrients from them. The requirement varies with crop stages of crop growth.

Antagonistic affects

- Excess of P adversely affects on utilization of Zn, Fe & Cu
- Excess of Fe adversely affect utilization of Zn & Mn
- Excess of Zn, Mn & Cu induces Fe deficiency in crops
- Excess of S & Cu induces Mo deficiency in crops
- Excess of N induces Zn deficiency
- Excess of lime induces deficiency of all micronutrients except Mo

TABLE 2: Indicator plants showing deficiency

Nutrient	Indicator plant (s)
Zinc (Zn)	Paddy (low land), potato, tomato, cotton, maize, beans, soybean, green gram, black gram, onion, flax, grapes and citrus fruits.
Copper (Cu)	Wheat, oats, beet, carrot, spinach, Lucerne, lettuce and citrus fruits.
Boron (B)	Cabbage, cauliflower, sugar beet, turnip, rapeseed, apple, pear, rose, sunflower and alfalfa.
Iron (Fe)	Maize, groundnut, vegetables, soybean, sorghum, field beans, flax, citrus fruits, barrier, grape and fruit trees.
Manganese (Mn)	Oats, sorghum, peas, bean, soybean, radish, lettuce, cucumber, tobacco, cotton, grapes, apple, peach, citrus fruits and strawberry.
Molybdenum (Mo)	Maize, cotton, cauliflower, spinach, lettuce, citrus fruits, legumes and clover.

Source: Secondary and micronutrients in agriculture. Guide Book- Cum – Directory (1991) By Dr. H. L. S. Tandon

TABLE 3: Micronutrient use by crops

Crop	Yield	Gram per hectare				
		B	Cu	Fe	Mn	Zn
Cotton	2.5 t/ha seed cotton	12	11	140	19	480
Rice	5.0 t/ha grain	60	20	810	60	215
Maize	4.0 t/ha grain	36	20	120	36	60
Wheat	3.0 t/ha grain	36	43	380	12	180
Groundnut	2.0 t/ha nuts	25	60	480	40	50
Rapeseed	3.0 t/ha seed	50	17	150	90	50

Source: Khan and Nortcliffe (1982) plus additions

Five Types of Visual Nutrient Deficiency Symptoms

- Chlorosis - Yellowing due to reduction in chlorophyll.
- Uniform or interveinal - Fe, Zn, Mn and Mo.
- Necrosis - Death of plant tissue - Mn, Cu.
- Lack of new growth or terminal growth resulting in rosetting - B.
- Anthocyanin accumulation resulting in reddish colour - Zn, B.
- Stunting with either normal or dark colour or yellowing - Mo, Zn.

Methods of Micronutrient Application

1. Foliar application: Low doses of micronutrients are applied through sprays on plant foliage. Crops in younger stages require less solution, while crops with more foliage or fruit trees like oranges, require more solution for spraying, *e.g.*, Fe, Mn, B.
2. Addition through mixed fertilizers: Uniform spreading of micronutrients essential for different regions is added to the spread fertilizer or to fertilizer mixture used, *e.g.*, phosphates mixed with boron, molybdenum or zinc.
3. Seed soaking: Low concentration of micronutrient solution is used to soak the seed for about 12 hours before planting, *e.g.*, Mo.
4. Seed coating: Micronutrient mixed with a small amount of soil made into a paste is coated around the seeds, dried and then used for sowing, *e.g.*, Mo.

The Four Main Classes of Micronutrient Sources are

1. **Inorganic products:** Inorganic sources include oxides and carbonates, and metallic salts such as sulfates, chlorides, and nitrates.
2. **Synthetic chelates:** A chelate is a word derived from the Greek word 'chela' meaning 'claw' to describe a kind of organic chemical compound in which the metal part of the molecule held so tightly that it cannot be 'stolen' by contact with other substances which would convert it into an insoluble form.
3. **Natural organic complexes:** These complexes are made by reacting metallic salts with some organic by-products of the wood pulp industry or related industries.
4. **Fritted glass products (frits):** Fritted glassy products (frits) in which solubility is

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controlled by particle size and changes in matrix composition.

Future Research Needs

- The physiological effects of micronutrient deficiencies, including their effect on the flowering and fruiting stage.
- Low-cost diagnostic techniques that can be used in the field by extension staff or farmers.
- Sampling strategies for both soils (soil testing) and crops (leaf analysis);
- Movement of micronutrients in soil and groundwater.

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Enhancing nutrient use efficiency in problem soils- Book - CSSRI, Karnal (2009)

Khan and Nortcliffe (1982) plus additions

34. AGRICULTURAL CHEMISTRY 15245

Customized Fertilizers: An Introduction

Pradeep Kumar Dewangan

M.Sc. (Ag) Department of Agronomy, Birsa Agricultural University, Ranchi-834006 (Jharkhand)
**Corresponding Author Email: dewangan2050@gmail.com*

INTRODUCTION: Fertilizer is an essential key input for production and productivity of crops. Fertilizer alone contributes towards 55% of additional food production. Since there is no scope for extending the cultivable area, more productivity per unit area is the only option and fertilizer is the main cart puller. Custom mixed fertilizer is a mixed fertilizer formulated according to individual specifications furnished by the consumer before mixing. The customized fertilizer may be combination of nutrients, secondary nutrients and micronutrients. A fertilizer formulated according to specifications that are furnished by/for a consumer prior to mixing, usually based on the results of soil tests. The sharp rise in fertilizer prices emphasizes the need for more research to improve the efficiency of fertilizer use.

Converting Energy to Food Security: Although the production of fertilizer is energy intensive, the benefits of using energy to enhance food security through fertilizer manufacture and use are enormous. Every 1 million Btu of energy use in the fertilizers sector produces an additional 218 kg of grain – enough to provide the minimum calorific intake for one person for a year. Thus, converting energy into food security through fertilizer (customized fertilizer) & associated inputs is probably the worlds (more so for India) most cost effective & human alternative for use of energy resources.

Guidelines for manufacture and sale of Customized Fertilizer under Clause 20'B' of Fertilizer Control Order.1985.

OBJECTIVES: The main objective of Customized Fertilizer is to promote site specific nutrient management so as to achieve the maximum fertilizer use efficiency of applied nutrient in a cost effective manner. The Customized Fertilizer may include the combination of nutrients based on soil testing & requirement of crop and the formulation may be of primary, secondary and micro-nutrients. It may include 100% water soluble fertilizers grades required in various stages of crop growth based on research findings.

DEFINITION: Customized Fertilizer is a concept around balanced plant nutrition. Such fertilizers are based on the sound scientific plant nutrition principle and research, Customized Fertilizer provide the best nutrition al package for premium quality plant growth and yield. They are defined as package for premium quality plant growth and yield. They are defined as multi nutrient carrier designed to contain macro and /or micro nutrient forms., both from inorganic and/or organic sources, manufactured through a systematic process of granulation, satisfying the crop's nutritional needs, specific to its site, soil and stage, validated by a scientific crop model capability developed by an accredited fertilizer manufacturing/marketing company. Such fertilizers also include water soluble specialty fertilizer as customized combination products. Prospective manufacturers or marketers are expected to use the software tools like. Decision Support System for Agro Technology Transfer (DSSAT). Crop Model etc. to determine the optimal grades of customized fertilizer.

Quality of Customized Fertilizers

The Customized Fertilizers to be used for based application shall be granular in size with minimum 90% between 1-4 mm IS sieve and Below 1mm should not exceed 5%. The moisture content should not exceed 1.5%. For foliar applications, however, the grades should be 100% water soluble. The specifications of the customized fertilizers provided by the company to manufacture of Customized Fertilizer, duly

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approved by the Ministry, shall be strictly adhered to.

Crop Formula	
Potato	8:16:24:6:0.5:0.18 (N:P:K:S:Zn:B)
Wheat	10:18:25:3:0.5:0 (N:P:K:S:Zn:B)
Sugarcane	7:20:18:6:0.5:0 (N:P:K:S:Zn:B)
Paddy	8:15:15:1:0.5:0.15 (N:P;K:S:Zn:B)
Maize	11:19:19:1.5:0.3:0.8:0.2 (N:P:K:S:Zn:Fe:B)

FIG. 1: Customized fertilizer programme

Benefits

1. Customized fertilizers is use to maximize crop yields while minimizing unwanted impacts on the environment & human health.
2. Fertilizer Best Management Practices will make it "easier " in "future" for farmers, extension agents, crop advisers & researchers to exchange their experiences and also to restrict the unwanted nutrient impact on the ecosystem.
3. Application of customized fertilizer is compatible with existing farmers system & hence it will be comfortably accepted by the farmers.
4. Production of customized fertilizers will ensure improved 'Fertilizer Use Efficiency' & creating a new "Virtual" source of nutrients – implying from the existing quantity of DAP, MOP, Urea, SSP & A.S. available & consumed in India, the agricultural produce output will increase, simultaneously the distribution & availability of fertilizer will be better. All this is achievable keeping the subsidy allocation constant.
5. Customized fertilizer satisfies crop's nutritional demand, specific to area, soil, and growth stage of plant.
6. As the micronutrients are also added with the granulated NPK fertilizer the plants can absorb the micronutrient along with macronutrient which prevents nutrient deficiency in plant.
7. Mixed fertilizers with micronutrients provide recommended micronutrient rates for the agricultural field at the usual fertilizer application.
8. The farmer need not buy micronutrient separately at extra cost, thus reducing the total cost. It is found that incorporation of micronutrient with granular fertilizer at the time of manufacturing results in uniform distribution of micronutrient throughout granular NPK fertilizer. This is because micronutrient source is in contact with the mixed fertilizer under the condition of high moisture and temperature. Micronutrient with the mixed fertilizer is one of the most convenient methods of fertilizer application and helps in more uniform distribution of nutrient with conventional application equipments. It is a very unique method developed in agriculture industry and has tremendous scope for future.

35. HORTICULTURE 14907

Method of Irrigation in Fruit Crops - II

V. A. Bodkhe[1*], P. L. Deshmukh[2] and K. N. Panchal[3]

[1&3] 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 Email: Vab380@gmail.com

Pressurized Methods: Advanced Techniques for increasing water use efficiency broadly divided in two groups:

1. **Subsurface Irrigation**: Subsurface irrigation (or simply sub irrigation) is the practice of applying water to soils directly under the surface. Moisture reaches the plant roots through capillary action. In natural sub irrigation, water is distributed in a series of ditches about 0.6 to 0.9 meter deep and 0.3 meter wide having vertical sides. These ditches are spaced 45 to 90 meters apart. Sometimes, when soil conditions are favourable for the production of cash crops (*i.e.,* high-priced crops) on small areas, a pipe distribution system is placed in the soil well below the surface. This method of applying water is known as artificial sub-irrigation. Soils which permit free lateral movement of water, rapid capillary movement in the root-zone soil, and very slow downward movement of water in the subsoil are very suitable for artificial sub-irrigation. The cost of such methods is very high. However, the water consumption is as low as one-third of the surface irrigation methods. The yield also improves. The conditions which favourable sub irrigation

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are as follows:

a) Impervious subsoil at a depth of 2 meters or more,
b) A very permeable subsoil,
c) A permeable loam or sandy loam surface soil,
d) Uniform topographic conditions, and
e) Moderate ground slopes.

2. **Micro- irrigation**: A scientific method of irrigation carrying desired water and nutrients direct to the root zone of the plant, drop by drop. Micro-irrigation systems apply water to the tree line of the orchard only, whereas other irrigation methods also wet the traffic-lane between rows. Irrigating only the treeline ensures traffic access to the orchard at all times for such essential operations as spraying and harvesting. The amount of water applied by micro-irrigation systems can be closely managed to match the requirements of the crop. Therefore, the frequency and volume of application are factors that can be used to control the growth of the crop to maximize marketable yield. Fertiliser can also be readily applied through the pipe network of microirrigation system so that the nutrient solution is applied directly to the active root zone. This reduces the losses of fertiliser that would occur through percolation or uptake by weeds. The main problem that can occur with micro-forms of irrigation is the blockage of the emitter. Micro-irrigation has a number of advantages over conventional methods of irrigation. The choice between types of micro-irrigation is not as easy and comes down to choosing with a wide choice of wetting pattern size and shape. There are different systems of micro-irrigation but care has to be taken in selection of irrigation method. Following methods of micro-irrigation are widely used in orchards according the requirement and availability of recourses.

a) Sprinkler Irrigation
b) Drip Irrigation
c) Others system like Talca Irrigation Management System (TIMAS), Partial Root Zone Drying (PRD).

Sprinkler irrigation: Sprinkling is the method of applying water in the form of a spray which is somewhat similar to rain. In this method, water is sprayed into the air and allowed to fall on the soil surface in a uniform pattern at a rate less than the infiltration rate of the soil. This method started in the beginning of this century and was initially limited to nurseries. In the beginning, it was used in humid regions as a supplemental method of irrigation. Sprinkler irrigation usually wets the whole orchard floor. Sprinkler systems offer reasonable control of irrigation run time. Rotating sprinkler-head systems are commonly used for sprinkler irrigation. Each rotating sprinkler head applies water to a given area, size of which is governed by the nozzle size and the water pressure. Alternatively, perforated pipe can be used to deliver water through very small holes which are drilled at close intervals along a segment of the circumference of a pipe. The trajectories of these jets provide fairly uniform application of water over a strip of cropland along both sides of the pipe. With the availability of flexible PVC pipes, the sprinkler systems can be made portable too. Sprinklers have been used on all types of soils on lands of different topography and slopes, and for many crops.

The following conditions are favourable for sprinkler irrigation:

1. Very previous soils which do not permit good distribution of water by surface methods,
2. Lands which have steep slopes and easily erodible soils,
3. Irrigation channels which are too small to distribute water efficiently by surface irrigation,
4. Lands with shallow soils and undulating lands which prevent proper levelling required for surface methods of irrigation.

There are so many advantages with the sprinkler system of irrigation like low water loss (efficiency up to 80%), saving in fertilizer, suitable for any topography, no soil erosion, better seed germination, free aeration of root zone and uniform application of water. The main difference between sprinkler systems and drip systems of irrigation is the wetting of a larger soil volume by the spray or jet emitters. This occurs by virtue of the water being distributed over a larger area of soil but the drip systems apply water to the one point and rely on the soil properties for distribution of the water. Some disadvantages also exists with this system of irrigation like high initial cost, cannot adopt by ordinary farmers, poor application efficiency in windy weather and high temperature, high evaporation losses, water should be free of debris, equipments need careful handling, physical damage to crops by application of high intensity spray and power requires for running pumping unit etc.

Trickle (Drip) Irrigation

Drip irrigation has enabled farmers, nurserymen and landscapers to conserve water for decades. Drip irrigation, also known as trickle irrigation or micro irrigation or localized irrigation, is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the remove all debris, sand and clay), pumps, fertilizer tanks, vacuum breakers, and

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pressure regulators. The drippers are designed to supply water at the desired rate directly to the soil. Low pressure heads at the emitters are considered adequate as the soil capillary forces causes the emitted water to spread laterally and vertically. Flow is controlled manually or set to automatically either to deliver desired amount of water for a predetermined time or to supply water whenever soil moisture decreases to a predetermined amount. Today it is more important than ever to use water resources wisely and to irrigate intelligently. Consequently, many farmers have turned to drip irrigation and have enjoyed improved profitability by increasing crop yield and quality while at the same time reducing costs from water, energy, labour, chemical inputs and water runoff. Many farmers have also enjoyed significant water and capital investment savings using drip irrigation, while simultaneously improving plant vigour by delivering water and nutrients directly to the plant roots and avoiding unnecessary wetting of plant leaves.

Drip irrigation is the targeted, intelligent application of water, fertilizer, and chemicals that when used properly can provide great benefits such as water use efficiency is maximal so water saving, maintaining high soil-water potential in root zone, partial soil wetting so no interference with agro technical practices, lesser number of weeds, no wetted canopy that may cause disease, even low quality water can be utilized, can be operational under heavy winds, easy application of fertilizer, herbicides and pesticides through drip lines, adaptation to marginal plot, high uniformity in water and fertilizer supply and comparatively pressure requirement is low in this system. In spite of the fact that drip irrigation has so many potential benefits, there a certain limitation also like sensitivity to clogging, moisture distribution problem and salinity hazards, high cost compared to furrow, high skill is required for design, install and operation and not suitable for closely planted crops.

Quality of Irrigation Water

Surface water, ground water, and suitably treated waste waters are generally used for irrigation purposes. Irrigation water must not have direct or indirect undesirable effects on the health of human beings, animals, and plants. The irrigation water must not damage the soil and not endanger the quality of surface and ground waters with which it comes into contact. The presence of toxic substances in irrigation water may threaten the vegetation besides degrading the suitability of soil for future cultivation. The various types of impurities, which make the water unfit for irrigation, are classified as:

1. Total concentration of soluble salts in water
2. Proportion of sodium ions to other ions
3. Concentration of potentially toxic elements present in water
4. Bacterial contamination
5. Sediment concentration in water

36. HORTICULTURE 15152

Painting of Flowers: Tinting

Sanchita Ghosh[1], Ratna Priyanka R., Rajiv G. and Jiji Allen J.

Ph.D. Scholar, Department of Floriculture and Landscaping, HC&RI, TNAU, Coimbatore
**Corresponding Author Email: sanchitajolly28@gmail.com*

Flowers are symbol of beauty, purity and love. Different colours and varieties of flowers stimulate moods of human being. Tinting is a method of artificial colouration of flowers using different types of dyes. Human has ever changing taste buds so tinting can be a viable way to satisfy their demands with bunch of colours. Colouring certain flowers with dyes can really enhance the value of flowers and can fetch high price in market. It can also provide a great variety of colours for aesthetic beautification. Colourants like acid dyes and food grade dyes can be used for artificial colouration of flowers. Acid dyes like bromophenol blue, erythrosine red, phenol red, tetrazine red, ammonium purpurate, carmoisine *etc.* are used for tinting flowers. Considering growing preference for natural colours in recent days, plant based bio colours form Gulmohar (*Delonix regia*) and marigold (flavonoids) and vegetable dyes can also be used. Different food dyes include lemon yellow, orange red, apple green, Pink Rose, Tomato Red, Falsa Blue etc. All these dyes are used in various concentrations but colour intensity increases with increase in duration of immersing in liquid.

A wide range of flowers especially white flowers can be used for tinting for good development of colours. Tuberose, Orchids, Carnation, Gypsophila, Tabernaemontana, Jasmine, Gerbera, Gladiolus are some of the potential flowers for tinting. The methodology comprises of dipping cut stems of flowers in colour solution having different concentrations. After few days flowers will develop different shades of colours along with the uptake of water. The intensity of colours depends upon immersion timing in the solution. Along with the colours we

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can use different floral preservatives readily available in market in order to prolong vase life of cut flowers. Rainbow rose is another concept in tinting where cut rose is artificially coloured with multiple colours at a time. This was designed by Peter van de Werken. Research showed that the best cultivar to use is 'Vendala', a cream coloured Hybrid Tea cultivated in The Netherlands, Colombia and Ecuador, as this cultivar absorbs the different colourants perfectly. Cut rose stems are splitted and each part is dipped in different coloured water, the colours are drawn into the petals resulting in a multi-colored rose. The Rainbow Rose has the 7 colours of the rainbow and this is the most popular rose in this category.

37. HORTICULTURE 15243

Prospects and Opportunities of Floriculture Industry in India: An Overview

[1]P. Manimaran, Sanchita Ghosh[2] and RatnaPriyanka[3]

Ph.D. Scholar, Department of Floriculture and Landscaping, HC&RI, TNAU, Coimbatore
**Corresponding Author Email: mmhorts@gmail.com*

Floriculture

Floriculture is the aesthetic branch of horticulture which deals not only with cultivation of ornamentals, annuals, biennials, and perennial plants including potted ones but also their marketing. This also includes marketing for local, distant markets and export of cut flowers, live plants and their economic products like scents, oils and medicines, etc.

Importance: In India, floriculture is emerging as an important commercial crop. A lot of importance has been given to this sector due to its multiple uses, satisfying the aesthetic needs of the people, creating more employment, ensuring higher rate of returns to rural people and facilitating earning more foreign exchange. More specifically, they are being used as raw materials in the manufacture of essence, perfumes, medicines and confectioneries for direct consumption by the society.

FIG: 1

The production of flowers is an age-old occupation. Until last decade, the growing and selling of flowers was confined to a few families. They grew a variety of flowers on the same land which were sold close to the house, as they could not survive a long journey. The situation in the last decade has however, changed. Now, different farmers are growing different flowers both for domestic market and export purposes. The flowers were, until 1960s, confined to domestic markets. These flowers are now moving long distances due to the availability of airfreight and hi-tech cooling systems.

Present Status of Floriculture Industry in India: Government of India considered floriculture as an extreme focus segment during the 8th 5 year plan. In India, Floriculture industry comprises flower trade, production of nursery plants and potted plants, seed and bulb production, micro propagation and extraction of essential oils. Now domestic floriculture industry is growing at an annual rate of 25 percent per annum. In India in the year 2012-13 the area under flower crop cultivation 233,000 Ha with a production of 17,29,000 MT of loose flowers and 76,732 lakh stems of cut flowers. Total area under floriculture in India is second largest in the world and only next to China. At present the share of Indian floriculture products in international market is 0.6%. Fresh and Dried cut flowers dominate floriculture exports from India. India has exported 22,947.23 MT of floriculture products to the world for the worth of Rs. 460.75 crores in the year 2014-15. TamilNadu is the leader in floriculture followed by Karnataka, accounting for 75% of India's total flower production and the state is having the highest area under both modern and traditional flowers.

TABLE 1: Area and production status of Tamil Nadu.

Product	2014-15 (Final)		2015-16 (3rd Estimate)	
	Area (000 Ha)	Production (000 MT)	Area (000 Ha)	Production (000 MT)
Cut Flowers		484		691
Loose Flowers	249	1659	243	1545

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Product	2014-15 (Final)		2015-16 (3rd Estimate)	
	Area (000 Ha)	Production (000 MT)	Area (000 Ha)	Production (000 MT)
Total Flowers	249	2143	243	2236

The Growth Driver's of Floriculture Sector

Floriculture products mainly consist of cut flowers, pot plants, cut foliage, seeds bulbs, tubers, rooted cuttings and dried flowers or leaves. The important floricultural crops in the international cut flower trade are rose, carnation, chrysanthemum, gargera, gladiolus, gypsophila, liatris, Nerine, orchids, achillea, anthurium, tulip, and lilies. Floriculture crops like gerberas, carnation, etc. are grown in green houses. The open field crops are chrysanthemum, roses, gaillardia, lily marigold, aster, tuberose etc.

Exports: The country has exported 22,518.58 MT of floriculture products to the world for the worth of Rs. 479.42 crores in 2015-16.

Major Export Destinations (2015-16): United States, Germany, United Kingdom, Netherlands and United Arab Emirates were major importing countries of Indian floriculture during the same period.

The Opportunities

The opportunities existing in this business are proper development of high quality flowers and bulbs for domestic and overseas markets; marketing of essential oils and other products like rose hip syrup, jam, jellies, cosmetics, perfumes and medicines; development opportunities for native flora for domestic and export markets both; identification of market niches that can be supplied taking advantage of the climate; widening of the networking ability of industry and advantage of working with key grower groups to increase market access; and an increase in industry's access to skill-based training schemes.

FIG: 2

Flowers, live plants, bulbs, seeds, etc. are sold in local market, produced locally or at distant places and are exported. Flowers like rose, gladiolus and tuberose as cut flowers are flown to distant markets from their production centres. For example, gladiolus and roses from Kashmir to Delhi, tuberose from Kolkata to Delhi or Mumbai. Loose flowers like marigold, jasmine, aster, gaillardia, kaner, malti, etc. are frequently taken to big cities from distant places. Jasmine flowers are regularly exported from South India to gulf countries. Similarly live plants, bulbs and seeds are regularly exported.

38. HORTICULTURE 15270

Phytohormones: Application in Vegetable crops

[1]Mekala Srikanth*, [2]Vijeth S. and [3]Telugu Ravi Kumar

[1,3]Ph.D. Scholar, Dept. of Vegetable Science, CCS Haryana Agricultural University, Hisar; [2]Ph.D. Scholar, Dept. of Olericulture Kerala Agricultural University, Kerala
**Corresponding Author Email: sricoolhortico@gmail.com*

INTRODUCTION: Thimann (1948) designated the plant hormones by the term 'phytohormones' in order to distinguish them from animal hormones. The word "Hormone" in fact comes from the Greek, where its meaning is 'to stimulate' or 'to set in motion'. According to Johannes van Overbeek (1950) "*organic compounds which regulate plant physiological process regardless of whether these compounds are naturally occurring and/or synthetic stimulating and/or inhibitory local activators or substances which act at a distance from the place where they are formed.*"

There are five major groups of phytohormones found:

A. Auxin
B. Cytokinins (CKs)
C. Gibberellins (GAs)
D. Abscisic acid (ABA)
E. Ethylene

A. Auxin

An organic substance known as Auxin became the first plant hormone to be discovered. Auxin is discovered by **Went**. Word Auxin is derived from the Greek word "***Auxein***". Which means "to increase". Auxin whose precursor is **Tryptophan.**

Active site of synthesis: Shoot tip, young

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expanding leaves & seeds

Role of Auxin in Plants

- Polar translocation (Apex to downward movement)
- Stimulates cell enlargement, cell division, vascular tissue differentiation and root initiation
- Promotes apical dominance, leaf senescence, fruit growth and setting.
  - Naturally occurring Auxin: Indole-3-acetic acid (IAA)
  - Synthetic Auxin: IBA, NAA, 2,4-D, 2,4,5-T.

B. Cytokinins

Cytokinins comprise another group of naturally occurring phytohormones. A Cytokinin is a plant hormone that, in combination with auxin, stimulates cell division and differentiation in plants.

Active site of synthesis: Root tips, Developing fruits.

Role of Cytokinins in Plants

- Initiation of cell division
- Morphogenesis in tissue culture
- Promotes growth of lateral buds
- CKs delay leaf senescence
- CKs promotes Chloroplast development
- CKs may enhance stomatal opening in some species.
  - Naturally occurring Cytokinin: Zeatin
  - Synthetic Cytokinin: Kinetin, BA (Benzyl adenine)

C. Gibberellins (GAs)

Gibberellins are named after the fungus ***Gibberella fujikuroi.*** Japanese plant pathologist **Eiichi Kurosawa** investigated Bakane ("foolish seedling") disease in the 1920s.

Gibberellins whose precursor is **Terpenoids.**

Active site of synthesis: Apical portion of roots, young leaves and immature seeds

Role of Gibberellins in Plants

- Stimulates the cell elongation, cell division (Internode elongation)
- Promotes the seed germination
- Tolerance to chilling
- Induction of bolting in long day plants.
- Breaking dormancy
- GA stimulates bolting in rosette plants.

Gibberellin synthesis inhibitors: Paclobutrazol (PBZ), Ancymidal, Flurprimodal.

D. Abscisic Acid (ABA)/ Stress Hormone

The first name given was "**abscisin II**" because it was thought to control the abscission of cotton bolls. At almost the same time another group named it "**dormin**" for a purported role in bud dormancy.

Active site of synthesis: Terminal bud, seeds mature green leaves, fruits and root caps

Precursor: Sesquiterpenoid pathway (Mevalonic acid)

Role of Abscisic acid in Plants

- Stomatal closure - water shortage brings about an increase in ABA which leads to stomatal closure.
- ABA inhibits shoot growth. This may represent a response to water stress.
- ABA induces storage protein synthesis in seeds.
- ABA affects the induction and maintenance of some aspects of dormancy in seeds.
- Increase in ABA in response to wounding induces gene transcription, notably for proteinase inhibitors, so it may be involved in defence against insect attack.

E. Ethylene

The gas ethylene (C_2H_4) is synthesized from methionine in many tissues in response to stress, and is the fruit ripening hormone. It is the only hydrocarbon with a pronounced effect on plants.

Active site of synthesis: Ethylene is synthesized by most tissues in response to stress. In particular, it is synthesized in tissues undergoing senescence or ripening

Precursor: Methionine

Role of Ethylene in Plants

- Stimulates Shoot and root growth and differentiation. (Triple response)
- Adventitious root formation.
- Stimulates Leaf and fruit abscission.
- Flower induction in some plants.
- Induction of femaleness in dioecious flowers.
- Initiation of fruit ripening

Practical Application in Vegetable Crops

Tomato

- Seed germination: GA @ 40-100 ppm, IAA @ 10-15 ppm as seed treatment
- Fruit set under high and low temperatures: PCPA @ 50-100 ppm
- Earliness & Parthenocarpic: 2,4-D @ 2-5 ppm
- Flower drop: NAA @ 10-20 ppm
- Fruit ripening: 1000 ppm Ethepon (CEPA) applied before harvest

Brinjal

- Earliness & Fruit set: 2,4-D @ 2-5 ppm foliar spray

Chilli

- Enhance flower & fruit set: NAA @ 40 ppm, GA_3 @ 10-100 ppm.
- Fruit ripening: Ethepon @ 1000 ppm as pre harvest spray, MH @ 50 -150 ppm

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Okra

- Seed germination: IAA @ 10-15 ppm, Napthoxy acetic acid @ 25-100 ppm for seed treatment
- Flowering & fruit set: Cycocel @ 250-500 ppm as foliar spray.

Pea

- Seed germination: GA_3 @ 10 ppm soaking for 12 hrs.
- Drought tolerance & yield: CCC @ 50 ppm

Onion

- Sprout suppressant: MH @ 1500-2000 ppm application before harvest

Potato

- Breaking tuber dormancy: 1 % thiourea and 1 ppm GA_3 solution for 1 hr., CIPC 25 mg a.i/kg of tubers

Cucurbitaceous

Induction of more male flowers in Cucumber Gynoecious lines, spray will be applied @ 2 and 4 true leaf stage.

- Silver nitrate ($AgNo_3$) @ 200-300 ppm
- Amino ethoxyvinyl glycine (AVG) @ 50-100 ppm
- GA_3 @ 500- 2000 ppm

Induction of more female flowers spray will be applied @ 2 and 4 true leaf stage

- Cucumber: Ethrel @150-200 ppm
- Bottle gourd: MH @ 50-150 ppm
- Ridge gourd: IAA @ 20-200 ppm
- Sponge gourd: NAA @ 25- 100 ppm
- Water melon: TIBA @25-250 ppm
- Musk melon and Pumpkin: Ethrel @ 250 ppm
- Summer squash: Ethephon @ 250 ppm
- Bitter gourd: CCC @ 100-500 ppm, MH @ 150-200 ppm.

39. HORTICULTURE 15301

Waste Utilization in Fruits

A. Roy and B. Khamari

College of Agriculture, OUAT, Bhubaneswar, 751003, Odisha

INTRODUCTION: A systematic mission mode approach is required with revolutionary and result oriented action plan for unwanted and unusable materials. The planning has to be long term and short term with intermittent review and manipulation in order to adjust to the dynamic world market scenario. In India processing of fruits and vegetable is only 2%. More than 25-30% of the produce is lost in post-harvest management, Huge Post harvest loss of fruits and vegetables is one of the measure reasons of low per capita availability. So by proper utilization of fruits and its wastes we can support per capita income.

Fruits wastes includes: Peel, rag, seeds, stones, Rind, Overripe and blemished fruits etc.

Mango: In the processing industry 30-50% of this fruit is discarded as waste mainly in the farm of peel, stones and pulp. The peel and fibrous pulp containing many flavoring substances and rich in sugars can be used for preparation of wine and vinegar after fermentation. The polysaccharides of mango waste composing the major part of dietary fibers which are beneficial to diabetics and heart patients since the fibers lower blood sugar and serum cholesterol levels. Mango byproducts, rich in pectic substances represent a potential fiber source likely to influence metabolic parameters in humans. Among the byproducts from mango peel, peel juice is one which can be extracted, concentrated and used as molasses for cattle and also for fermentation into alcohol etc.

Citrus: In citrus fruits, the most important waste materials are the peels from oranges, the rags and seeds and the sludge. Peels are generally employed for candying (or) for the extraction of essential oils. Orange peel oil of high quality got by cold pressing is extensively used in the soft juice beverage industry for flavouring. The rags can be utilized for the preparation of citrus pectin. Orange and lime seeds can be utilized for the extraction of seed oil. The by-products of juice making (The pulp, rind and seed) are utilized for cattle feed and molasses as well as flavouring, perfumes, pharmaceuticals and soap and fermented orange juices produce vinegar and liquor.

Grape: In the preparation of grape juice and wine, stems and skins are the main waste products. Grape skin can yield about two per cent of cream of tartar when chopped in short lengths (or) ground and extracted with boiling water. Grape seed oil is effective in correcting blood cholesterol levels in certain individuals. It is an excellent source of Vitamin 'E' and fatty acids. The waste can be used for the preparation of grape jelly and also grape chutney. The press cake is suitable for stock feed by mixing it with bran (or) alfalfa meal to reduce the tannin.

Banana: In the processing of banana for canning and dehydration, the banana peel is a

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waste product. The pulpy portion scraped from the thick peel of the banana can be utilized for the preparation of banana cheese. The pseudostem of the banana plant can be utilized for the preparation of banana cheese. The pseudostem of the banana pant can be utilized as raw material for the preparation of paper pulp. Banana waste can be used for cattle feed. Banana waste is used as a mulching material in field crops. Banana sap can be used as dye, and banana ash is used in making soaps. In Indonesia, the production of floor wax and shoe polish from banana peel is also being explored.

Jack Fruit: Nearly 70 per cent of the jackfruit is discarded after the fleshy parts are taken out. The jackfruit waste, consisting of aerial, skin seed and heart parts has a high potential as a ruminant feed, especially for sheep. Supplementary 'N' is needed to optimize digestibility and in cattle, it appears this is best given as a molasses – urea cake rather than by mixing urea in the jackfruit waste. The seeds which are starchy, can be roasted (or) cooked in salt water and eaten as a food, Jack fruit 'leather' similar to mango leather which is dried and can be made from broken bulbs.

Guava: The most important product prepared from guava waste is guava cheese. It is prepared from the cores, seeds and peels left after extracting the juice and is just like 'halwa'.

Apple: The pomace left over after the extraction of apple juice can be dried and utilized for the preparation of pectin. Apple pomace is a rich source of pectin and fairly good source of sugars, can be utilized on a small scale for blending with fruits poor in pectin for the preparation of jams, jellies etc.

Papaya: In the processing of ripe papaya fruit, greenish fruit can be lanced on the free for the collection of the latex, which can be dried to get the proteolytic enzyme papain. The enzyme papain is used in textile industries and pharmaceutical industries. After tapping the fruit can be allowed to ripen, (or) it can be collected and utilized for the preparation of pectin.

Pear: The peel and core can be fermented into an alcoholic beverage called "Perry" which can also be converted into a fruit vinegar by further acetic fermentation.

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40. HORTICULTURE 15335

Vertical Garden: Go Green with Green Wall

Aakanksha Mahindrakar

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

A vertical garden (Living wall, Green wall, Bio-wall) is a wall covered with vegetation. It is the growing of plants on the vertical surfaces of wall of a home or facade of a building. Technology for vertical gardening is relatively new. It consists of natural elements interlaced with aspects of urban living, architecture and environment. Vertical gardens are a great solution for small urban spaces. It helps to get fresh air in the atmosphere at the limited area. They can be used indoors as an interior wall or used as a space separator and provides privacy.

Green wall technologies may be divided into two major categories

1. Green facades: This can be created two ways by covering the walls with climbing plants or cascading vegetation or the plants can be trained to cover specially with designed supporting structures. The plants used for this structure should be fast growing, foliage from ground to top and resistant to wind.
2. Living walls: These walls are also called as green walls. It is composed of pre-vegetated panels or vertical modules are fixed on the walls. Plant species grown should have a limited root zone volume preferably fibrous root system, resistant to wind, good growth habit and the orientation should be such that it gets full exposure or shade depending upon the plant species.

TABLE 1: List of plants used for vertical garden depending upon the use

Special Feature	Examples
Fast growing	Violet trumpet vine, morning glory, climbing roses
Drought tolerance	Moss rose, sunflower
Attractive foliage	English ivy, Algerian ivy, parsley, lettuce
Fragrant	Night blooming jasmine, lily, rosemary
Vegetables	Tomatoes, squash, cucumbers, lettuce
Fruits	Strawberries, grapes, passion fruits,

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Special Feature	Examples
	kiwifruit
Herbs	Rosemary, mint, cilantro, thyme, basil, sage, lavender
Edible flowers	Dill, day lily, chives, nasturtiums
Medicine	Aloe Vera, eucalyptus, chamomile

The Methods of Vertical Gardening

1. Climbers can be used, wherein they are planted in the ground and later trained to supports which are fixed to the wall and they can be used in a facade.
2. Modular wall panels: These contain sections of growing medium. The main advantage of using these panels is that they allow larger plants with wider root systems to be grown vertically. The panels used depends on the use, it may consist of iron panel, wooden panel or plastic panel. The selection depends on the site and the type of plants used and the strength required by the panels.

Soil Growth Medium

The growth medium is where the plant finds its nutrients and grows roots in search of water. The minimum depth of growing medium should be 150-250 mm. The basic precautions to be taken care of are that the growing medium to be kept moist and it should have good drainage system. Irrigation is of prime importance and has to be done efficiently. Drip irrigation is normally followed and accordingly the pipes are adjusted for discharge of water.

Benefits of Green Walls

Having vertical garden can reduce indoor volatile organic compounds (VOCs) and headache is reduced by at least 20%. Vertical gardens can elicit a wakeful and relaxed state which characterizes quicker stress recovery time.

1. Reduce urban heat island effect: Green walls naturally promote cooling by the process of evapotranspiration. This results in lowering the temperature in urban areas. The green walls break the vertical air flow which then cools the air as it slows down.
2. Improved energy efficiency: As the green wall help to trap the hot air of the atmosphere, it helps to reduce the consumption of energy. It also limits the heat through the thick vegetation mass. During winter, it creates a buffer against the wind thereby reducing the consumption of energy. This in turn helps in reduced usage of air conditioning and heating systems.
3. Improved air quality: The green vegetation captures airborne pollutants and atmospheric deposition on leaf surfaces. The leaves filter the noxious gases and VOCs from carpets, furniture and other building elements.
4. Noise reduction / Sound insulation: The growing media in living wall systems will contribute to a reduction of sound levels that transmit through or reflect from the living wall system.
5. Economic advantages: It improves the quality of air and water. It also helps in upgrading the fire safety and ads natural surplus value to the building.

In India, commercially installation of vertical gardens is being taken up by ELT India Enterprise Pune, Maharashtra, India. This trend is also catching up in metropolitan cities like Chennai, Delhi and Mumbai.

Conclusion: Recently, we have seen in Delhi the ill effects of pollution on Diwali and its preceding days. China too has been reeling in pollution and they have come up with Asia's largest vertical garden which could produce 60 kg of oxygen. Hence, India can also take a cue and establish vertical garden in metropolitan cities. Thus, it can be concluded that vertical garden is a boon for limited space.

41. HORTICULTURE 15341

An Edible Cactus Dragon Fruit

Anuradha and Mahantesh Kamatyanatti

Ph.D. Scholar, Dept. of Horticulture, CCS Haryana Agricultural University, Hisar, 125004

Dragon fruit (*Hylocereus undatus*) emerged as miracle cactus for commercial cultivation in many countries. It belong to family Cactaceae. As it named, the dragon fruit's outer skin is cactus-like, resembling that of the scales of a mythical dragon. Considered a cactus plant, its vibrant green and reddish-pink hues indicate that the fruit is full of nutrients, while the creamy white flesh spotted with black seeds gives way to many rich and natural properties. It is also known as night blooming, night blooming cereus, pitaya, pitahaya, strawberry pear, belle of the night, Cinderella plant and Jesus of the cradle'. Fruits with low calories are rich in antioxidants (betalains, phyto albumins, polyphenols, vitamins A and vitamin C). These are useful in scavenging ABTS cation radicals and effective in controlling diabetes, cholesterol level, cancer and heart

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disease.

It is native to Central America, South America and West Indies. India is importing dragon fruit from Vietnam and Thailand.

Dragon Fruit

It is very fast growing, highly branched lithophytes or hemiepiphytic succulent cactus with sprawling or creeping habit. Stems are photosynthetic with three ribs and undulated, horn like margins. Leaves are modified into conical or needle shaped greyish brown to black spines which come out from areoles in cluster on the ridge of the stem. Roots grow 15-30 cm deep, flowers are large scented with tapering greenish yellow to white tepals and thick overlapping bracteoles. Since flower open during night and pollinated by bats and moths. Fruits are oblong to oval with overlapping bracteoles. Individual berry fruit weigh 150-600 g. fruits have red or yellow skin with red to purple or white pulp with numerous black seed. Pulp accounts 70-80 % of the fruits which has refreshing flavor, slightly sweet and melon like taste.

Pigments: Pigments in the fruit have high antioxidants properties. Red colour in the skin is due to anthocyanin. Betacyanin is also present in the skin. Deep purple to red colour in the pulp is due to the presence of betalains. The main betalain pigment is betacyanin. The other betalain pigments are betaxanthin and indicaxanthin. Flavonoids are water soluble polyphenolic substances responsible for yellowish white to cream colour.

Uses: *Hylocereus* is grown as ornamental cactus, pot plant and fruit crop. Its fruits are used for making juice, sherbet, syrup, jam, jelly, preserve, candy, wine, flavouring drink, ice cream and pastries. The unopened flower buds are cooked and eaten in Taiwan. The flowers are also used for preparing tea. They can be used for preparing colourants. Fruit skin is potential source of fibre with anti-radical activity.

Health Benefits: Fruits are used as thirst quencher and refresher. Phyto albumins and flavonoids are fight against cardiac disease and blood pressure. Antioxidants boosts immune system and prevent cancer. Phyto albumins neutralize heavy metal toxic substances in blood system. Fibre aids in digestion and prevent constipation. Lower blood glucose level in type II diabetes. Helps control cholesterol level. Aids in weight reduction and improve in memory.

Cultivation: Well drained soil with high organic matter are suitable for cultivation. It prefer slightly acidic soil. Plants grow well in dry tropical and subtropical climate. It require sunlight or semi shade condition. It grows up to the mean sea level up to 2700 m. it require annual rainfall of 600-1300 mm. The optimum temperature for cultivation is 35-45° C. Plants tolerates up to 45° C. Temperature should not be less than 10° C in winter. It is sensitive to waterlogging. It is propagated through stem cuttings. Stem cuttings of 10-40 cm are cut dried for a week for planting. Stem cuttings are planted at spacing of 3-4 m to 3-4 m. Seeds can also be used for propagation. The ideal temperature for germination is 18-21° C. It takes 15-20 days for germination. Main stem is allowed to climb concrete or wooden pillars, fences, walls and trees. It is known trellising. After planting, main branch is allowed and lateral branches should be trained till it reaches top of the pillar. Once it reaches, tip of the stem is to be removed to encourages lateral branches. To increases the production, over grown branches dead and diseased stem should be removed periodically. Since it is a shallow rooted crop, it require fertigation properly. Watering should be done regular basis from March to August. Watering is given once in week during August to January. It is stopped from January to February to aid flower induction. After flower formation, water should be given regularly.

Vegetatively propagated plants produce fruits within 1-2 year of planting. Commercial yield start within 5 year. Flowering occurs during July-September. Fruits can be harvested from September to December. Changes from green fruit to pink red with green scales is the right stage of harvesting. It takes 50-60 days from flowering to peak ripening. Fruits can be stored at 10° C for 35-40 days.

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42. HORTICULTURE 15372

Vegetable Gardens in Beautification

Sanganamoni Mallesh

Department of Vegetable Science, G.B. Pant University of Agriculture and Technology, Pantnagar-263145 (Uttarakhand), India.

**Corresponding Author Email: mallesh.horticulture@gmail.com*

INTRODUCTION: A typical ornamental garden is primarily recognized for showing the beauty of plants rather than their practical uses. But in case of vegetable garden many may think it is typically filled with plain and boring plants, but that does not have to be the case. There are quite a few very interesting vegetables and herbs you can grow in your vegetable garden that not only please the taste buds, but also the eye. There are a multitude of colorful vegetables that can be added to create interest in containers as well as the garden. By borrowing design strategies used in ornamental gardening, these goals are easily attainable. Colorful flowering plants, attractive enclosures and crisp edges are just a few of the details that can transform an ordinary kitchen garden into a masterpiece.

History: The idea of bringing edible and ornamental gardening together certainly isn't a new concept. The French have been doing it in their potagers (vegetable gardens) for centuries, providing beauty and bounty in the form of flowers, vegetables, fruits, and herbs that enrich their gardens and tables throughout the seasons.

Tips for Beautification of Vegetable Garden

- The key to success with your vegetable garden design is to make sure you have the right spot. Most vegetables do best with full sun at least eight hours of direct light a day. If soil is not suitable amend the ground with organic matter (such as compost) before planting. Site your garden where you can get to it easily. Harvesting fresh fruits, vegetables, and herbs is easier.
- Entrance can be with a simple white arbor bedecked with climbing roses does the trick. While climbing roses are a classic pick for growing on an arbor, you can grow anything from ornamental clematis or morning glories to edible scarlet runner beans or kiwi in your vegetable garden design.
- One trick to make your vegetable garden design look more attractive is to mix flowers in with your vegetables. Here, *Gaillardia* 'Oranges and Lemons' adds a bright splash of color. Flowers, especially those in the daisy family, attract beneficial insects. Many of these beneficial bugs attack and kill pests such as tomato hornworms or aphids. Other beneficial bugs pollinate fruit-bearing vegetables, such as tomatoes, eggplants, peppers, cucumbers, squash, and melons so you have bigger harvests.
- Protect your plants (as here, with a simple three foot tall fence) so the pests don't harvest more than you do. Chicken wire attached around the fence's perimeter keeps small animals out of your vegetable garden design.
- Raised beds offer many benefits for vegetable garden design. You can fill them with any type of soil you want (an advantage if your ground is full of clay, sand, or rocks). Raised beds also warm earlier in the spring so you can get a jump on the planting season. And, if you build them three to four feet wide so you can easily reach the middle from both sides.
- Take advantage of garden design secrets in your vegetable garden design. Here's a great example of the power of repetition: Bright red poppies echo the round fruits of tomatoes. The climbing rose on the arbor is similar to the orange gaillardias and nasturtiums in the far corner
- Add colorful containers of edible plants to your vegetable garden design or to decks and patios to expand your space.
- An inch or two of mulch helps your soil hold moisture during hot, dry weather. It also stops most weeds from sprouting. Plus, mulch keeps many soil-borne diseases from splashing up onto plant leaves and infecting them.
- Flowers aren't the only way to add color to

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your vegetable garden design a number of vegetables can, too. For example, the Swiss chard shown here adds a bright note to the bed. Other attractive vegetables include eggplant, red cabbage, purple kohlrabi, and red-leaf lettuce. Different tomatoes and peppers bear fruits in shades of red, orange, yellow, cream, purple, and green. And many herbs offer good looks, including thyme, chives, and parsley.

- Natural gardeners know the value of attracting birds to a vegetable garden design. Many common birds, including robins, mockingbirds, wrens, and warblers eat harmful insects. Include a source of water in your garden to attract your feathered friends. Here, a simple birdbath set among herbs does the trick.
- Use garden ornaments from birdhouses to statuary to embellish your vegetable garden design. Anything goes, as long as it suits your personal style. This blue birdhouse does double duty: It looks good and provides a spot for birds to live.
- Primped pathways are another feature that can give the garden an attractive look. Laying down wood chips or crushed-gravel paths will freshen the scene and make visitors feel invited to come in and explore. Granite and brick not only are good for edges but also can dress up your pathways. Make sure your passageways are wide enough for a wheelbarrow.

Recommended Vegetable crops as ornamentals

Plant name	Picture	Flower color	Bloom	Comments and hints
Abelmoschus esculentus (Okra, gumbo, gombo)		Yellow, red	Mid-July to August	Full sun, hot weather; prefers clay to clay loam. (A)
Allium schoenoprasum (Chive)		Lavender, red to purple	May to June	Separate florets to serve. Forms clumps; part shade to full sun; indoors. (P)
Allium tuberosum Garlic (chive)		White	August to frost	Separate florets to serve. Partial shade to full sun; also indoors. (P)
Anethum graveolens (Dill)		Yellow	June to frost	Resows readily, tolerates poor soil but prefers well-drained soil; full sun. (A)
Brassica oleracea var. italica (Broccoli)		Buds: blue-green	June to August	Prefers full sun; rich, well-drained soil. Sow indoors six weeks prior to transplant. B (A)
Coriandrum sativum (Coriander)		White	June to frost	Herb. Sow continuously for several harvests; sun; rich, well-drained soil. (A)
Cucumis Spp. (Squash or pumpkin)		Orange, yellow	July to August	Vegetable. Enrich soil with compost; prefers full sun. (A)
Cynara scolymus (Artichoke)		Immature head: green	Fall	Prefers rich soil, abundant moisture; propagate from division for annual harvest. (A)

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Plant name	Picture	Flower color	Bloom	Comments and hints
Foeniculum vulgare (Fennel)		Pale yellow	July to August	Tolerates wide range of soils; part shade to full sun. (P)
Mentha spp. (Mint)		Lavender, pink to white	July to September	Herb. May be invasive; tolerates a wide range of soils; prefers part shade. (P)
Ocimum basilicum (Basil)		White to pale pink	July to frost	Sow continuously for several harvests; well-drained rich soil; full sun. (A)
Pisum sativum (Garden pea)		White, tinged pink	May to June	Vegetable. Prefers full sun; sandy, well-drained soil. (A)
Raphanus sativus (Radish)		White, pink, yellow	One month after planting	Prefers full sun; well-drained, sandy soil but will grow in almost any soil. (A)

A = annual; B = biennial; P = perennial

Conclusion: When our country moving forward from food security to nutritional security, Vegetable gardens (kitchen gardens) takes prime value. It is due to its extraordinary benefits in multifold. In most of the cases, vegetable gardens laid out with simple manner as same as traditional vegetable cultivation. But by adopting simple tips and methods, we can convert normal and dull looking vegetable garden in to delight beautiful spot in your backyard, which ultimately leads to better place to serve both purposes of nutrition as well as aesthetic sense.

43. HORTICULTURE 15377

Flowering Manipulation in Mango

Lipsa Prit Bhusan

Ph.D. Scholar, Department of Fruit Science and Horticulture Technology, OUAT, BBSR

The Mango (*Mangifera indica* L.), one of the 73 genera of the family Anacardiaceae in order Sapindales, is amongst the most important tropical fruits of the world. It is also called as king of the fruits (Purseglove, 1972). It is originated in the South East Asia or Indo-Burma Region. It is grown in more than 111 countries but nowhere it is as greatly valued as in India where 40 % of total fruits grown is only mango. In India, mango enjoys supreme place in fruit production has nearly 1000 varieties and grown in an area of 2.5 million hectare (NHB, 2014). India is the largest producer of mango in the world with the production of approximately 18.4 million tones, contributing more than 20.7 % share of the world production (NHB, 2014).

Growth Pattern and Flushing Episode of Mango Flower

Growth of mango is not continuous. Flushing refers to emergence of new shoots on terminals of old shoots. Mango completes four to five flushing episodes per year depending upon cultivars and growing condition (Davenport and Nunez-Elisea, 1997), while blooming occurs on a few of them (Issarakraisila *et al.,* 1991*).* Terminal inflorescences or panicles are initiated in dormant apical buds on stems that developed vegetative from lateral buds following the previous flowering seasons (Litz, 1997).

Need of Flowering Manipulation in Mango: To obtain early harvest, extend the period of harvesting, bring regularity in flowering, regulate the age of last vegetative flush (terminal intercalary unit) the more likely is to flower when next flushes occur and to enhance yield and quality.

Components to be considered for Manipulation of Flowering: Vegetative growth & flushing episodes, Florigenic promoter, Number of leaves, Environmental factors like, temperature, humidity, rainfall, water stress. Phytohormones like gibberellins, auxins, cytokinins, ethylene, abscisic acid,

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carbohydrates.

Two Switches have to be Turned on for Flowering: Switch 1: The shoot itself must be initiated to grow (Something must cause the bud to grow from a resting state to growing state). Switch 2: What kind of growth will occur, vegetative (producing leaves), generative (producing panicles), mixed (producing both leaves and panicles)

Flowering Manipulation by Interrupting Vegetative Growth Cycle: Pruning: Synchronous vegetative growth is a necessary first step in the flowering management program. It is best accomplished by tip pruning. It causes a uniform flush of growth throughout the canopy. It removes growth and flower inhibiting factors in stems derived from the previous season's flowering and fruiting panicles. Pruning not only helps to induce axillary panicles (to control biennial bearing and removal of malformed panicles) but has also been adopted for rejuvenation of orchards along with crop regulation (Shinde *et al., 2002)*

Girdling: It may be one of the flower inducing methods. In relatively older plants, secondary or tertiary branch may be selected for girdling, whereas primary branch may be selected for young plants (up to 10 years). A strip of bark (8-10mm) should be completely removed. Girdling should be done in September- October. Callus starts developing after 3-4 weeks of injury and healing is completed in 3-4 months. Girdling is not effective if plants are subjected to annual pruning during June-July as shoot maturity is essential for flower induction. To induce flowering in subsequent years girdling may be performed about 10 cm above the last girdled person.

Paclobutrazol: A gibberellins inhibitor. It increases Auxin: gibberellins ratio, reduces vegetative promoter level (VP), increases FP (flowering promoter)/VP ratio. Efficacy depends on rate and time of application, pruning intensity, soil texture, soil moisture status, soil organic matter content and residual level. Dose vary with age, canopy volume and pruning intensity.

Dynamics of PBZ Residue

High dose causes sever compaction of shoot and panicle, Increases persistence in soil. Water contamination also can increase if applied continuously at high dose. According to the "Globally Harmonized System of Classification and Labeling of Chemicals" (GHS), PBZ has been classified under category 4 and considered moderately hazardous for human being (WHO, 2010). However, paclobutrazol is neither geno toxic nor carcinogenic up to maternally toxic dose levels (USEPA 2007)

Use of nitrate: Floral stimulation with nitrate application must be accomplished at the time periods depending upon cultivar, night temperatures. Application of nitrate earlier than recommended results in vegetative instead of flowering flushes. Any nitrate salt or thiourea must be applied at the proper time. First apply nitrate on 1 to 2 plants. If the plant ready to respond, the entire tree will initiate growth immediately with new shoots visible by 10 days.

If stems are too young: a vegetative response is observed on the first application date. If a vegetative response occurred, then one is advised to wait two months before applying nitrate to a new set of such test trees. It is likely that KNO3 is not inducing flowering directly, but is stimulating initiation of growth. Flowering was evident within seven days after treatment and was effective on shoots that were between 4.5 and 8.5 months old when treated.

Flowering Manipulation by Eco-Physiological Factor

Temperature: Cool temperatures of 15^0 C day/10^0 C night induce flowering in subtropical condition (Davenport and Nunez-Elisea 1997). Flowering can also be affected by cool temperatures in high altitude Tropics. Very high and very low temperature during flowering is harmful to pollen and tree fails to flower.

Management of leaf nitrogen levels: Key to Controlling Unwanted Flushes of Vegetative Growth

It is critical to maintain annual leaf nitrogen levels sufficiently low to discourage unwanted flushes of vegetative growth in the months approaching the desired flowering date. The leaf nitrogen levels for mango should be 1.1 to 1.4% at the time of the synchronizing prune event. It is advisable that leaf analyses should be conducted on the last flush of leaves at least once preferably twice/year. 1st analysis should be done just prior to the synchronizing prune. The second analysis should be conducted just prior to floral stimulation. Sufficient nitrogen should be applied in the bulk fertilizer at the time of flowering to provide the levels needed to maintain good fruit set and development without retaining any residual nitrogen after harvest.

Water Management

Row furrow irrigation in mango: It has the disadvantage of providing water periodically around the base of tree. The major problem is that many roots outside the limits of the irrigation ditches never get watered during the dry season; hence, water moves from roots located in or near the irrigation ditches to not only the canopy but also out to the dry roots in response to water potential gradients in the root system.

Drip irrigation: It provides a constant source of water to the canopy but it waters only those roots that are located near emitters as does in-

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row furrow irrigation.

Microjet irrigation: It has the advantage of providing continuous water availability, since water is distributed in an area up to 6 m in diameter to most of the roots, the entire root system remains well hydrated throughout the dry period.

Smudging: It is making the Smokey fire below the tree canopy and allows smoke to pass through the foliage for several days. It is an early commercial method of inducing mango to flower, only mature shoots of 1 year or older with very brittle, dull grayish green to copper coloured leaves and plump terminal buds are suitable for smudging. Smudging is done continuously for several days and is stopped if flower buds do not appear within two weeks. The process may be repeated 1-2 months later, but results are uncertain.

Phytohormones

Auxin: It influence flowering. Increasing trends in auxins is vital to floral induction

Cytokinins: It promotes cell division. Considered important regulator of shoot meristematic activity. Its high production in apical meristem during active growth facilitates reproductive morphogenesis

Ethylene: The fact that smudging and external applications of ethrel stimulates mango flowering, ethylene plays important role in floral induction. This was confirmed subsequently from the analysis of endogenous ethylene concentration during flowering.

Abscisic acid: It has an inhibitory effect on cell elongation. It regulates adaptive stress response in plants. As stress conditions are required floral morphogenesis, its increased concentrations is expected to facilitate floral growth though stress adaptive mechanism involving osmotic adjustment and synthesis of stress responsive genes. In mango, studies dealing with ABA role in floral inductions have not been made in great detail.

Gibberellins: In many perennial fruit species including mango, gibberellins have been shown to suppress floral process (Davenport, 2009). The floral inhibitory response of gibberellins depends upon concentrations, growth stage, and climatic conditions of the location.

Conclusion: Research in mango tree though expensive, time consuming and limited to production aspects but there is an essential need to manipulate the flowering physiology and particular practices may be recommended varying upon different factors to enhance the yield and quality of mango.

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44. MUSHROOM CULTIVATION AND PROCESSING 15132

Mushroom Cultivation: Improving Food and Nutritional Security

Divya Sharma

(Ph.D. Scholar), Department of Agricultural Economics, Extension Education & Rural sociology, College of Agriculture CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur- 176062, India

INTRODUCTION: India has achieved the food security and produced over 253.16 million tonnes of food grains in 2015-16. However, our struggle for nutritional security is still on. The increasing population, depleting agricultural land, deteriorating environment, water shortage and demand for quality food are emerging vital issues need to be addressed in the years to come. The average size of the landholding has declined to 1.16 ha during 2010-11 from 2.28 ha in 1970-71. If this trend continues, the average size of holding in India would be mere 0.68 ha in 2020 and would be further reduced to 0.32 ha in 2030. This situation in India calls for an integrated effort to address the emerging livelihood issues. It is imperative to develop strategies and agricultural technologies that enable adequate income and employment generation, especially

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for small and marginal farmers who constitute more than 85 per cent of the farming community. (Dashora and Singh, 2014). To meet these challenges, it is important to diversify agricultural activities. Diversification in any farming system imparts sustainability and mushrooms are one such component.

Mushroom is a fungal growth that typically takes the form of a domed cap on a stalk, with gills on the underside of the cap. Mushrooms also called 'white vegetables' or 'boneless vegetarian meat' contain ample amounts of proteins, vitamins and fibre. The land resources in the world for raising the food crops are limited. Since, most of the crops are grown outside in the fields. The mushroom production is an indoor activity hence, does not need agricultural land thus, suited to small farmers and landless labourers. Many agricultural wastes can be utilized to produce quality food and organic manure for field crops. Besides mushroom have high bio efficiency *i.e.*, conversion of dry substrate into fresh mushroom. Spent mushroom substrate can be used to produce organic manure. It can generate self-employment. Families living below poverty line can be brought above poverty line through mushroom production and improving their socio-economic status. It can provide nutritional security particularly to poor people through incorporating mushrooms in their diets. Mushrooms occur under various ecological conditions. They comprise a large heterogeneous group with different shapes, sizes, colour and edibility. Of the 2000 known edible species, only a few are commercially cultivated and some are poisonous in nature. The edible species are popularly known as mushrooms, the poisonous ones as toadstools. There are different types of mushroom Terrestrial/Terricolous mushroom (which grows on soil), Lignicolous mushroom (which grows on wood) and Mycorrhizal mushroom (which grows due to some association with plants). Mushrooms are considered to be the highest producer of protein per unit area and time. Water requirement for mushroom production is far less (25 litres per kg fresh mushrooms) than field crops as they are cultivated indoors (Sharma *et al.*, 2010). Mushrooms are a source of good quality protein and are rich in vitamins B- complex. Mushroom production is an important secondary source of income for millions of rural families and has assumed important role in providing employment and income generating opportunities to rural masses.

Origin: Globally, France was the leader in the formal cultivation of mushroom. Mushroom cultivation was started in the reign of Louis XIV the great emperor of France (1638-1715). In India, mushroom cultivation was initiated in 1966, when a scheme entitled "Development of Mushroom Cultivation in Himachal Pradesh" was started at Solan by Himachal Pradesh Government in collaboration with ICAR, New Delhi. In 1964 cultivation of *Agaricus bisporus* on experimental basis was started by CSIR and state government at Srinagar in Jammu and Kashmir. But, its commercial cultivation started in 1968 and mushrooms are raised as a seasonal crop on a commercial scale round the year under the controlled environmental conditions. As per official declaration made on September 10, 1997, Solan City is said to be the "Mushroom City of India" (Kangotra and Chauhan, 2013). Some important mushrooms grown in world are white mushroom / button mushroom (*Agaricus bisporus*), the black forest mushroom / shiitake (*Lentinus edodes*), the winter mushroom (*Flammulina velutipes*), the paddy straw mushroom (*Volvariella volvacea*) and oyster mushrooms (*Pleurotus spp.*) (Thakur MP, 2013).

Mushroom Production in India

The importance of mushroom growing in India can be realized by the fact that it added value worth Rs 422.96 crore (Rs 302.37 crore at constant prices) to Indian economy in 2010-11 (Table 1). It is evident from this table that the three northern states of Punjab, Haryana and Himachal Pradesh accounted for 71 per cent of the total value of mushroom output in the country. Not only that the share of these states witnessed an increase of about 5 per cent points over 2004-05 in 2010-11. Further, while the value of mushroom output registered a compound growth rate 4.49 per cent per annum at the country level, it increased at about 8.0 per cent per annum during this period. The mushroom exports fetched Rs 108.73 crore for the TE 2015-16 of which the dried and prepared/preserved accounted for about a major share (Table 2).

TABLE 1. State- wise value of mushroom output (At2004-05 prices) (Rs. lakh)

Sr. No.	State	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Growth rate (%)
1.	Punjab	6,000 (25.48)	5,700 (22.64)	6,000 (23.11)	6,000 (23.28)	6,000 (22.28)	9,000 (28.26)	9,120 (30.16)	8.06 (0.0109)
2.	Haryana	3,150 (25.00)	2,720 (23.00)	3,015 (23.00)	3,060 (23.00)	3,240 (23.00)	3,645 (28.00)	3,600 (30.00)	3.85 (0.0056)
3.	Himachal Pradesh	2,250	2,250	2,385	2,385	2,655	3,320	3,320	7.61

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Sr. No.	State	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Growth rate (%)
		(10.00)	(9.00)	(9.00)	(9.00)	(10.00)	(10.00)	(11.00)	(0.0059)
4.	Others	12,150 (39.49)	14,512 (45.79)	14,558 (44.58)	14,333 (44.20)	14,333 (44.12)	15,885 (33.06)	14,197 (28.70)	2.28 (0.0057)
5.	Total	23,550 (100.00)	25,182 (100.00)	25,958 (100.00)	25,778 (100.00)	26,228 (100.00)	31,850 (100.00)	30,237 (100.00)	4.49 (0.0043)

Source: CSO publication "State-wise estimates of value of output from agriculture and allied activities, 2013".

TABLE 2: Exports of Indian mushrooms for the triennium ending 2015-16

Sr. No.	Product	Quantity (MT)	Value (Rs. lakh)
1.	Mushroom Spawn	3.32	10.91
2.	Mushroom of the genus *Agaricus*, provisionally preserved	477.41	518.60
3.	Mushroom of the genus *Agaricus*, dried but not further prepared	165.25	3,088.35
4.	Mushroom of the genus *Agaricus*, fresh/chilled	260.67	388.53
5.	Mushroom of the genus *Agaricus*, prepared/preserved otherwise than by vinegar /acetic acid	180.67	6,867.49

Source: http://agriexchange.apeda.gov.in [9th August, 2016]

Conclusions: Mushroom growing has become a popular supplementary enterprise across some select states during the past two decades or so. It is evident from the growing contribution of mushrooms to the value of output added to the Indian economy. The economics of its growing has attracted the landless households and marginal farmers for whom conventional agriculture is no longer a profitable venture. The finding of this study clearly indicated that management plays a crucial role in increasing the mushroom yield. As such greater efforts are needed to train the less endowed farmers properly.

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45. MEDICINAL AND AROMATIC PLANTS 14758

Medicinal Properties of Garlic

Pranjal S. Deshmukh

Assistant Professor, Sau Vasudhatai Deshmukh College of Food Technology, Amravati, MS
**Corresponding Author Email: pranjald097@gmail.com*

Garlic (*Allium sativum*) is a spice with a strong flavor, universal flavor and medicinal value. As a medicine, garlic was largely used by the ancient physicians of India to administer in fevers, coughs, and debilitating conditions. Garlic has been used as an attempted cure for dropsy, pherenitis, scrofulous swellings of the neck, bronchitis, tuberculosis and many other ailments. Externally, garlic is used as a remedy for skin and ear diseases. Garlic juice mixed with 3 or 4 parts of ordinary or distilled water has been used as a lotion for washing wounds. The inhalation of garlic oil or garlic juice has been recommended in cases of pulmonary tuberculosis, rheumatism, sterility and impotency. Garlic juice is used for various ailments of stomach, as a rubefacient in skin diseases and as ear drops in ear-ache. The juice diluted with water can be used against duodenal ulcers. In Cambodia, the leaves are used in treatment of asthma. Because of its highly curative properties, it is described as derived from Amrita or Ambrosia. On the other hand, it is one of the cheapest and most efficient folk medicine in the hands of housewife and the layman alike for day to day use. Recent scientific tests on rabbits proved that garlic inhibited to a certain degree. The development of extremely severe forms of experimental

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hypercholestrinaemia. In an acute experiment on 75 cats, garlic fractions displayed a considerable hypotensive effect. In dogs, with experimental hypertension, garlic reduced their systolic arterial tension to values nearly as the normal ones. Clinical application of garlic in 114 human patients with a clear-cut hypertension and atherosclerosis, markedly improved their complaints, and in the overwhelming majority, provoked a drop of their systolic arterial tension by 8 to 33 mm and their diastolic one by 4 to 20 mm mercury. In small doses, garlic intensified the tones of the intestinal muscles, thus increasing peristaltic movements, while in large doses, it inhibited them. In experiments on animals and human workers exposed to chronic lead intoxication, garlic has been found to be an efficacious preventive and curative drug against saturnism. In Ayurvedic system, garlic has been reported to be beneficial in over 18 diseases of man.

Garlic use for Cancer

One of its uses for cancer is much of the important. Garlic antibiotic allicin and malignant tumour of humans as well as of animals has been found useful. Transplanted tumors of Jensen sarcoma in rats regressed, and in some cases, completely disappeared after the injection of 1-3 mg of allicin, given either intramuscularly or directly into the tumor.

Garlic Residue with Antimicrobial Properties

According to an American patent, the residue of garlic, obtained by alcoholic extraction and distillation, contains a bacteriostatic and bactericidal substance, identified as 'allyl disulphide oxide'. On steam distillation of crushed garlic at atmospheric pressure, the major odor-producing principle 'allicin' decomposes down to diallyl disulphide and other disulphides that explains why the volatile oil of garlic consists chiefly of disulphides. However, 'allicin' can be isolated by steam distillation at a reduced pressure. It may also be clarified that the mother precursor alliin does not possess bactericidal properties. It is only allicin produced as a result of enzymic cleavage of alliin which is bactericidal.

46. MEDICINAL AND AROMATIC PLANTS 15383

Valuable Herb for Mankind

Dr. Madhumita Bhattacharjee

Associate Professor, P. G. Govt. College for Girls, Sector -11, Chandigarh
**Corresponding Author Email: madhumita3680@gmail.com*

Botanical name: *Trigonella foenum graecum*
Vernacular or common name: Methi or Fenugreek
Family: Fabaceae

Trigonella has been used both as food and medicine since long time. Trigonella has wide distribution in world. It is available in many parts of Asia, Europe and Africa. The leaves and seeds of the Fenugreek plant are widely used in Indian cuisine. It is cultivated both under irrigation and as a rainfed crop. Fenugreek is grown as a cool season crop in India. It will grow on a wide range of well drained soils

Morphology of Plant

Trigonella plant is an erect, annual herb of about 1-2 ft. high. It is strongly scented. Trigonella has compound leaves. Leaflets are 2-2.5 cm long, light green in colour, lanceolate and slightly toothed. Flowers are axillary and yellow in colour, pods are 2-3 inches long, thin and pointed. There are around 10-20 seeds per pod. The seeds of methi are brownish yellow in colour, bitter in taste, have mucilage and emits a peculiar odour. Most useful parts of Trigonella are leaves and seeds.

Composition of Leaves per 100 grams

Contents	Percentage
Moisture	86.1%
Protein	4.4%
Fat	0.9%
Minerals	1.5%
Fibres	1.1
Carbohydrates	6.0

Composition of Seeds per 100 grams

Contents	Percentage
Moisture	13.7%
Protein	26.2%
Fat	5.8%
Minerals	3.0%
Fibres	7.2%
Carbohydrates	44.1 %

Trigonella leaves and seeds also contain calcium, phosphorus, carotene, thiamine, riboflavin and niacin. Beside these methi leaves also contain iron and vitamin C, while seeds contain alkaloids, trigonelline, trigonellic acid, choline, essential and volatile oil and saponin. The saponin reduces cholesterol levels.

Beneficial Practices of Trigonella Leaves

1. Leaves of Trigonella are aromatic and have

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cooling effect.
2. They are prescribed as an aperient (laxative) for relieving indigestion and flatulence.
3. As the leaves are rich in iron, so methi leaves, commonly known as "Methi Saag" is helpful to prevent anaemia.
4. Paste of leaves can be apply to head to prevent premature hair loss.
5. Due to cooling effect the paste of leaves can be apply to swellings and burns.
6. Doing gargles with infusion of leaves is helpful in curing mouth ulcers.
7. As cosmetic paste of leaves can be apply on face every night and washed with luke warm water to prevent dryness of face and early appearance of pimples.

Beneficial Practices of Trigonella Seeds

1. The seeds of Trigonella is also useful in treatment of colic, flatulence, dysentery and diarrhoea.
2. Being rich in iron the consumption of seeds in any form is also helpful in recovering anaemia.
3. Fenugreek seeds are rich in vitamin E and is one of the earliest spices known to man as preservative and added` to pickles.
4. Seeds when soaked in water become mucilaginous. Tea made from this is helpful to provide cooling effect on inflamed stomach and intestine.
5. The tea made from methi seeds is helpful in reducing fever.
6. The tea made by methi seeds is effective in early respiratory tract infections as bronchitis and influenza.
7. It is also helpful in peptic ulcers by forming a protective layer.
8. Gargle by decoction of roasted seeds is helpful in curing disorder of throat and chest.
9. Trigonella seeds paste with milk and sugar can be used by lactating mothers.
10. Two teaspoon of roasted powdered seeds of methi soaked in water at night and taken in morning is helpful to stabilize the level of blood sugar in the body.
11. Seeds are an effective substitute for cod liver oil.
12. Application of paste of soaked methi seeds on scalp for 15-20 minutes is helpful to get rid of dandruff.
13. Halwa made from wheat flour, sugar, ghee and fried methi seeds is helpful in quick normalization after delivery.

47. POST-HARVEST MANAGEMENT 15231

Recent Trends in Packaging Technology of Fruits and Vegetables

Sumit Biswas and Manoj Kumar Dev

College of Agriculture, Ambagarh Chowki, Raj nandgoan
**Corresponding Author Email: biswas.sumit609@gmail.com*

The increasing demand for fresh and quality packaged food, consumer convenience and manufacturers concern for longer shelf life of the food products is driving the market for Global active and smart packaging technology for food Markets. Being perishable, fruits and vegetables require to be preserved until they are sold and used by consumers. This offers challenges in food preservation. The package must not only act as an inert barrier to the external environment but also resist respiration issues. Demands on package performance continue to increase as a result of market and social changes. Active packaging reduces the need for additional preservatives in perishable food stuffs. Thus the shelf-life is extended and the food stuffs maintain freshness longer and are mildly preserved. Research work in this area brings out newer methods and technologies for improving the active packaging.

Some of the New Developments

Ethylene Scavenger: Ethylene (produced by all plants) is a plant growth hormone and has a detrimental impact even at low concentrations on the quality and shelf-life of many fruits and vegetables during storage and distribution. Ethylene induces fruit ripening and accelerates fruit softening and ageing. There are several methods used by the horticultural industry to minimize the impact of ethylene during storage and distribution. The two major methods are:

1. Low temperatures of storage: reduces the production of ethylene by lowering respiration and metabolic rates of the produce.
2. Controlled atmospheric storage with low oxygen and high level of carbon dioxide: suppresses respiration rates and renders the produce less sensitive to the effects of ethylene. There is a need to generate varying concentrations of carbon dioxide to suit specific food requirements. Since carbon dioxide is more permeable through plastic films than is oxygen, carbon dioxide will

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need to be actively produced in some applications to maintain the desired atmosphere in the package.

Packaging technologies with an aim to scavenge or absorb ethylene from the surrounding environment of packaged produce have also been developed.

The most widely used ethylene-scavenging packaging technology is based on a sachet that contains either potassium permanganate or activated carbon with a metal catalyst. Several ethylene-removing plastic film-based products consisting of PE impregnated with finely dispersed minerals like clays, zeolites and carbon have been developed. Oxygen scavengers can be incorporated in the packaging system itself rather than being added as sachets or labels as seen above. The oxygen scavenger can be incorporated into crowns, cans and a variety of metal and plastic closures. A novel plastic based ethylene-scavenging technology developed by Food Science Australia is based on irreversible and specific reaction between diene (Tetrazine) and ethylene. Tetrazine is colored while its product with ethylene is colorless.

This feature can provide the indication of the residual ethylene scavenging activity.

The disadvantage however is that Tetrazine is sensitive to moisture. Another alternative approach is to use of ethylene inhibitors such as 1- methylcyclopropene (1-MCP). 1-MCP binds to the ethylene receptors in plant tissue and, as a result prevents the hormonal action of ethylene. However, it requires a dedicated fumigation chamber. A chemical reagent, incorporated into the packaging film, traps the ethylene produced by ripening fruit or vegetables.

The reaction is irreversible and only small quantities of the scavenger are required to remove ethylene at the concentrations at which it is produced.

Oxygen Scavenger: The presence of oxygen in food packages accelerates the spoilage of many foods. Oxygen can cause off-flavour, colour change and nutrient loss, among other degradation. One of the most promising applications of oxygen scavenging systems in food packages is to control mould growth.

Most moulds require oxygen to grow and in standard packages it is frequently mould growth which limits the shelf life. This also delays oxidation of and therefore rancidity development. Sachets containing oxygen absorbents, where the scavenging material is usually finely divided iron oxide.

Antimicrobial Packaging: Extends shelf-life and promotes safety by reducing the rate of growth of specific microorganisms by allowing direct contact of the package with the surface of solid foods. The packaging could be self-sterilizing or sanitizing to greatly reduce the potential for recontamination of processed products and simplify the treatment of materials to eliminate product contamination. Antimicrobial systems can be constructed by using antimicrobial packaging materials, antimicrobial inserts (such as sachets) to generate antimicrobial atmosphere conditions inside packages, or antimicrobial edible food ingredients in the formulation of food.

Since antimicrobial packaging systems are designed to control the growth of microorganisms in packaged foods, the systems essentially consist of packaging materials, the in-package atmosphere, target micro-organisms, and antimicrobial agents. These elements are related to one another and to the final system design features. Antimicrobial packaging technologies have been developed considerably.

Technologies that release volatile or gaseous microbial control agents are preferred due to the typically limited contact of the produce with the package surfaces.

Controlled Release of Sulfur Dioxide: Sulfur dioxide (SO_2) is an effective gaseous microbial agent, in use for over 80 years. SO_2 is traditionally used as antioxidant and preservative in fruit and vegetable products, dried fruits, snack products and wine.

The main advantage of SO_2 is the combination of antioxidative activity with its ability to inhibit polyphenol oxidase, which is catalyzing browning of food products. Furthermore, sulphur dioxide acts as food preservative preventing microbial growth. However, SO_2 and sulphites strongly reduce vitamin B1 uptake. Reduced uptake of this vitamin can lead to several health problems such as chronic headache and disturbance of the memory.

Modified Atmosphere Packaging (MAP): A technique used for prolonging the shelf-life period of fresh or minimally processed foods. In this preservation technique, the air surrounding the food in the package is changed to another composition. This way the initial fresh state of the product may be prolonged. Shelf-life is prolonged with MAP since it slows the natural deterioration of the product.

Fruits and vegetables are respiring products where the interaction of the packaging material with the product is important. If the permeability (for O_2 and CO_2) of the packaging film is adapted to the products respiration, an equilibrium modified atmosphere will establish in the package and the shelflife of the product will increase. Instead of preserving foods through the extremes of heat (sterilization) or cold (freezing), MAP utilizes "minimal processing" - preserving food with the absolute least amount of damage to quality, texture, taste and nutrition. MAP has been in existence for the last several decades.

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Several technologies have been developed with an aim to replace the existing headspace gas mixture with the ideal ratio of oxygen and carbon dioxide to preserve the produce until it is consumed by the user. Some of the most common MAP systems are:

- Micro perforation of PE packaging film
- Incorporation of inorganic particles along with micro perforated PE film

Humidity and Condensation Control: Water loss from fresh produce or minimally processed foods as a result of normal respiration, microbiological activity, or physical activity can occur as a result of evaporation from the product followed by permeation through the package material, when the package material does not provide an adequate water-vapor barrier. Condensation or "sweating" is a problem in many kinds of packaged foods, particularly fresh fruit and vegetables.

When one part of the package becomes cooler than another, water vapor condenses as liquid droplets in the cooler areas. If the liquid water is kept away from the product, it harms package appearance and consumer appeal, both of which are important.

When condensation moistens the product's surface, soluble nutrients leak into the water, encouraging rapid growth of mold spores and leading to loss of nutrients. The use of humidity-control technology reduces condensation inside packages of respiring and other high-water-content foods and eliminates water films on the food without further drying the food.

Therefore, moisture-sensitive humidity of the tray is controlled by:

- The presence of sodium chloride;
- Overwrap material claimed to be capable of controlling the relative humidity within a package that consists of a duplex of two sheets: the external sheet is a water-vapor barrier and the inner sheet is a water-vapor-permeable (but not water-permeable) film;
- A sandwich package composed of two sheets of polyvinyl alcohol (PVA) film sealed along the edge. Between the two sheets is a layer of propylene glycol humidifying agent.
- The PVA film is very permeable to water-vapor but is a barrier to the
- propylene glycol;
- A sheet made of aluminum metallized film with nonwoven fabric on the reverse side, to absorb meat and fish exudations.
- Multilayer package containing a layer of PVOH or cellulosic fiber like paper sandwiched between PE films.

Although active packaging may provide many benefits to shelf life extension, there are several issues to consider before implementing such a packaging system.

The regulatory status of the active packaging system, cost-to-benefit ratio, production capability, commercial viability, consumer acceptance, and sensory effects on the food.

Generally, the shelf life has clearly been extended through implementation of active packaging.

Combinations of systems along with new technologies to be further developed will continue to improve the quality and safety of food.

48. POST-HARVEST MANAGEMENT 15246

Chemical Toxicological Studies of Irradiated Foods

Poornima S[1], Vandana[2], N. Manda Devi[3] and Palmei Gaibimei[4]

[1,4]Ph. D. Scholar, Department of Post-Harvest Process & Food Engineering, G.B.P.U.A. & T., Pantnagar, Uttarakhand

[2]Ph. D. Scholar, Department of Foods & Nutrition, G.B.P.U.A. & T., Pantnagar, Uttarakhand

[3]Ph. D. Scholar, College of Food Processing Technology & Bio-Energy, AAU, Gujarat

INTRODUCTION: Food safety is a global issue which raises major environmental and public health consequences if inadequately maintained. Therefore, a variety of procedures have been developed to reduce food-borne contamination Since the late 1980's, the WHO and the FDA have approved the irradiation of food by ionizing radiation at the beginning of the food supply chain as an inexpensive and effective procedure.

Irradiation

Food irradiation is a technology typically uses electron beam and ionizing radiation. The energy from the irradiation breaks chemical bonds produces toxic ions and free radicals that react with cellular constituents in food to form radiolytic products. It is by disrupt the DNA structure and prohibit the replication of the microorganisms that prevents spoiling and food borne illness. However, irradiated food is not radioactive. The irradiation dose applied to a food product is measured in terms of gray (Gy){1 Gray = 1 Joule/Kg}. The radiolytic products increase in proportion to the amount of radiation dose.

Chemical Changes in Food: In addition to the

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destruction of microorganisms, the radiation dose and exposure time can affect the taste and consistence of the exposed foods. Specifically, foul odors and discoloration have been noted in meat due to radiolytic compounds that cause oxidation of myoglobin and fat. Irradiating food at under appropriate conditions (reduced O_2 environment and/or a frozen state) and appropriate doses can minimize these effects.

Presence of Unique Radiolytic Products (URP'S): The presence of several compounds, most notably 2-alkylcyclobutanones and furan has generated some concerns about the safety of irradiated foods.

2-Alkylcyclobutanones: Irradiation of fat-containing food generates 2-alkylcyclobutanones (2-ACBs) that results from the radiation induced breakage of triglycerides. This family of cyclobutanones includes 2-dodecylcyclobutanone (2-DCB) from irradiation of palmitic acid, 2-tetradecylcyclobutanone (2-TDCB) from oleic acid and 2-tetradecylcyclobutanone (2-TCB) from stearic acid. To date there is no evidence that 2-ACBs are found in any non-irradiated foods treated by other food processes. In irradiated foods, the amount of 2-ACBs generated is proportional to the fat content and absorbed dose. Depending on the amount of radiation that a food absorbed, the concentration of 2-ACBs in irradiated food ranged from 0.2 to 2μg/g of fat. Hence, these compounds were considered to be unique markers for food irradiation.

Results

In order to test irradiated foodstuffs, several in-vitro studies have been conducted using bacterial mutagenic assays by utilizing natural juices, extracts or digests from irradiated food. The majority of the studies did not depict 2-DCB as mutagenic. However, cytotoxic and other biological effects were observed. But in the case of in-vivo toxicological evaluation, some radiolytic products have been shown to be probable tumor promoters.

Experimental Animal Studies with Whole Food

Wistar rats received a daily solution of 2-ACBs (while controls received ethanol solution) in combination of a known carcinogen azoxymethane (AOM). Observations were made at two distinct intervals. After three months of the exposure, no significant changes in the number of pre-neoplastic colonic lesions were observed among the rats. At six months, however, the total number of tumours in the colon was threefold higher in the 2-ACB-AOM treated rats than in the ethanol-AOM control rats. This demonstrated that 2-ACBs found exclusively in irradiated dietary fats may promote colon carcinogenesis in animals treated with a known carcinogen. It also suggested that the 2-ACBs alone do not initiate colon carcinogenesis. However, it is worth noting that the amount of 2-ACBs consumed was much higher in this study than that a human would consume from the irradiated food.

Human Studies with Whole Food

In one study, ten children (2 to 5 years old) suffering from severe protein-calorie malnutrition were fed irradiated wheat (N = 5) for six weeks. These ten children were compared to a control group of five children who were fed un irradiated food during the same time period. The first group of five children developed significantly more polyploid cells and other cellular abnormalities in their lymphocytes than the five children who were fed the un irradiated food. However, the abnormality persisted for up to two months after the feeding period ended.

Conclusion: It is quite clear that additional research is needed in order to fully address the issue and concerns of irradiated food. The toxicity of unique radiolytic products (2-ACB) should be tested vigorously, especially in regards to the tumor promoting activities. Global regulatory agencies need to be proactive in resolving these health concerns prior to the ubiquitous consumption of irradiated food.

49. POST-HARVEST MANAGEMENT 15247

Importance of Cryogenic Grinding

Palmei Gaibimei[1], Poornima S[2], Vandana[3] and N. Manda Devi[4]

[1,2]Ph. D. Scholar, Department of Post-Harvest Process and Food Engineering, G.B.P.U.A. & T., Pantnagar, Uttarakhand

[3]Ph. D. Scholar, Department of Foods & Nutrition, G.B.P.U.A. & T., Pantnagar, Uttarakhand

[4]Ph. D. Scholar, College of Food Processing Technology and Bio-Energy, AAU, Gujarat

Introduction: The term "Cryogenics" originates from Greek word which means creation or production by means of cold. Cryogenic grinding is a method of powdering herbs at sub-zero temperatures ranging from 0 to -70°F. The extremely low temperature are produced by using substances called "cryogens" such as liquid nitrogen and liquid helium. Cryogenic grinding, also known as freezer milling, freezer grinding, and cryomilling is the act of cooling or chilling a material and then reducing it into a small particle size. This process does not damage or alter the

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chemical composition of the plant in any way. Normal grinding processes which do not use a cooling system can reach up to 200°F. These high temperatures can reduce volatile components and heat-sensitive constituents in spices/herbs. Cryogenic size reduction (grinding) of spices is an acceptable technique that helps to retain the natural quality of spices. Use of liquid nitrogen provides the required low temperature so that volatile components and essential oils content which preserve the spice flavor retains during grinding process.

N_2 and CO_2 – the Ideal Refrigerants or Cryogens

The N_2 gas makes up the major portion of the atmosphere (78.03% by volume), liquid N_2 is inert, colourless, odourless, non-corrosive, non-flammable liquid, extremely cold, boiling point of -195.8°C and similar appearance to water. Liquid nitrogen is stored in vacuum flask.

The CO_2 is colorless, slightly acidic, pungent and biting taste, non-flammable, non-reactive and non-toxic. The CO_2 content in atmosphere is 0.035% and has a boiling point of -78^0 C. Liquid carbon dioxide and dry ice are used to freeze food, blood and other materials. Gaseous carbon dioxide is used in the beverage industry to carbonate drinks from beer and wine. Liquid carbon dioxide is stored in thermally insulated tanks.

Process Example for Grinding Spices: Cryogenic grinding of spices is a method of pulverizing the material at low temperatures. The spices are frozen with cryogen such as liquid nitrogen (LIN/N_2) or carbon dioxide (CO_2) as they are ground into a fine powder. This process preserves the quality of aroma and flavor within the product without damaging or altering the chemical composition of the spices. Spices are fed through a hopper to a conveyor system. While moving along the conveyor, the spices are sprayed with the appropriate amount of cryogen. The material is then moved to a stainless steel auger that transports, grinds, and mixes the product and cryogen for an efficient cooling process. The cryogen absorbs the heat and is vaporized to a gaseous state, which is then expelled from the system through an exhaust system. The results are high quality spices at controlled partial sizes with no evaporation of essential values and negligible loss of volatile components.

Advantages of Cryogrinding

- Higher production rate
- Lower energy consumption
- Finer particle size
- More uniform particle distribution
- Lower grinding cost
- No heat generation which is good while grinding spices, pharmaceuticals and scrap plastics
- Provides an inert atmosphere thus eliminating the possibility of oxidation

Comparison of Traditional Grinding and Cryogenic Grinding

Disadvantages of Existing Grinding System	Advantages of cryogenic Grinding System
The heat is developed inside the grinding mill	Temperature used is below 0ºC inside the grinding mill
This heat, which developed during grinding, leads on the one hand to evaporation of the essential oils and on the other hand, heat sensitive fats are melted. This is turn can lead to the grinding elements become grassy (oily) and clogged or even to machine blockages	Minimal loss of volatile components
High energy consumption	Low energy consumption
Low throughput	High throughput
Existing grinding equipments more than two times recycle into the mill for required particle size	Approx. 2-3 times higher grinding capacity
Fire Risk	No Fire Risk
High capacity motors are required to grind the material	Low capacity motors are required to grind the material
Air pollution due to evaporating essential oil into the atmosphere	No evaporation of essential oil into the atmosphere
No control on particle size	Particle size under control

Superiority of the Whole Cryogenically Process over Standard Grinding Process Spices w. r. t Essential Oil Content

Spices	Ungrounded essential oil content (ml per gm)	Cryogenic grinded essential oil content (ml per gm)	Standard grounded essential oil content (ml per gm)
Turmeric	5.5	5.5	3.4
Coriander	0.6	0.6	0.4
Black pepper	2.9	2.9	1.5
Cumin garam	3.5	3.5	1.6
Garam masala	4.6	4.6	2.0

General Application of Cryogenic Grinding

1. **Cryogrinding of steel**:-The large amount of heat generated during grinding at high speed raises the temperatures at cutting zones excessively. Cryogens such as liquid nitrogen will help in reducing the effect of heat on tool and work piece, thereby increasing the life of the tool.
2. **Thermoplastics**:-Nylon, PVC, Polyethylene,

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Polypropylene are usually machined using cryogenic grinding to form fine powders.

3. **Thermo sets**:-Synthetic and natural vulcanized rubber and materials such as bakelite can be economically machined with cryogenic grinding and recycled.
4. **Adhesives and waxes**:- Sticky materials such as adhesives and waxes are difficult to machine using the conventional grinding methods. By using cryogenic grinding, they can be embrittled easily and machined into fine particles.
5. **Explosives**:- Explosive materials explode when their temperature increases to ignition temperature in the presence of oxygen. By using cryogens the ignition temperature can be reduced effectively and then be machined.
6. **Spices**:- Spices like pepper, cinnamon can be made into powdered by cryogenic grinding which helps in the preservation of the taste and aroma.

Conclusion: Nowadays due to rise of energy and raw material prices and concerns for environment leads to difficult disposal of safe waste and costly resource recovery which is vital matter for today's business. The studies of cryogenic systems enable food processors to improve both their product quality and operational efficiency. Cryogenic grinding technology can efficiently grind most tough materials and can also facilitate Cryogenic recycling of tough composite materials. It employs a cryogenic process to embrittle and grind materials to achieve consistent particle size for a wide range of products. The cryogenic process also has a unique capability for recycling difficult to separate composite materials. Cryogenic freezing is an upcoming food processing technology that is fast gaining popularity because of the lower setup costs and improved food quality when compared to mechanical freezing.

50. FOOD PROCESSING AND PRESERVATION 15362

Food Preservation: Principles and Methods for Prevention of Food Spoilage

Shivashankar Sanganamoni[1]* and Srilatha Pattem[2]

[1]Ph.D. Scholar, Department of Post-Harvest Process and Food Engineering, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand – 263 145 (India).
[2] Assistant Professor, College of Food Science and Technology (PJTSAU), Rudrur, Telangana
**Corresponding Author Email: shiva14cae@gmail.com*

Food is an essential part of everyone's lives. It gives us the energy and nutrients to grow and develop, be healthy and active, to move, work, play, think and learn. Currently, there is a trend towards a healthier way of living, which includes a growing awareness by consumers of what they eat and what benefits certain ingredients have in maintaining good health. Preventing illness through diet is a unique opportunity to use innovative functional foods. The development of new functional foods requires technologies for incorporating health promoting ingredients into food without reducing their bioavailability or functionality. In many cases, microencapsulation can provide the necessary protection for these compounds. Food preservation now becoming necessary activity in human's life to prevent spoilage and make it available in all seasons and location.

Spoilage of Food

Food broadly classified into three major groups based on its water activity and shelf life viz., Perishable, Semi-perishable and non- Perishable foods. Spoilage of food can be following three ways.

1. Microbial spoilage
2. Chemical spoilage
3. Spoilage due to rodents, insect etc.

Need for Food Preservation

Need of preservation is growing day by day with increasing population growth of the countries. The need of preservation is as follows

- Improve the shelf life of food
- Prevents the spoilage of perishables
- Long term storage of fresh produce
- Convenience - ready to serve in minutes
- Prepare for emergencies and/or illness

Principles of Food Preservation

Food preservation can be done by following three ways principles. They are

1. Prevention (or) delay of microbial decomposition
   a) By keeping out microbes
   b) By removal of microbes
   c) By prevent the growth of microorganisms
   d) By killing microorganisms
2. Prevention (or) delay of self-decomposition due to enzymes and chemicals.
   a) By prevention (or) delay of enzyme activity

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b) By prevention (or) delay of chemical reactions
3. Prevention of damage due to rodents and insects.

Methods of Food Preservation

1. Methods for prevention (or) delay of microbial decomposition
   a) Aseptic processing
   b) Filtration, Trimming, Washing and Sorting
   c) Lowering temperature, Using preservatives, reducing water activity and pH
   d) Heat treatment and some Non-Thermal treatments such as High pressure processing, Ultra-sonication, Ultraviolet treatment, Pulsed electric field etc.
2. Methods for prevention (or) delay of self-decomposition
   a) Application of heat (Blanching)
   b) Providing anaerobic conditions
   c) Lowering temperature
   d) Adding some chemicals to prevent the chemical decomposition
3. Methods for prevention of damage to food
   a) Proper packaging
   b) Use of chemicals to kill insects and rodents

Some of the important methods are described below.

Drying and Heating: The most ancient method is drying, and it was employed early for fruits, grains, vegetables, fish, and meat. A more recent variation, known as freeze-drying, is now being used on such foods as instant coffee, meat, orange juice, and soup. The early method of drying was by direct exposure to the sun rays. The use of sugar was early combined with drying, Smoking a method mainly used for fish and meat.

Preservatives: In modern food preservation, preservatives function in two ways. One is by delaying the spoilage of the food, while the other is by ensuring that the food retains, as nearly as possible, its original quality. The first method includes the use of sugar, vinegar for pickling meats and vegetables, salt (one of the oldest preservatives), and alcohol. The second method includes the use of ascorbic acid (which prevents color deterioration in canned fruits), benzoic acid, sulfur dioxide, and a variety of neutralizers, firming agents, and bleaching agents. The excessive or unacknowledged use of these chemical agencies has been legislated against by most governments.

Irradiation: Irradiation has also been used successfully to destroy many of the microorganisms that might cause spoilage in food. Irradiation has been declared safe by the Food and Drug Administration and World Health Organization. Thus, despite opposition from those who fear that health hazards from its use will be discovered later, this method is gradually gaining acceptance.

Conclusion: Preservation is became the essential method for serving of food to the countries which population growth is high. Preservation methods are efficiently decrease the spoilage of food and increase the shelf life of the products. Preservation by adding chemicals (Viz., Ascorbic acid etc.) may also increase the nutritional value of the product.

51. FOOD PROCESSING AND PRESERVATION 15363

Application of Drying Technique in Food Processing

Srilatha Pattem[1*] and Shivashankara Sanganamoni[2]

[1]Assistant Professor, College of Food Science and Technology (PJTSAU), Rudrur, Telangana
[2]Ph.D. Scholar, Department of Post-Harvest Process and Food Engineering, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand – 263 145 (India).
**Corresponding Author Email: srilatha2708@gmail.com*

Food drying is a method of food preservation in which food is dried (dehydrated or desiccated). Drying inhibits the growth of bacteria, yeasts, and mould through the removal of water. Water is traditionally removed through evaporation (air drying, sun drying, smoking or wind drying), although today electric food dehydrators or freeze-drying can be used to speed the drying process and ensure more consistent results.

Drying Processes

Drying processes fall into three following categories

1. Air and contact drying under atmospheric pressure. In air and contact drying, heat is transferred through the foodstuff either from heated air or from heated surfaces.
2. Vacuum occurs more readily at lower pressures than at higher ones.
3. Freeze drying. In freeze drying, the water vapour is sublimed off frozen food. The food structure is better maintained under these conditions. Suitable temperatures and pressures must be established in the dryer to ensure that sublimation occurs

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Drying Mechanism

Drying mechanism involves the Heat transfer and Mass transfer principles. Heat is transferred to the product to evaporate liquid, and mass is transferred as a vapor into the surrounding gas.

Rate of Drying: Drying operation may be done with constant rate and falling rate depends on its critical moisture content. In some products having relatively high initial moisture content, an initial linear reduction of the average product moisture content as a function of time may be observed for a limited time, often known as a "constant drying rate period". Usually, in this period, it is surface moisture outside individual particles that is being removed. The drying rate during this period is mostly dependent on the rate of heat transfer to the material being dried. Therefore, the maximum achievable drying rate is considered to be heat-transfer limited. If drying is continued, the slope of the curve, the drying rate, becomes less steep (falling rate period) and eventually tends to nearly horizontal at very long times. The product moisture content is then constant at the "equilibrium moisture content", where it is, in practice, in equilibrium with the dehydrating medium.

In the falling-rate period, water migration from the product interior to the surface is mostly by molecular diffusion, *i.e.* the water flux is proportional to the moisture content gradient. This means that water moves from zones with higher moisture content to zones with lower values, a phenomenon explained by the second law of thermodynamics. If water removal is considerable, the products usually undergo shrinkage and deformation, except in a well-designed freeze-drying process.

Types of Drying

1. **Sun drying**: Sunlight is a portion of the electromagnetic radiation given off by the Sun, in particular infrared, visible, and ultraviolet light.
2. **Tray drying:** The dryers are made of trays held in a cabinet which is connected to a source of air heated by gas, diesel or bio-mass such as rice husk.
3. **Tunnel drying:** The tunnel dryer is a modification of the tray dryer in which the oven is replaced by a tunnel which receives damp materials at one end and discharges the dried products at the other end.
4. **Roller or Drum Drying**: Drum drying is a method used for drying out liquids from raw materials with drying drum. In the drum-drying process, pureed raw ingredients are dried at relatively low temperatures over rotating, high-capacity drums that produce sheets of drum-dried product.
5. **Fluidized bed drying:** Fluidized bed drying is the optimal method for controlled, gentle and even drying of wet solids.
6. **Spray Drying:** Spray drying is a method of producing a dry powder from a liquid or slurry by rapidly drying with a hot gas.
7. **Pneumatic drying:** Pneumatic or flash dryers, one of the most common types of industrial drying units, are characterized by continuous convective heat and mass transfer processes.
8. **Rotary drying:** The Rotary Drying and Cooling equipment utilizes a hot gas stream or cold gas stream that mixes with the product. The product is mixed with the air stream by utilizing lifters that shower the product in the air stream.
9. **Tough dryer:** The materials to be dried are contained in a trough-shaped conveyor belt, made from mesh, and air is blown through the bed of material. The movement of the conveyor continually turns over the material, exposing fresh surfaces to the hot air.
10. **Belt drying:** Belt dryer is a continuous convective belt dryer. A well-ventilated layer of product is put on a wire mesh or perforated plate belt conveyor and conveyed continuously through drying chambers
11. **Vacuum drying:** vacuum the pressure is reduced around the substance to be dried and boiling point of water inside that product decreases and rate of evaporation of water increases significantly thus increasing drying rate. The pressure maintained in vacuum drying is generally 0.0296 –0.059 atm and the boiling point of water is 25-30°C. The vacuum drying is a batch operation and at reduced pressures the relative humidity is also lower and that is why the drying occurs faster.
12. **Freeze drying:** Freeze drying or lyophilisation is a drying method where the solvent is frozen prior to drying and is then sublimed, *i.e.*, passed to the gas phase directly from the solid phase, below the melting point of the solvent.

Conclusion: Drying technique used for reducing moisture content and concentrating the food products. The reducing in water content may leads to decrease the growth of microorganisms which prevents the food spoilage. Reduction in water content may also prevent the additional transport cost etc. the article can be concluded that the use of drying technique in food industry is essential method.

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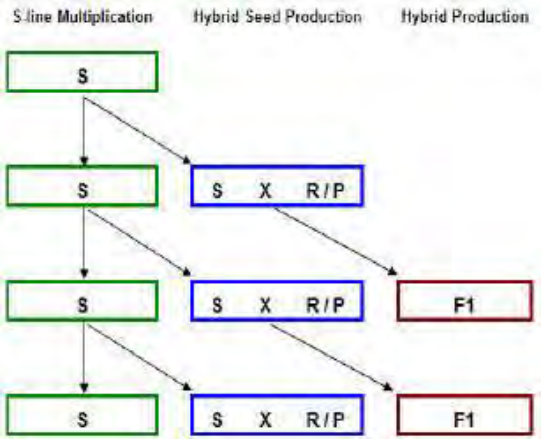
52. PLANT BREEDING AND GENETICS 15083

EGMS in Development of Hybrid Rice

Rani Soundarya G. S. Priya Patel H. G. and Swetha Sudhakaran V.

Mahatma Phule Krishi Vidyapeeth, Rahuri.

Environment sensitive Genetic Male Sterility is one where male sterility is governed by environment. This male sterility system is controlled by single or pair of recessive nuclear gene(s) which influenced by environmental factors like temperature, day length or both. It was first observed in pepper by Martin and Crawford in 1951. EGMS is mainly used to develop two line hybrid rice.



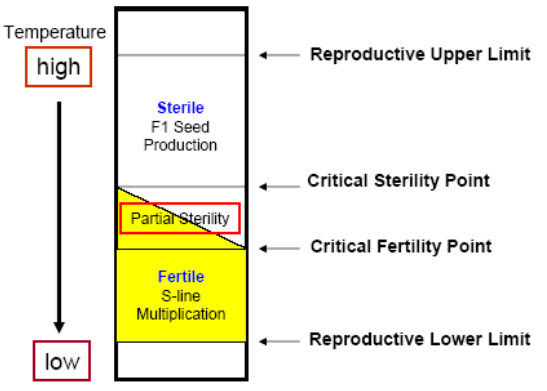
Two-line hybrid rice cultivation

Features of Ideal CGMS Lines

- The proportion of male sterile plants in a population should be 100% during critical period.
- Each male sterile plant should have 99.5% pollen sterility.
- The male sterility phase should lasts for >4 consecutive weeks.
- Critical temperature or photoperiod for inducing male sterility should be low as possible.

Classification of EGMS: There are five types of EGMS depending on the influence of environmental factor(s) on expression of male sterility inducing gene (s), They are

1. **TGMS:** Temperature sensitive genetic male sterility are sensitive to temperature for expression of male sterility or fertility. TGMS lines are remain male sterile at high temperature (>30°C day temp./>24°C night temp.) and fertile at low temperature (<24 °C day/>16°C night temp.). The stage at which rice sensitive to temperature lasts from formation of pollen mother cells to meiosis.



Model of Sterility / Fertility Expression for TGMS Rice

2. **rTGMS:** Reverse temperature sensitive GMS lines are sterile at low temperature and fertile at high temperature.
3. **PGMS:** Photo sensitive GMS lines are sterile under long day length (>13 hr 45 min) and fertile under short day length (<12 hr).
4. **rPGMS:** Reverse PGMS lines are sterile under short day length and fertile at long day length.
5. **PTGMS:** Photoperiod temperature sensitive GMS are sensitive to both temperature and photoperiod. These lines are sterile under long day length (>13 hr 45 min) and fertile under short day length (<12 hr) provided the temperature within critical range (24-32°C), the temperature above critical range leads to male sterility under any photoperiod. Sensitivity to photoperiod in rice lasts from differentiation of secondary rachis branches to formation of pollen mother cells.

Among the above categories of EGMS systems, TGMS and PTGMS are most commonly used to develop hybrid rice.

Advantages of EGMS

1. No need of maintainer line for seed multiplication.
2. Any fertile line can be used as pollen parent
3. Negative effects of sterility inducing cytoplasm are not encountered.

Disadvantages of EGMS

1. Fluctuation in environmental factors will influence the stability of EGMS lines.
2. multiplication of EGMS lines in hybrid seed production is restricted by space and season.

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53. PLANT BREEDING AND GENETICS 15091

A Synoptic View of G X E Interaction Models

Neha Sharma* and Ranjana Patial

Ph.D. Scholar, Department of Crop Improvement, CSK HPKV Palampur
**Corresponding Author Email: neha.sh914@gmail.com*

Introduction: For the description of the mean response of genotypes over environments and for studying and interpreting G×E in agricultural experiments, three classes of models are commonly used are linear models, bilinear models and linear-bilinear models. One class of linear models, namely factorial regression (FR) models, and one class of bilinear models, namely Partial Least Squares (PLS) regression, allow incorporation of external environmental and genotypic covariables directly into the model.

Linear Models (Additive Models)

The G×E is modeled directly using regression on environmental (and/or genotypic) variables. A useful linear model for incorporating external environmental (or genotypic) variables is the factorial regression (FR) model in which the combinations of the levels of the factors are represented in a design. The FR models approximate the G×E effects by the products of one or more of

- genotypic covariables (observed) × environmental potentialities (estimated),
- genotypic sensitivities (estimated) × environmental covariables (observed).

Bilinear Model

Regression on the Environmental Mean Model given (Yates and Cochram 1938): It represents data as a bundle of non-parallel lines. Yield for the several genotypes is regressed on the mean yield of all genotypes in a particular environment. Interaction here is simple heterozygosity of the regression slope. The main requirement of this model is that the deviations from regression should be comparably small or non-significant. The model allows the plant breeders to predict yield for environments not in the experiment, in the presence of interaction and did not require extra measurement on environmental variables. Concurrence model: Tested by Tukey's test for non-additivity, in case all the lines intersect in the same point, when the requirement is not fulfilled.

Multivariate Partial Least Squares (PLS) Regression Models (Aastveit and Martens1986): A linear modeling method for predicting the multivariate relationships. It gives simple linear approximation to relationships. It provides extraction of minor but relevant factors in the presence of strong background level of irrelevant factors and random noise. The drawback of these models is that they provide simple descriptions of the interaction between genotypes and environments by means of a one-dimensional representation of the environments to which genotypes are supposed to differ in sensitivity.

Linear-Bilinear Model

It is a generalized regression mean model with more flexibility for describing GEI because more than one genotypic and environmental dimensions are considered. More than one environmental variables can be taken at a time. A popular model of this type is the additive main effects and multiplicative interaction (AMMI) model.

Important Multiplicative Models

- Additive Main Effects and Multiplicative Interaction (AMMI) Model
- Shifted Multiplicative Model (SHMM)
- Genotype × Environment Interaction effects (GGE) Model
- General Linear-Bilinear Model (GLBM)
- Best Linear Unbiased Prediction (BLUP)

Additive Main Effects and Multiplicative Interaction (AMMI) Model

Shifted Multiplicative Model: When distinction between cross over interaction and non-cross over interactions is failed as cross over interactions results in rank change of genotypes over different environments then GEI complicate identification of superior genotype for range of environment Shifted multiplicative model is developed by Seyedsadr and cornelius (1992)

It is a tool to analyse the saparatibility of

- Genotypic effects from environment effects
- Environment effects from genotypic effects
- Complete seperability (cultivar effect is separable from environment effect)

Requirements: Condition for absence of significant genotypic rank change interaction

- SHMM adequate fitting of data
- Primary effect should have same signs of environments.
- Condition for absence of significant environment rank change interaction
- SHMM adequate fitting of data
- Primary effect of genotypes should have same signs.

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- Condition for absence of significant genotypic and environment rank change interaction
- SHMM adequate fitting of data
- Primary effect of genotype and environment should have same signs.

Importance of SHMM

- Categorization of locations with similar environments helps breeders to efficiently utilize resources and effectively target germplasm
- Useful tools to breeder in making decision on release of cultivar
- It helps in selection, testing and identifying superior genotypes
- Subsets of environments represent similar selection environments facilitate the exchange of germplasm.

General Linear-Bilinear Model (GLBM)

This model is given Cornelius and Seyedsadr, 1997. This mode includes linear bilinear model known as AMMI, Column Regression and SHMM as special case but later allows for inclusion of regression on covariates as additional linear terms and for estimation of missing cells. It is known as balanced if least squares estimates of its linear effects are free of the bilinear effects. If it is unbalanced then Newton-Raphson and generalized EM algorithms are developed. AMMI and GRE are two special cases of GLBM.

Genotype × Environment Interaction Effects (GGE) Model

The GGE model is sometimes called the Sites Regression (SREG) model. It was given by Crossa and Cornelius, 1997. The analysis of MET data for single trait includes three major aspects

I) Mega-environment analysis II) Test-environment evaluation III) Genotype evaluation

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Genetic Improvement of Pigeon Pea (*Cajanus cajan* L.) through Conventional and Modern Genetic Approaches

Sruba Saha

Ph.D. Scholar, Department of Genetics & Plant Breeding and Crop Physiology, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan-731236

**Corresponding Author Email: sruba.saha@gmail.com*

Pigeon pea (*Cajanus cajan* L.) is one of the most important food legumes in semi-arid tropics. In India, it is the second most important pulse crop after chick pea (Fig:1). Pigeon pea is a diploid species (2n=2x=22) and its genome comprises of 833.1 Mbp arranged into 11 pairs of chromosomes (Varshney *et al.*, 2012). It is a hardy and drought tolerant crop assuring sustainable returns from marginal lands with minimal inputs, hence it is considered as a very suitable crop for subsistence agriculture. Pigeon pea seeds contain about 20-24% protein and reasonable amounts of essential amino acids making it an important source of dietary protein, mainly in vegetarian-based diets (Bohra *et al.*, 2012). As a member of the sub tribe Cajaninae, pigeon pea is contained in an early diverging lineage of tribe Phaseoleae, a monophyletic group of legumes that contains several of the world's most important food legumes including soybean, common bean, cowpea and mung bean (Fig. 1). Although India is the world's largest producer of pigeon pea and the presumed centre of origin, the total production of pigeon pea is 2460 thousand tons in 2016, whereas in 2013-14 it was 3170 thousand tons (Fig. 2). The major causes of relatively low productivity of pigeon pea in India are attributed to non-availability of improved cultivars as well as high sensitivity to number of biotic and abiotic stresses throughout the growing regions. Narrow genetic diversity in cultivated germplasm has further hampered the effective utilization of conventional as well as modern breeding methods, resulting in earning the adjective as *'orphan crop legume'*. In pigeon pea, plant growth with flowering is highly influenced by the environment. Hence, breeding for wider adaptation is a major issue to be tackled. Moreover, various traits such as indeterminate growth habits, long duration, asynchronous maturity, spreading type plant appearance, susceptibility to Fusarium wilt, sterility mosaic, blight and pod borer, are the major constraints towards yield improvement. Although often cross pollinated, breeding in pigeon pea has been more challenging compared to other pulses, because of the absence of effective selection strategies and/or mating design. To address this challenge and finding a solution, short duration, semi dwarf and compact plant type, determinate growth habit with high yield potential lines should be developed to bridge the country's growing demand-supply gap in pulses. Conventionally, pure-line breeding,

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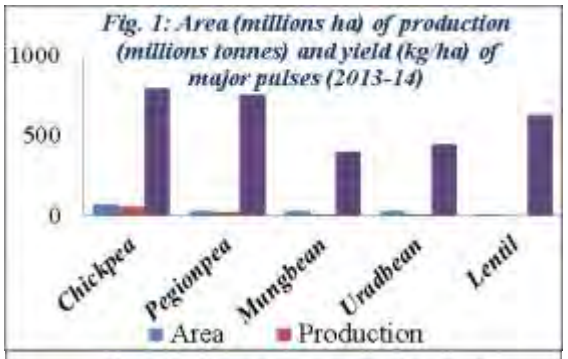
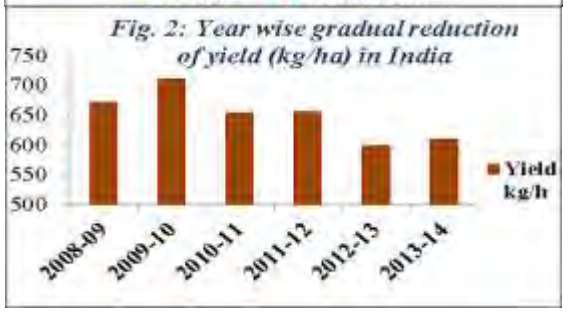
population breeding, mutation breeding, wide hybridization, genetic male sterility system have been widely used for development of new varieties including hybrids. However, in addition to conventional breeding and hybrid technology, pigeon pea improvement through molecular breeding should be accelerated to utilize the substantial variability present in the landraces and germplasm lines for further amelioration of its production and productivity. Marker assisted selection and transgenic developments should be taken into consideration to reach the target.

In this article we aimed: 1) to find the major causes related to current low productivity of pigeon pea; and 2) to identify future scopes of research in pigeon pea breeding.





Genetic Improvement through Conventional Breeding Method

Through Hybrid Technology: ICPH 2740--released under the name *Mannem Konda Kandi*–is the first pigeon pea hybrid for the state of Telangana. It was released from the Regional Agricultural Research Station (RARS). The hybrid possesses resistance to wilt and sterility mosaic diseases and is suitable for deep black soils of the state. With a yield potential of 3.5 tons per ha it registered a 40% yield increase over the local cultivars.

Current Status of Pigeon Pea Breeding Research through Molecular Approaches: *Helicoverpa armigera* is the most important yield constraint in pigeon pea for which there is no absolute resistance available in the cultivated germplasm expression of a chimeric cry1AcF (encoding cry1Ac and cry1F domains) gene in transgenic pigeon pea has been discovered by ICRISAT towards resistance to *H. armigera.* P5CSF129A gene in pigeon pea transgenic showed a higher proline accumulation and a lower lipid peroxidation than their non-transformed counterparts when subjected to 200 mM NaCl. This manifested in an enhanced growth, more chlorophyll and relative water content under high salinity, thereby suggesting that overproduction of proline could play an important role against salt shock and cellular integrity in pigeon pea.

Pusa-16, a Newly Released Pigeon Pea Variety: Pusa Arhar 16, a semi-dwarf, high-yielding pigeon pea variety created by scientists at the (IARI) has synchronous maturity, determinate growth habit and it can be harvested using combine harvesters.

We found that the major causes of relatively low productivity of pigeon pea in India are attributed to: 1) non-availability of improved cultivars, 2) narrow genetic diversity, and 3) high sensitivity to multiple biotic and abiotic stresses throughout the growing regions.

Future Research Directions: In absence of availability of traits/genes conferring resistance to biotic and abiotic constraints in the primary/cross-compatible gene pool, application of genetic engineering technology is a viable option to address complex problems in pigeon pea cultivation. Genetic transformation of pigeon pea can be seen as a logical extension of plant breeding research that has a considerable potential to benefit the global pigeon pea production systems.

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Pre-Breeding Concept: Its Important Applications in Crop Improvement

Ingle A. U.* and K.G. Kandarkar**

**PhD Scholar, (Genetics and plant breeding), PGI, MPKV, Rahuri.*
**Corresponding Author Email: anant.ingle100@gmail.com*

Introduction: Plant breeding is an art and science of genetically improving plants for the benefit of humankind. It is practiced worldwide by professional plant breeder centuries. The genetic diversity of crop plants is the foundation for the sustainable development of new varieties for present and future challenges which arises due to the various biotic and abiotic stress. Genetic diversity provides an option to crops / varieties through selection, hybridization and breeding, that are resistant to virulent pests and diseases and adapted to changing environmental conditions. Plant genetic resources for agriculture (PGRFA) are the biological cornerstone of global food security. They comprise diversity of genetic material contained in traditional varieties, modern cultivars, crop wild relatives and other wild species. The agricultural diversity and efficiently both to maintain current levels of food production and to confront future challenges (FAO, 2007).

WHAT IS PRE BREEDING? Pre-breeding refers to all activities designed to identify desi unadapted materials that cannot be used directly in breeding populations, and to transfer these traits to an intermediate set of materials that breeders can use further in producing new varieties for farmers. It is a necessary first step in the "linking genetic variability to utilization" use of diversity arising from wild relatives and other unimproved materials. These activities are a collaboration between the germplasm curator and the plant breeder who need to work germplasm collections and how new traits from these collections can be bred into new varieties.

WHY PRE-BREEDING IS REQUIRED? Progress in breeding is limited from perceived lack of diversity:

- Current limited genetic base of agriculture today is apparent a threat to food security.
- Reduction of Biodiversity: genetically uniform modern varieties are replacing the highly inverse local cultivars and landraces in traditional agro-ecosystems.
- Genetic uniformity: Increases genetic vulnerability for pests and diseases.
- The effects of climate change: search for new genes/traits for better adaptation.
- Evolving pest and pathogen populations: motivating plant breeders to look for new sources of resistance in genebanks.

The decision to do pre-breeding is based on the expected efficiency and efficacy of ultimately moving the target traits into cultivars for farmers and source of desired gene(s). Pre-breeding is necessary, if desired genes are available only in one of the following: (1) Genebank accessions those are not well-adapted to the target environment; (2) Closely related wild species that are easily crossed with the crop species and; (3) More distant wild species which are more difficult to cross.

Methods of using Plant Genetic Resources (PGR) in Crop Improvement

Classical approaches of using plant genetic resources in crop improvements (Cooper et al., 2001) are: (1) Introgression (2) Incorporation or broadening of genetic base and (3) Wide crosses: synthesis of new base populations.

The tools of genome research may finally unleash the genetic potential of our wild and cultivated germplasm resources for the benefit of the society (Tanksley and McCouch, 1997). The utility of molecular markers and genomic tools/techniques in the context of using PGR for crop improvement includes: (1) Diversity assessment (2) Somatic Hybridization (3) Anther culture (4) Embryo rescue (5)

Marker assisted breeding (6) Mapping of quantitative trait loci (QTL) (7) Introgression libraries, association studies and (8) Genetic transformation.

Major Applications of Pre-Breeding in Crop Improvement

There are major four applications of pre-breeding:

1. Broadening the genetic base, to reduce vulnerability
2. Identifying traits in exotic materials and moving those genes into material more readily accessed by breeders
3. Moving genes from wild species into breeding populations when this appears to be the most effective strategy and
4. Identification and transfer of novel genes from unrelated species using genetic transformation techniques.

The adoption of pre-breeding facilitates the

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efficiency and effectiveness of crop improvement programmes by enabling increased access to, and use of, genetic variations conserved in genebanks

Challenges

1. Lack of characterization and evaluation data;
2. Knowledge of the genetic diversity;
3. Inter species relationship and;
4. Strong breeding program and funding sources.

The use of genebank accessions in breeding programmes is limited by the high degree of difficulty and length of time often associated with separating the desirable genes from the undesirable ones.

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Significance of Chickpea as a Pulse Crop

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 Email: paneliyamehul.mp@gmail.com[1]*

INTRODUCTION: Among the food crops, pulses are an important group which occupies a unique position in the world of agriculture by virtue of their high protein content. India is one of the major pulses growing country of the world, accounting roughly for one third of total world area under pulse cultivation and one fourth of total world production. Over 60 per cent of pulses produced in India are grown during the *Rabi* season (Anonymous, 2017). They help maintain the soil health by way of fixing atmospheric nitrogen. They also form an ideal component of cropping patterns involving cereals by presenting a situation where the balance exploitation of minerals and nutrients from the soil profile is made possible. Pulses occupy a key position in Indian diet and meet about 30 per cent of the daily protein requirement. Popularly known as the poor man's meat, they are the important source of vegetable protein and help in fighting the malnutrition of predominantly vegetarian based Indian diet, particularly seen in the vast majority of poor masses. Among the pulses, chickpea is the most important *Rabi* crop with high acceptability and wider use.

History of Chickpea: Chickpea was domesticated in association with other crops of wheat, barley, rye, peas, lentil, flax and vetch (Abbo *et al.*, 2003), and with sheep, goats, pigs and cattle (Diamond, 1997), as part of the evolution of agriculture in the Fertile Crescent 12,000–10,000 years ago (Bar-Yosef, 1998). In this broad arc extending from western Iran through Iraq, Jordan and Israel to southeast Turkey, there developed a balanced package of domesticates meeting all of humanity's basic needs (Diamond, 1997). Desi chickpea was probably imported to Kenya by Indian immigrants during the later 19th century (Van der Maesen, 1972).

Classification and Origin of Chickpea: Chickpea (*Cicer arietinum* L.) belongs to genus *Cicer*, tribe *Cicereae*, family *Fabaceae* and sub family *Papilionaceae* of the family *Leguminoceae,* (Bentham and Hooker, 1972). The origin of the crop is considered to be Western Asia from where it spread in India and other parts of the world (Rathore and Sharma, 2003). Chickpea is also called garbanzo (Spanish), poischiche (French), kichar or chicher (German), chana (Hindi), and gram or Bengal gram (English). In Turkey, Romania, Bulgaria, Afghanistan, and adjacent parts of Russia, chickpea is called 'nakhut' or 'nohut' (Van der Maesen, 1987).

Importance of Chickpea: Chickpea is an excellent source of the essential nutrients, protein, minerals (calcium, potassium, phosphorus, magnesium, iron and zine), fiber, unsaturated fatty acids and ß-carotene. It contains 17.21% protein, 61.5% carbohydrates, 4.5% fat, 0.49% lysine, 0.11% methionine, 0.04% tryptophan. Thus, it holds a good promise as protein source for humans and as a component of feed for ruminants and non-ruminants (Jukanti *et al.*, 2012). Chickpeas are low in fat with mostly polyunsaturated fats. The nutrient profile of the smaller varieties appears to be different, especially in fiber content, which is higher than the larger light coloured varieties. In general, the cotyledons and embryo make up most of the nutritionally beneficial part of the seed, whilst the seed coat contains many of the anti-nutritional factors such as tripsin inhibitor. Desi types have a thicker seed coat than the Kabuli types, which is reflected in the greater fiber content of Desi types (Knights and Mailer, 1989). Owing to its high nutritional qualities, chickpea is considered as one of the most nutritious food grain legume for human consumption with potential health benefits. High fiber content in chickpea has the ability to lower the cholesterol level and prevent blood sugar levels from rising too rapidly after a meal, and

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thus, making it a healthy food for diabetic patients (Pittaway *et al*., 2006).

In India, the area under chickpea was 8.25 million hectares with a production of 7.33 Million tonnes and productivity of 889 kg/ha during *Rabi* 2014-15. In Gujarat, area under chickpea was 1.61 million hectares with a total production of 1.99 million tonnes and productivity of 1236 kg/ha during 2014-15. Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Karnataka are the major growing states (Dixit, 2016). However, India being largest producer of chickpea is unable to meet the demands of its own.

Traditionally, chickpea is one of the most favoured of all pulses in Indian society. It is consumed in north, west, east and south of India, in tribal areas, villages and cities – everywhere chickpea has found a place in the daily diet. During cropping season green leaves are used as a vegetable, fully developed green pods are used in vegetable dishes, rice and pulav, and some are roasted with salt. After harvesting and threshing, dried seeds are used for the preparation of dhal, which has an attractive yellow colour, and is used in various preparations. From dhal, a yellow flour known as besan is prepared, and both dhal and flour are used in various preparations. Chickpea dhal blends well with vegetables, meat and sauces, and can be used to make a main course and snack items. Considering its wide uses in every home as well as on a commercial scale, its acceptability in Indian society is universal.

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Self-Incompatibility

Patel Prakash Kumar Kanjibhai and Patel Umang Mahendrabhai

(Msc) agri (Department of Genetics and Plant breeding), N.M. College of Agriculture, Navsari Agricultural University, Navsari.

INTRODUCTION: It is the failure of pollen from a flower to fertilize the same flower or other flowers of the same plant. **OR** The inability of a plant with functional pollen to set seeds when self-pollinated. The term self-incompatibility was originally coined by Stout in 1917. Koelreuter, in the middle of 18th century, first reported self-incompatibility in *Verbascum phoeniceum* plants.

Main Features of Self-Incompatibility

(1) When a plant does not set seed when self-pollinated with its own functional pollen, but form normal seed setting when cross-pollinated, it indicate the presence of self-incompatibility.(2) Self-incompatibility is an important out-breeding mechanism, which prevents self-pollination and promotes cross pollination. (3) Self-incompatible species do not produce seed on self-pollination but lead to normal seed set on cross-pollination.(4) It maintains high degree of heterozygosity in a species due to out-breeding and reduces homozygosity due to elimination of inbreeding or selfing.(5) Self-incompatibility results due to morphological, genetic, physiological and biochemical causes.

Physiological Barriers of Self-

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Incompatibility: (1) Failure of the pollen to germinate on the stigma.(2) If some pollen grains do germinate, pollen tube fails to enter the stigma *e.g.* Rye, Radish, Cabbage etc. (3) If the pollen tube enters the style but they grow too slowly to effect fertilization before the flower drops.(4) Sometimes fertilization is effected but the embryo degenerate at very early stage *e.g.* Sugarbeet.(5) Self-incompatibility appears to be biochemical reaction but the precise nature of this reaction is not clearly understood. (6) The genetic control of incompatibility reaction is relatively simple and governed by multiple alleles of single gene.

Importance of Self-Incompatibility: (1) Self-incompatibility may be used in hybrid seed production.(2) For that, two self-incompatible but cross-compatible lines are to be inter planted and seeds obtain from both the lines would be hybrid seed.(3) One self-incompatible but cross-compatible and one self-compatible line is to be inter planted and seeds obtain from self-incompatible lines would be hybrid seed.(4) There is a limited use of self-incompatibility due to problems associated with the maintenance of inbred lines through hand pollination as it is tedious and costly.

Types of Self-Incompatibility: (1) Heteromorphic system: This system is characterized by difference in the morphology of flowers. *e.g. Primula*. There are two types of flowers: (1) *Pin* and (2) *Thrum.* Pin flowers have long style and short stamens, while thrum flowers have long stamens and short style. This is characteristic is governed by a single gene, '**S/s'**. Allele **'S'** is dominant over 's'. Ss produces Thrum and 'ss' produces Pin flowers. The incompatibility reaction of pollen is determined by the genotype of plant producing them. Therefore, this system is called heteromorphic sporophytic system. Pin flower produces genotypically and phenotypically same pollen grain and all would be **'s'** type. Thrum flower produces genotypically **'S'** and **'s;** type of pollen grains but all of them would be phenotypically **'S'** type. The different pollen size restrict the possibilities of thrum x thrum and pin x pin crosses. However, pin x pin crosses can occur, but at low frequency and thrum x thrum crosses is mechanically impossible It is also occurs in sweet potato and buckwheat.

Results of Four Types of Crosses in Primula

Crosses between	Genotypes	Results
Pin *x* Pin	ss x ss	Incompatible
Thrum x Thrum	Ss x Ss	Incompatible
Thrum x Pin	Ss x ss	1 Thrum 1 Pin
Pin x Thrum	ss x Ss	1 Thrum: 1 Pin

(2) Homomorphic system: Incompatibility reaction is not associated with the morphological differences of flower. It is two types – Sporophytic and Gametophytic

(A) Sporophytic: Incompatibility reaction of pollen may be controlled by the genotypes of the plant on which it is produce. Example – Radish, diploid brassica crops.

(B) Gametophytic: Incompatibility reaction of pollen may be controlled by its own genotypes. Example – Pineapple, Ryegrass, diploid coffee, diploid clovers.

Mechanisms of Self-Incompatibility

- Pollen and stigma interaction,
- Pollen tube and style interaction,
- Pollen tube and ovule interaction.

Hybrid Seed Production Problems Associated with SI System

1. Productions and maintenance of parental lines by hand pollination is tedious and costly.
2. Raises the cost of hybrid seed.
3. Continuous selfing/inbreeding also responsible for depression of self incompatibility.
4. Extreme environmental factors overcome the effect of SI & which is responsible for high proportion of self seed (> 30 %).
5. Bees are often like to remain stay within parental lines when they are morphologically different, which also increase the proportion of self seed.
6. Transfer of S – allele from one variety to another variety is tedious & complicated.

Overcoming Self-Incompatibility

- Bud pollination
- Surgical technique
- End of season pollination
- High temperature
- Irradiation
- Grafting
- Double pollination
- Other techniques
  - Treatment of flower with carbon monoxide
  - Application of electrical potential differences
  - Phytohormone treatment
  - Treatment of some protein synthesis inhibitors
  - Steel brush pollination

Elimination of Self-Incompatibility

1. In case of single locus gametophytic system incompatibility eliminated by doubling the chromosomes numbers. *e.g.* potato
2. Isolation of self-fertile (Sf) mutation.
3. Self-compatibility alleles may be transferred from related species or from self-compatible varieties of the same species, if available

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through a back cross programme.

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Protoplast Fusion

Mamata Behera[1] and SP Monalisa[2]

[1]Ph.D. Research Scholar Department of Plant Breeding and Genetics, OUAT, Bhubaneswar
[2]Ph.D. Research Scholar Department of Seed Science and Technology, OUAT, Bhubaneswar
**Corresponding Author Email: mamatabehera7205@gmail.com*

INTRODUCTION: The protoplast includes the plasmalemma and everything contained within i.e., the entire cell without its inherent cellulosic cell wall. In protoplast technology, two genetically different protoplast isolated from the somatic cells and are experimentally fused to obtain parasexual hybrid protoplasts. The hybrid protoplast contained heteroplasoic cytoplasm and two fused parent nuclei. Protoplast fusion may be used to produce interspecific or even intergeneric hybrids. Protoplast fusion becomes an important tool of gene manipulation because it breakdown the barriers to genetic exchange imposed by conventional mating systems. Protoplast fusion technique has a great potential for genetic analysis and for strain improvement. It is particularly useful for industrially useful microorganisms.

Enzymes used for breaking of cell walls: For protoplast fusion it is important that the cell wall of plant and microorganisms is degraded. So various enzymes used for this process. Cellulase and pectinase or macerozyme acting on plant cell wall. Bacterial cell wall are degraded by the action of lysozyme. Fungal wall degraded by Novozyme -234 which includes glucanase and chitinase. Streptomyces cell wall degraded by action of lysozyme and achromopeptidase.

Methods of Protoplast Fusion

Protoplast fusion can be broadly classified into two categories:

Spontaneous fusion: Protoplast during isolation often fuse spontaneously and this phenomenon is called spontaneous fusion. During the enzyme treatment, protoplast from adjoining cells fuse through their plasmodesmata to form multinucleate protoplasts.

Induced fusion: Fusion of freely isolated protoplasts from different sources with the help of fusion inducing chemicals agent s is known as induced fusion. Normally isolated protoplast do not fuse with each other because the surface of isolated protoplast carries negative charges (-10mV to -30mV) around the outside of the plasma membrane. And thus there is a strong tendency in the protoplast to repel each other due to their same charges. So this type of fusion needs a fusion inducing chemicals which actually reduce the electronegativity of the isolated protoplast and allow them to fuse with each other's. The isolated protoplast can be induced to fuse by three ways;

Mechanical fusion: In this process the isolated protoplast are brought into intimate physical contact mechanically under microscope using micromanipulator or perfusion micropipette.

Chemofusion: Several chemicals has been used to induce protoplast fusion such as sodium nitrate, polyethylene glycol, Calcium ions (Ca^{++}). Chemical fusogens cause the isolated protoplast to adhere each other and leads to tight agglutination followed by fusion of protoplast. Observed successful fusion suggest that endoglucanase is the key enzyme in the success of fusion. Chemofusion is a nonspecific, inexpensive, can cause massive fusion product, can be cytotoxic and non-selective and having less fusion frequency.

Electrofusion: Recently, mild electric stimulation is being used to fuse protoplast. In this two glass capillary microelectrode are placed in contact with the protoplast. An electric field of low strength (10Kvm-1) gives rise to dielectrophoretic dipole generation within the protoplast suspension. This leads to pearl chain arrangement of protoplasts. Subsequent application of high strength of electric fields (100 kvm-1) for some microseconds results in electric breakdown of membrane and subsequent fusion. Groth DI (1987) et al carried out electofusion of Penicillium protoplasts, after diaelectrophoresis and found viable fusion products. Dimitrov AP and Christov AM (1992) reported electrically induced protoplast fusion using pulse electric field for diaelectrophoresis and suggest the possibility of electrically induced protoplast fusion at cation concentration that prevents fusion when sine – wave fields are applied. Gaint protoplast of Pleurotus cornucopiae were fused using the glass microelectrode fusion technique. To induce fusion Ca ++ was necessary. Polyethylene glycol 400 (PEG) promoted fusion but also increased the adhesion of protoplasts. Electrofusion is easy to control having fusion frequency upto 100% gives reproducibility. Less cytotoxic. But equipment is sophisticated and expensive.

Mechanism of protoplast fusion: The

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mechanism of protoplast fusion is not fully known. Several explanations have been put forward to understand the mechanism of protoplast fusion. Some are explained here:

When the protoplasts are brought into close proximity, this is followed an induction phase thereby changes induced in electrostatic potential of the membrane results in fusion. After the fusion. The membranes stabilizes and the surface potential returns to their former state. Other literature showed when the protoplasts are closely adhered, the external fusogens cause disturbance in the intramembranous proteins and glycoproteines. This increases membrane fluidity and creates a region where lipid molecule intermix, allowing coalescence of adjacent membranes. The negative charge carried by protoplast is mainly due to intramembranous phosphate groups. The addition of Ca ++ ions causes reduction in the zeta potential of plasma membrane and under this situation protoplasts are fused. The high molecular weight polymer (1000-6000) of PEG acts as a molecular bridges connecting the protoplasts. Calcium ions linked the negatively charged PEG and membrane surface. On elution of the PEG, the surface potential are disturbed, leading to intra membrane contact and subsequent fusion, Besides this, the strong affinity of PEG for water may cause local dehydration of the membrane and increase fluidity, thus inducing fusion. Protoplast fusion takes place when the molecular distance between the protoplasts is 10A or less. This indicates that protoplast fusion is highly a traumatic events.

Limitations of Somatic Hybridization

There are certain limitations to the use of these types of somatic hybridization since plants regenerated from some of the combinations are not always fertile and do not produce viable seeds. Following are the few problem faced in somatic hybridization:

1. Somatic, hybridization does not always produce plants that give fertile and viable seeds.
2. The lack of an efficient selection method for fused product is sometimes a major problem.
3. Somatic hybridization between two diploids results in the formation of an amphidiploid which is not favourable. For this reason, hybridization of two haploid protoplasts is recommended in somatic hybridization.
4. It is never certain that a particular characteristic will be expressed after somatic hybridization.
5. Production of somatic hybrid plants has been limited to a few species.
6. Intergeneric crosses between widely related plants which are not compatible sexually are not possible.
7. For hybrid identification, selection and isolation at the culture level, there is no standardized method which is applicable for all material.
8. Techniques for protoplast isolation, culture and fusion are not available for many important crop species like many cereals and pulses.

Advantages of Somatic Hybridization

1. Symmetric hybrids can be produced between species, which cannot be hybridized sexually. These hybrids can be readily used in breeding programmes for transfer of useful genes to crops or may be useful as new crop species.
2. Hybrids can be produced even between such strains, which are completely sterile, *e.g.*, monoploids.
3. Cytoplasm transfers can be affected in one year, while backcrossing may take 5-6 years. Even where backcrossing is not applicable, cytoplasm transfers can be made using this approach.
4. Mitochondria of one species can be combined with chloroplasts of another species. This may be very important in some cases, and is not achievable by sexual means even between easily crossable species.
5. Recombinant organelle genomes, especially of mitochondria, are generated in somatic hybrids and hybrids. Some of these recombinant genomes may possess useful features.

59. PLANT BREEDING AND GENETICS 15305

Transcriptome Analysis in Plants

Namrata Dhirhi

Department of Genetics and Plant Breeding, I.G.K.V., Raipur (C.G.)

INTRODUCTION: The complete set of messenger RNA (mRNA) and noncoding RNA (ncRNA) transcripts produced by a particular cell, cell type, or organism are known as transcriptome. And the collection and analyzing genes that are expressed (transcript) usually in different backgrounds (diseased vs. normal).

Need for Transcriptome Analysis

- Assumption that more abundant

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genes/transcripts are more important.
- Assumption that gene expression levels correspond to protein levels.
- Assumption that a normal cell has a standard expression profile/signature.
- Changes to that expression profile indicate something is happening.

Why Measure Gene Expression

- Gene expression profiles represent a snapshot of cellular metabolism or activity at the molecular scale.
- Gene expression profiles represent the cumulative interactions of many hard to detect events or phenomena.
- Next step after genome sequencing is transcriptome analysis.

Techniques involved in Transcriptome Analysis

- Northern blotting
- Serial Analysis of Gene Expression (SAGE)
- RT Real Time-PCR
- DNA Microarrays or Gene Chips

Northern Blotting

- The northern blot technique was developed in 1977 by James Alwine, David Kemp, and George Stark at Stanford University.
- Technique for detecting specific RNA fragments in agarose gel of electrophoresis complementary to a given DNA or RNA, by hybridization to a labeled DNA probe.
- It differs from southern blotting that RNA is analyzed instead of DNA in DBM (diazobenzyloxymethyl paper).

SAGE

- SAGE invented at Johns Hopkins University in USA (Oncology Center) by Dr. Victor Velculescu in 1995.
- Serial analysis of gene expression (SAGE) is a powerful tool that allows digital analysis of overall gene expression patterns.
- It is series of 3 cDNA SAGE tags concatemerised in long chain.
- First sequencing based method.
- It was developed to identify difference in steady state mRNA levels between two RNA samples. (Diseased vs. normal).
- It is widely used in human cells than in plants.

Principles Underlie the SAGE Methodology

- A short sequence tag (10-14bp) contains sufficient information to uniquely identify a transcript provided that the tag is obtained from a unique position within each transcript
- Sequence tags can be linked together to from long serial molecules that can be cloned and sequenced
- Quantitation of the number of times a particular tag is observed provides the expression level of the corresponding transcript.

DNA Microarray

- **DNA microarray (chip), allows scientists to** efficiently measure the expression of thousands of genes at the same time by looking at the amount of RNA that is transcribed from those genes.
- A DNA microarray is a plastic chip or glass slide that has been "printed" (spotted at precise locations) with thousands of short single-stranded pieces of DNA for known genes.

Principle of Microarray

- Hybridization of unknown sample to immobilised DNA on microarray of known sequences, so fluorescently labeled target sequences that bind to a probe sequence generate a signal that depends on the strength of the hybridization determined by the number of paired bases.
- Total strength of the signal, from a spot (feature), depends upon the amount of target sample binding to the probes present on that spot.

RT-PCR

Semi Quantitative RT- PCR

Initially cDNA synthesized, and then this is amplified with gene specific primers. PCR product is resolved on 1% agarose gel and compared the intensities in controlled and treated samples. It does not indicate the exact quantity of amplified product. It just gives approximate idea about the products.

Quantitative RT PCR (Real Time)

- cDNA synthesized is normalized with a actin.
- Quantification of expression of selected genes is done by performing real time quantitative PCR on Mx3000 QPCR system using gene specific primer.
- Real -Time PCR is a method to quantify expression of mRNA and cDNA in real time.
- A *quantitative PCR* method measures the buildup of fluorescence with each PCR cycle.
- Generates quantitative fluorescence data at earliest phases of PCR cycle when replication fidelity is highest.

Advantages

- Measurement of relative level of number of transcripts at a time.
- Involves series of DNA elements arranged as grid on small solid chips, so reduces time.
- *SAGE* is used to study transcriptome at different stages.
- Recently SAGE is used to characterize genes associated with developmental arrest and

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longevity in *C. elegans*.

Disadvantages

- DNA array is "closed systems"-only the sequences represented on microarrays are measured.
- Unable to detect novel transcripts in micro array.
- No ability to study the coding sequences of detected transcripts in SAGE.
- Accurate sequencing essential
- It involves cloning
- Produce short sequence tags which are different to resolve with similar coding sequences

Conclusion

- Transcriptome analysis is rapidly becoming an essential tool for identifying and analyzing genes involved in, or controlling, various biological processes ranging from development to responses to environmental cues.
- Expression profiling provides new information about what genes do under various conditions.
- Research in the field has progressed from candidate gene-based detection of RNAs using Northern blotting to high throughput expression profiling driven by the advent of microarrays.

60. PLANT BREEDING AND GENETICS 15334

Biofortification

Hemant Sahu

Department of Genetics and Plant Breeding, IGKV, Raipur (C.G.)-492012
**Corresponding Author Email: hemant.sahupant@gmail.com*

Biofortification is the idea of breeding crops to increase their nutritional value. This can be done either through conventional selective breeding, or through genetic engineering. Biofortification 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. As such, biofortification is seen as an upcoming strategy for dealing with deficiencies of micronutrients in the developing world. In the case of iron, WHO estimated that biofortification could help curing the 2 billion people suffering from iron deficiency-induced anemia.

Methodology

Plants are bred using one of two main methods:

(i). Selective breeding: Using this method, plant breeders search seed or germplasm banks for existing varieties of crops which are naturally high in nutrients. They then crossbreed these high-nutrient varieties with high-yielding varieties of crops, to provide a seed with high yields and increased nutritional value.

This method is prevalent at present, as it is quicker, cheaper, and less controversial than genetically engineering crops.

(ii). Genetic modification: Golden Rice is an example of a GM crop developed for its nutritional value. The latest version of Golden Rice contains genes from a common soil bacterium Erwinia and maize, and contains increased levels of beta-carotene which can be converted by the body into vitamin A. Golden Rice is being developed as a potential new way to address vitamin A deficiency.

Types of food fortification

Conventional fortification	Home fortification	Bio-fortification
Staple foods (flour, sugar, milk, oil, rice)	Crushable/soluble tablets	Agricultural products (rice, maize, sweet potato,…)
Dairy (milk, yoghurt)	Powder	
Spreads (margarine)	Spreads	
Condiments (salt)		

Comparative Advantages of Biofortification

- **Reaching the Malnourished in Rural Areas.** The biofortification strategy seeks to put the micronutrient-dense trait in the most profitable, highest-yielding varieties targeted to farmers and reaching consumers in both rural and urban areas. The direction of the flow, as it were, is from rural to urban in contrast to complementary interventions that begin in urban centers.
- **Cost-Effectiveness and Low Cost.** Biofortified staple foods cannot deliver as high a level of minerals and vitamins per day as supplements or industrially fortified foods, but they can help to bring millions over the threshold from malnourishment to micronutrient sufficiency.
- ***Sustainability of Biofortification.*** The nutritionally improved varieties will continue to be grown and consumed year after year. To be sure, recurrent expenditures are required for monitoring and maintaining

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these traits in crops, but these recurrent costs are low compared with the cost of the initial development of the nutritionally improved crops.

Breeding and Release Progress

Conventional breeding research has thoroughly demonstrated that micronutrient density can be increased in food staples without negative effects on other farmer-preferred traits. Progress in breeding orange sweet potato, pro-vitamin A maize, pro-vitamin A cassava, high zinc rice and high zinc wheat, and high iron beans and high iron pearl millet is reviewed below.

Orange-Fleshed Sweetpotato: Mozambique and Uganda released high-provitamin A varieties in 2002 and 2007, respectively. Biofortified varieties are now being introduced in many parts of Africa and South America, as well as China. These sweetpotato varieties contain high levels of all-*trans*-β-carotene, and therefore reaching 100 μg β-carotene equivalents/g

Maize: Pro-vitamin A maize breeding is led by the International Maize and Wheat Improvement Center (CIMMYT) and International Institute of Tropical Agriculture (IITA) in conjunction with NARES in southern Africa. Germplasm screening discovered genetic variation for the target level (15 ppm) of provitamin A carotenoids in temperate maize, which was then bred into tropical varieties.

Cassava: Biofortified cassava is being developed for Nigeria and the DRC. The initial breeding target was set at 15 ppm pro-vitamin A.

Rice: In many Asian countries, rice provides up to 80 percent of the energy intake of the poor. High zinc rice varieties for Bangladesh and India are developed by the International Rice Research Institute (IRRI) and the Bangladesh Rice Research Institute (BRRI). Golden Rice is the result of transgenic approaches to enhance provitamin A concentrations in the rice grain. Golden Rice β-carotene concentration has reached 37 μg/g dry weight (Paine 2005).

Wheat: The development of high-zinc wheat for India and Pakistan is led by CIMMYT. The initial breeding target for whole wheat was set at 33 ppm zinc, an increment of 8 ppm above the baseline zinc concentration.

Transgenic Projects

several transgenic crops have been developed which includes golden and high-iron rice; cassava with increased levels of provitamin A and iron, bananas biofortified with provitamin A; and sorghum with elevated levels of provitamin A, reduced phytate, and an improved protein profile. Golden rice, expected to be one of the first released transgenic biofortified crops.

TABLE 1. Schedule of Product Release.

Crop	Nutrient	Countries of first release	Agronomic trait	Release year[a]
Sweetpotato	Pro-vitamin A	Uganda, Mozambique	Disease resistance, Drought tolerance, acid soil tolerance	2007
Bean	Iron, Zinc	Rwanda, DR Congo	Virus resistance, Heat and drought tolerance	2010
Pearl millet	Iron, Zinc	India	Mildew resistance, Drought	2011
Cassava	Pro-vitamin A	Nigeria, DR Congo	Disease resistance	2011-12
Maize	Pro-vitamin A	Zambia	Disease resistance, Drought tolerance	2011-12
Rice	Zinc, Iron	Bangladesh, India	Disease and pest resistance, cold and submergence tolerance	2012-13
Wheat	Zinc, Iron	India, Pakistan	Disease resistance, Lodging	2012-13

[a] Approved for release by National Governments after Intensive multi-location testing for agronomic and micronutrient performance.

Significance of Biofortification

Deficiencies of various micronutrients, including vitamin A, zinc, and iron are common in the developing world and affect billions of people. These can lead to, amongst other symptoms, a higher incidence of blindness, a weaker immune system, stunted growth and impaired cognitive development. The poor, particularly the rural poor, tend to subsist on a diet of staple crops such as rice, wheat and maize, which are low in these micronutrients, and most cannot afford or efficiently cultivate enough fruits, vegetables or meat products that are necessary to obtain healthy levels of these nutrients. As such, increasing the micronutrient levels in staple crops can help prevent and reduce the micronutrient deficiencies – in one trial in Mozambique, eating sweet potatoes biofortified with beta-carotene reduced the incidence of vitamin A deficiency in children by 24%.

This approach may have advantages over other health interventions such as providing foods fortified after processing, or providing supplements. Although these approaches have proven successful when dealing with the urban poor, they tend to require access to effective markets and healthcare systems which often just do not exist in rural areas. Biofortification is also

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fairly cost effective after an initial large research investment – where seeds can be distributed, the "implementation costs [of growing biofortified foods] are nil or negligible", as opposed to supplementation which is comparatively expensive and requires continued financing over time, which may be jeopardized by fluctuating political interest.

61. PLANT BREEDING AND GENETICS 15350

Role of DNA Methylation in Crop Improvement

Dr. A. V. S. Durga Prasad

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

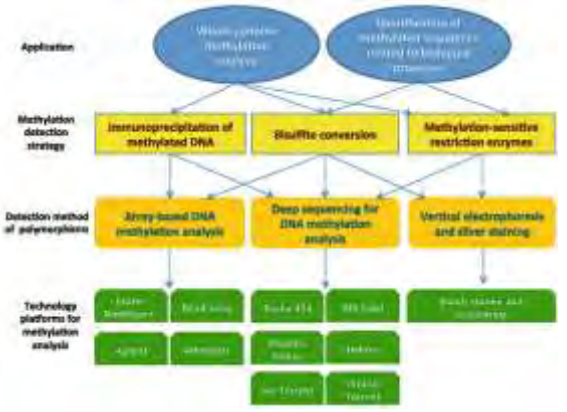
INTRODUCTION: DNA methylation is a heritable epigenetic enzymatic modification resulting from the addition of a methyl group in the cyclic carbon-5 of cytosine. DNA methylation can increase the functional complexity of prokaryotic and eukaryotic genomes by providing additional avenues for the control of cellular processes. Levels of methylation vary greatly between organisms: 0–3% in insects, 2–7% in vertebrates, 10% in fish, more than 30% in some plants. The four main roles of methylation: (i) to provide a heritable epigenetic mark directing the developmental program of organisms (ii) to provide defense against the activity of parasitic mobile elements (iii) to reduce background transcriptional noise in organisms that have a large number of genes and (iv) to "memorize" patterns of gene activity by stabilizing gene silencing brought about by other mechanisms. In plants, epimutations (due to DNA methylation) have important phenotypic consequences, since they can be inherited through the transmission of epigenetic alleles (epialleles) over many generations. These heritable epigenetic alleles can be considered as a source of polymorphism, which may produce novel phenotypes and could be a source of variation for selection. For example, epialleles can originate as a genome response to stressful environments to enable plants to tolerate stresses.

Methods for DNA methylation analysis

DNA immunoprecipitation methods, bisulfite-converted DNA, and DNA restriction generated by methylation-specific restriction enzymes can be used for advanced array-based and high-throughput deep sequencing–based genome-wide DNA methylation analyses, and for the identification of genes activated or inactivated due to methylation or demethylation, induced by biological processes.

Applications of DNA methylation in crop Improvement

- DNA methylation was shown to be relevant for several important traits and phenomena related to plant breeding, and are receiving attention to complement classical genetics.
- DNA methylation affects important parameters of conventional plant breeding programs including creation of favorable genetic variation that will form the basis for subsequent selection schemes, selection of superior genotypes through their phenotypes, single plant heritability, hybrid vigor, plant-environment interactions, stress tolerance and preservation and stability or even further improvement of pure line cultivars.



- DNA methylation was also shown to be important for transgenic technology because of the interference with the phenotypic stability in new transgenic cultivars. Until recently, the general assumption was that heritable variation involves only changes in DNA sequences. However, epigenetic information is meanwhile an accepted and important source of variation.
- Biomarkers based on DNA methylation are complementary to classical markers. In fact, they represent different DNA variation, which can be used to develop better varieties and to better understand mechanisms underlying plant development, diseases resistance, and plant reproduction and evolution.

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62. PLANT BREEDING AND GENETICS 15391

Poor Man's Crop and Rich Man's Saviour: Barley

Kuduka Madhukar*, Banoth Vinesh and Dilruba A Bano

Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, BHU, Varanasi
**Corresponding Author Email: kuduka_madhukar@yahoo.com*

Barley, often referred as a poor man's crop for its important role in fulfillment of dietary needs of poor who cannot afford other costly cereals and due to its hardy nature to survive under adverse environmental conditions with minimal input requirement which goes easy on poor man's pocket. As barley is a poor man's crop and is being mostly cultivated in marginal lands and environments where other grain crops can't grow – from arctic latitudes and alpine altitudes to saline desert oases. Barley has been documented as a high-energy food since the Roman times, when the gladiators were called "hordeari" (from *Hordeum*) because they were fed a barley diet before going to the Circus.

Keeping aside the assumption of barley being poor man's crop, in the recent past, barley is more of a rich man's crop for its major role in serving the rich man's luxury. Barley is produced majorly for malt purpose which is the main ingredient in manufacturing whiskey and beverages like beer. It is also used for manufacturing of liquors in western countries. Due unhealthy food habits, work style and routines, rich people have high health risks. Therefore, including barley in one or the other way in their diet to counter those negative impacts on the health can be proved beneficial in the long run.

Certain barleys are remarkably high in protein – some Ethiopian landraces are up to 18% protein. Barley contains about 75% carbohydrate, 9% protein and 2% fat. In energy terms, each gram provides about 3.3 calories. It is also rich in zinc (up to 50 ppm), iron (up to 60 ppm) and soluble fibers, and has a higher content of Vitamins A and E than other major cereals.

Although barley has been known as poor man's crop and grown mostly on marginal and underutilized lands with little to no inputs, it still enjoys the status of world's fourth largest cereal only after maize, wheat and rice with a share of 7 per cent of the global cereal production.

Barley is annual, erect medicinal herb. Its whole plant is used in Ayurvedic system of medicine for treatment of diseases. It is known as *Yavah* in Sanskrit. Its grains are also eaten as cereal. The grains of barley plant are cooked as whole grain or ground and used as flour. It is used to make *dalia* or porridge. Since the gluten content of barley is low, so it cannot be used to make bread. But it can be mixed with wheat flour to make mix *atta*. Barley seeds can also be enjoyed as sprouts.

In Ayurveda, Barley is used for treatment of various diseases. It is also useful in treatment of urinary calculi or stones of urinary tract. A clinical study done on rats has supported antiurolithiatic and antioxidant activity of barley seeds. Barley prevents calcium oxalate urolithiasis. It works by increasing urine output and thus decreasing concentration of electrolytes. This causes removal of calcium and phosphorus through urine. The result is decreased formation and the growth of urinary stone.

Scientifically proven properties of Barley

- **Diuretic activity:** Diuretics are those agent which cause increased urine production. Increased urination helps body to get rid of excess accumulated toxins through fluids. This in turn helps body in fighting many diseases. Barley acts as a mild diuretic and helps you urinate frequently, thereby flushing out toxins. Lemon barley water consumption has been effective for flushing out kidney stones.
- **Antiurolithiatic activity:** Urolithiasis is formation of one or more calculi in any location within the urinary tract; it is one of those oldest diseases known to mankind. Cause is multifactorial and is related to dietary life style habits or practices. Barley is one such medicinal herb that has property to prevent stone formation in body.
- **Antioxidant activity:** The literal meaning of antioxidant is 'one that prevent or delay deterioration by oxygen'. In any living organism, antioxidants protects cells and tissues from free radical damage. Free radical are damaged cells of body that attack other healthy cells, in turn, affects whole body and can be reason of various diseases. Barley contains a flavonoid *i.e.*, saponarin which on hydrolysis gives equilibrium mixture of saponarin and vitexin, which is responsible for its antioxidant effect.

Few home remedies using barley to cure/prevent various diseases

- Low haemoglobin and diabetics: Barley is rich in phosphoric acid and iron. Iron being the central component of haemoglobin aids in the production of blood. Experiments on

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rats by feeding barley bran significantly improved the serum lipid profile parameters. It decreased the total cholesterol, triglycerides, low density lipoproteins, and very low density lipoproteins and increased the useful cholesterol (high density lipoproteins)

- Improving memory and cognition: Regular intake of helps to improve brain power. Glucose regulation was associated with cognitive performance with normal glucose tolerance. Dietary carbohydrates of barley proved to enhance cognition in individuals with poor memories
- Constipation and bowel movement: Studies demonstrated that barley intake has beneficial effects on lipid metabolism and bowel function and suggests that the intake of a high-fiber food, *i.e.*, barley, should be recommended to prevent chronic diseases.
- Urinary problems and burning sensation: Take 10 gram barley seeds, 5 grams sesame, and 3 grams of *methi* / fenugreek seeds. Grind coarsely. Take 500 ml water in earthen pot and soak the coarse powder at night. Next morning mash it and strain. Drink the filtrate on empty stomach every morning.

Barley *Sattu*

It is an excellent blend of all natural, pure & special herbs selected for their unique abilities to control diabetes, blood pressure, obesity, weakness, urine problem, stomach pains, menses and many more.

Ingredients: Barley, Chickpeas, Soya and Fennel

Barley *Sattu* is very light and easily digestible. It quenches thirst, cools the body, and gives instant energy, especially in the summer. It is good for hyperacidity, urinary tract infection, skin disorders, and heat-induced headache. It also helps reduce weight, if taken with honey. It is the most traditional drink in summers. It refreshes the brain and contains neither artificial color nor any type of chemicals. It can be consumed by whole family members as there is no Age Limit. It is made of Roasted Barley which gives Power, Energy and is easy to digest. Regular use of Barley *Sattu* will Increase and Boost energy, reduce Weakness, Stress and bring a feeling of well-being. After experiencing the subtle, positive effects of Barley *Sattu*, you will naturally be encouraged to continue this ritual and reap the benefits.

Health Benefits of Barley Water

Barley water ranks high in the category of healthy beverages because it is loaded with essential nutrients. Since barley is a good source of soluble and insoluble fibre, vitamins, essential minerals (calcium, iron, manganese, magnesium, zinc and copper), anti-oxidants and phytochemicals which are believed to lower the risk of heart disease and diabetes, barley water too draws out these benefits to make itself a health booster. Below are some exciting benefits of barley water to give a try.

- Aids in detoxification due to diuretic property.
- It is a best home remedy for urinary tract infections.
- Helps in digestion related problems like constipation.

***Directions to prepare barley water*:** Place the water and barley into a medium saucepan; cover, set over high heat and bring to a boil. Once the barley comes to a boil, decrease the heat to low and simmer for 30 minutes. While the liquid is cooking, peel the lemons, being careful not to cut into the white pith. Juice the lemons and place the juice along with the peel into a pitcher and set aside. After 30 minutes, strain the barley water through a fine mesh strainer into the pitcher. Discard the barley. Add honey and stir to combine. Refrigerate to preserve until served.

PRECAUTIONARY NOTE: Since barley contains gluten, and it should be avoided by people with celiac disease. Make sure to drink plenty of liquids as you increase your fiber intake, it is of more importance. Increase your fiber intake for 1 or 2 months gradually to prevent digestive discomfort as your body adjusts to the change.

It is the total diet or overall eating pattern that is of paramount importance in disease prevention and achieving good health. Therefore, it is better to eat a varied diet than to concentrate on individual foods as the key to good health.

63. SEED SCIENCE AND TECHNOLOGY 14977

Seed Hardening

Chawhan R. G.

Ph.D. Scholar, Department of Agriculture Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri

INTRODUCTION: Drought is the most common calamity that affect farmers severely. To overcome on such adverse situation it is necessary to exposed seeds with changing and often adverse environments in the soil for a considerably long period beginning with sowing

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and ending with emergence. Therefore, to decrease the period between sowing and emergence on the assumption that quick germination or emergence will spare the seed, the 'agony' of prolonged exposure to hostile environment during imbibition and seedling establishment and thus improve crop stands. pre-sowing treatments like 'hardening' also practiced to defy the ill effects of drought on emergence and growth of crop.

What is seed hardening? It is the process of hydrating the seed to initiate the pro-germinutive metabolism followed by dehydration which fixes the biochemical events.

Why it is done? In order to impart resistance against stress conditions viz., drought and cold, to the emerging seedlings.

How it is done? Seeds or grains are allowed to take up a certain amount of water, and then they are kept moist at 10° - 25°C for several hours before drying in a steam of air.

The best results are claimed for seed subjected to two - three cycles of wetting and drying, although for some seeds one cycle is sufficient.

Mode of action

- The basis for presowing seed hardening is significant increase in hydrophilic property of protoplasmic colloids namely viscosity and elasticity;
- Increased phosphorylation activity of their mitochondria.
- Reduction in solute leakage by regaining cell membrane integrity (Simon and Raja Harun, 1972).
- Resumption of rate of protein and RNA synthesis characterized in the first period of imbibition and shortening of the time of DNA replication in the second hydration period.

PRINCIPLE: During hardening process, a number of physicochemical changes occur and modifies the protoplasmic characters and increases the physiological activity of the embryo and associated structures.

Dry seed
⇩
Imbibition
⇩
Permits initial process of germination
⇩
Dehydration
⇩
Prevent cell and radical emergence
⇩
Shade and sun drying to bring back to its original water content or weight
⇩
Stops the germination process
⇩
Hardened seed
⇩
Sowing
⇩
Remembered the germination process where it had stopped
⇩
Rapid germination and quick establishment of seedling with available soil moisture
⇩
Increased growth and productivity

Steps in Seed Hardening

Dry seed
⇩
Soaking in water and dilute solutions of growth regulator and chemicals for 1-12h at 15-25°c
⇩
Shade drying (1 to 24 hr.)
⇩
Sun drying (1 to 2 days) to bring back to its original water content or weight
⇩
Hardened seed

Chemicals used for seed hardening

In addition to water, the following chemicals are recommended.

Chemicals: Aqueous solution of sodium chloride, sodium sulphate, potassium nitrate, calcium chloride, ammonium sulphate, potassium chloride, zinc sulphate, potassium dihydrogen phosphate.

Growth regulators: Gibberellic acid, CCC, kinetin, ascorbic acid, riboflavin, biotin, phosphonic acid, succinic acid.

Vitamins: Vit. Ka, nicotinic acid, pantothenic acid, adenine etc.

Plant products: Garlic extract, coconut water, leaf extracts of Prosopis, Moringa, Pongam and neem.

Advantages

- Accelerate rapid germination and growth rate of seedling.
- Plants from the treated seeds recover quickly from wilting when compared to plants from untreated seeds.
- 3i Flowering is slightly accelerated in treated plants.
- Induces resistance to drought and salinity.
- Seeds also withstand higher temperature (80-105°C) for prolonged periods (24-48h) without loss of viability.
- By emerging early, seedlings will be able to compete more effectively with weeds.
- Treated plants are generally better in growth and yield.

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64. SEED SCIENCE AND TECHNOLOGY 15202

Seed Pelleting: Seed Quality Enhancement Technique

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

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

**Corresponding Author Email: amitautade2013@gmail.com*

Seed Pelleting

"Seed Pelleting is the process of adding inert materials to seeds to change their size and shape for improved plantability"

1. Small and irregularly shaped seeds, such as lettuce seeds, can be treated as larger, round-shaped seed by pelleting.
2. Seed pelleting technique were commercially developed in the past 40-50 years, using techniques from the pharmaceutical industries.
3. Pelleting simplifies singulating seeds in the field and planting them in precise locations.
4. For crops like onion, precise seed placement is of great advantage as uniform bulb development is assured with equal distance planting.

Types of Seed pelleting

Types	Material used
Inoculant pelleting	Biofertilizer viz., Rhizobium, PSB, Azospirillum
Protective coating	Biocontrol agents like Rhizobacteria bataticola, Bacillus spp., Streptomyces Spp., pesticide
Herbicide coating	Filler antidote or absorbent coating
Nutrient coating	Coating with macro micronutrient eg. $ZNSO_4$, $FESO_4$,
Borax	
Hydrophilic coating	Starch graft polymers, magnesium carbonate
Oxygen supplier coating	Peroxides of zinc and calcium

Pelleting Material Use

- Gypsum
- Calcium carbonate (chalk powder)
- Charcoal
- Flyash
- wood ash
- Leaf powder *(Albizia, Pongamia, Prosopis)*

Selection of Pelleting Materials

- Pelleting materials must be porous to allow movement of air to the seed.
- The coating must weaken or breakdown when it comes in contact with soil moisture to prevent any physical impedance to seed germination.
- Material used must not have any toxicity to the seed.
- It must be possible to apply the coating on commercial basis.

Adhesives used for Pelleting

- Maida
- Starch
- Rice gruel
- Revive
- Sago gruel
- Gum Arabic

Chemicals used for Pelleting

- Macronutrient
- Micronutrient
- Vitamins
- Growth regulators
- pesticides

Procedure

- Seed in rotating drum is wetted, and blends of powered materials (*e.g.* chalk, clays, lime, peat) plus water-attracting or hydrophobic materials are progressively added, along with more water, until desired pellet wt. or size increase is achieve.
- Wet-coated seed then dried with heated air, usually in separate equipment.

Benefits of Seed Pelleting

- Improve ballistic property.
- Uniform field emergence.
- Reduce seed rate due to precision sowing.
- Easy handling of small and irregular shaped seed.
- Prevent damage of insect pest at time of seedling establishment.
- Protection from birds, animals and insects.
- Attraction of moisture.
- Saving chemicals/fertilizers applied to soil.
- Increased oxygen penetration/availability.
- Maintain plant to plant distance.
- Increase yield.
- Wider pellet density range allowing more accurate spacing of seed in a wide range of planting conditions.
- Enhanced seedling vigour when pelleted with fertilizer by nourishing young seedling.

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65. PLANT PATHOLOGY 15190

Wheat blast- A Fearsome Fungal Disease and its Threat to Wheat Cultivation

Elangbam Premabati Devi[1], Deepshikha[2] and E. Bidyarani Devi[3]

[1]Wheat Research Station, Vijapur, Mehsana, S.D.A.U., Gujarat; [2]G.B. Pant University of Agri. & Technology, Pantnagar, Uttarakhand; [3] Assam Agricultural University, Jorhat, Assam

Introduction: Wheat blast is a serious fungal disease which caused a significant economic yield loss during epidemic years. It was first identified in the state of Parana, Brazil in 1985 with large scale destruction in wheat cultivation. First epidemic occurred in Paraguay caused more than 70% losses. But losses can vary from very low to almost 100% since it can infect all the aboveground portion of plant especially on spike. The risk for introduction of wheat blast strains from South America to other countries is high due to the seed-borne nature of the fungus and the increased trading in countries where the disease occurs. Although fungicides are not effective in controlling wheat blast if warm, rainy weather occurred during the heading stage. Only few resistance genes have been identified for wheat blast.

Distribution: Wheat blast has prevalence in Brazil, Bolivia, Paraguay, Argentina, Uruguay and Bangladesh. In the year 2016, the occurrence of wheat blast in Bangladesh has become the biggest shock in wheat cultivation where it has led to the burning down of standing crop in 15,000 hectares. It became a warning signal for wheat cultivation in tropical and sub-tropical areas of the world. Recently in 2017, it has now invaded India, affecting around 800 to 1000 hectares in eight blocks of wheat crop in two bordering districts *i.e.,* Murshidabad and Nadia of West Bengal. Therefore, a network for development of rapid action against outbreak of new wheat diseases remain a foremost work to be done by all scientists before it's too late.

Causal organism: Initially the causal organism of wheat blast was thought to be *Pyricularia oryzae* (teleomorph *Magnaporthe oryzae*). Some authors named it as *Triticum* isolate of *P. oryzae.* Sprague (1950) applied the name *P. oryzae* for rice isolates and *P. grisea* for other cereal grasses. Using a multilocus phylogenetic analysis, Couch and Kuhn (2002) described *M. oryzae* distinct from *M. grisea* and used former for isolates of rice, whereas later for wheat, rye grass, millets. Recently, Castroagudin *et al.* (2016) conducted phylogenetic assays using 10 housekeeping loci for 128 isolates of *P. oryzae* from sympatric populations of grasses growing in or near wheat fields. The analyses categorized isolates into three clades. Clade 1 comprised isolates associated with *P. oryzae* from rice. Clade 2 isolates belonged exclusively to wheat previously described as *P. oryzae* pathotype *Triticum*. Clade 3 contained isolates obtained from wheat as well as other Poaceae hosts. Clade 3 is distinct from *P. oryzae* and represents a new species *P. graminis tritici*. They claimed it to be the cause of wheat blast in Bangladesh. It appears to be a logical nomenclature of pathogen.

Symptomatology: It infects all the above ground part of plant *i.e.,* glumes, awns and rachis along with the most conspicuous symptom is on head/spike infection. Head infection can be easily confused with *Fusarium* head blight. Infected glumes shows an elliptical lesions with reddish brown to dark grey margins with white to light brown centre. Blackening of the rachis, lower nodes, shriveling of grains, sterility, low test weight has also been observed depending on time of infection. Then, partial or total spike sterility occurred since infection on spike blocks the translocation of photosynthates and nutrients to spike. On leaves, lesions with white centre and reddish brown margin on upper side, dark grey on the underside of the leaf can be observed with varying in shape and size depending on the stage of plants. Infection on seedlings can be very damaging under high temperature and humidity which can result into total death of the plant.

Epidemiology: The severe form of blast years have coincided with wet and humid conditions which are characterized by several days of continuous rains and average temperatures between 18-25°C during the flowering stage of the crop followed by sunny, hot and humid days. Sprinkler irrigation along with rise in global temperature may predispose wheat plants to blast infection.

Disease cycle: The characteristic feature of the pathogen is the production of pyriform conidia with 3 celled conidium having single nucleus per cell. Seed act as primary source of inoculum for disease development but infection through seed seems to be a minor role in the disease development since severe form of spike infection occurs from the air-borne conidia mainly disseminated from several secondary hosts of grass weeds like *Eleusine indica, Echinochloa crus galli, Digitaria sanguinalis,*

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Brachiaria plantaginea, Pennisetum setosum etc. Air borne conidia can be detected up to 1000 meter from the infected fields.

Management: The avoidance of early sowing crop and crop rotation can reduce the disease severity. Avoid seeds from blast infected areas for sowing. Seed treatment with tricyclazole 75 WP @2g/kg or carbendazim 50 WP 1g/kg seed can manage seed inoculum. Initial infections can be managed by need based application of carbendazim 50 WP @1g/L or tricyclazole 75 WP @ 0.6g/L or Propiconazole 25EC or carpropamid 30 SC @1ml/L or Isoprothiolane 40EC @2g/L at spike initiation or at flowering stage. Clear cut information regarding genetic bases of resistance to wheat blast is not very clear due to tricky and variable nature of pathogen.

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66. PLANT PATHOLOGY 15225

Integrated Disease Management in Greenhouses

[1]Akhilesh Jagre and [2]Shanu Meshram

[1]M.Sc.+Net Qualified (Senior Research Fellow)
JNKVV Jabalpur MP and [2]Assistant Director of Horticulture Burhanpur MP

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 preventative or curative measures can be put in place to minimize the risk of disease infection and spread. During the cropping cycle, regular crop monitoring is used to decide if and what action is needed.

Hygiene

The most effective way to manage diseases is to prevent the pathogens from getting to the crop. Make sure that any materials, containers, or equipment that you bring into the greenhouse is clean. For more information refer to Preventing pests and diseases in the greenhouse.

Control Entry: Control access to the greenhouse. It is important to understand that pathogens (and pests) are easily carried on clothing and shoes. Many diseases in greenhouse crops first appear near doorways. The fewer people entering the greenhouse, the smaller the chance that pathogens (and pests) will be carried into the crop.

Control the Growing Environment: Controlling the greenhouse environment to make conditions less favourable for disease organisms is a very effective method of disease control. Good temperature and humidity management are essential to minimizing disease in greenhouse crops, particularly for Downy and Powdery mildews and Botrytis. Guttation is an important way in which pathogens can infect greenhouse crops. When guttation occurs, pathogens are picked up off the leaf surface by the exudate from the leaf and then can be sucked into the plant during the day.

Control Insects and Weeds

Control insects and weeds inside and outside the greenhouse. Weeds can harbour diseases and pests. Insects can carry diseases. If feasible, place insect screens over all openings in your greenhouse. Be aware that screens reduce the flow of air and will impact on the venting capacity of the structure. Poor air circulation can result in diseases such as Botrytis (grey mould), Alternaria (leaf spot) and Pseudoperonospora (Downy Mildew). The use of a double-door entry to the greenhouse, with a footbath, greatly reduces both pests and diseases getting into the crop.

Fungicides: There are two different types of fungicides used to manage diseases – protectants and eradicants.

Protectants sit on the surface of plants and their mode of action relies on contact with pathogens for control. As new growth needs to be protected, growing plants need on-going protectant spray applications. These chemicals generally control a wide range of fungal pathogens. When using protectants, make sure plant coverage is thorough and even.

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67. PLANT PATHOLOGY 15253

Sex Hormones in fungi

B. Khamari and A. Roy

Ph.D. Scholars, CA, OUAT, Bhubaneswar, Odisha.

Chemical communication is essential for coordination of activities in a multicellular organism. Fungi also monitor its environment through its chemosensory system. Specific chemicals are used as signaling molecules in a range of activities of fungal cells. These chemicals are diverse in their chemical structures, in their effective concentrations, specificities and types of action. These chemicals are known as hormones which play an essential role in communication as signaling molecules. It releases in small amounts from one portion of an organism and transported by any means including diffusion to other portions of the same individual or other individuals of the same species where they induce specific responses. Thus, a number of fungal messenger molecules, their receptors, signal transduction mechanisms and other biochemical processes exist. Hormones that play specific role in sexual reproduction are known as sex hormone. There are a number of sex hormones exist in fungi. Machlis (1972) coined the term erotactins, erotropins and erogens. Erotactins attracts motile cells ("Sperm attractant"). Erotropins induces chemotropic growth of sex organs. Erogens controls the induction and differentiation of sex organs. There is evidence of existence of number of sex hormones in fungi, but few are identified and chemically characterized such as Sirenin, Antheridiol, Oogoniol and Trisporic acid.

Sirenin

Sirenin is the first fungal sex hormone to have its structure determined. This sperm attractant produce by water mold *Allomyces arbuscula*. The female gametes release sirenin which diffuses into the surrounding water and male gametes are chemotactically attracted to the female gametes. The female gametes, by anisogametic copulation, give rise to diploid motile zygotes. However, it has recently been demonstrated that a female-attracting hormone is produced by the male. This hormone has been named "Parisin". 5 types of motile cells are formed in the life cycle of Allomyces (*viz.,* haploid & diploid zoospores, male & female gametes and the zygotes), but only male gametes respond to sirenin.

Antheridiol

It is the only completely characterized steroid sex hormone outside the animal kingdom. Antheridiol, originally termed hormone A, was discovered by John Raper during a study on mating in the oomycete water mould *Achlya.* The female hormone of the water mold *Achlya* produces Antheridiol which brings about the formation of numerous slender branches, the antheridial initials, near the tips of vegetative hyphae of a nearby male strain.

The male then produces hormone B (now known as Oogoniol), which causes the tips of vegetative hyphae of the female strain to swell to become oogonial initials. These then produce hormone C which causes the antheridial initials to grow towards them and, on contact, to develop cross walls and become antheridia.

Oogoniol

It is produced by the male isolates only in presence of Antheridiol. It helps in formation of oogonia. Barksdale *et al.*, 1974 reported that Oogoniol is produced by some hermaphrodite strains without the stimulus of Antheridiol.

Trisporic Acid

Trisporic acid, a terpenoid triggers sexual reproduction of several *Mucorales.* The hormone is synthesized only in presence of the compatible partner in collaboration otherwise, only asexual reproduction takes place. It suppresses the formation of asexual spores and triggers sexual reproduction. The Trisporic acids are only formed when there is free interchange of soluble materials between the two mating types. It is helpful in formation of zygophore in compatible hyphae.

Sex hormones play great role in sexual reproduction of fungi. There are number of sex hormones still exist which is yet to be discovered.

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68. PLANT PATHOLOGY 15262

Mycotoxins and Mycotoxicosis

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

Department of Plant Pathology[1], Department of Genetics and Plant Breeding[2]
Junagadh Agricultural University, Junagadh- 362001, Gujarat
**Corresponding Author Email: bhargavgolakiya79@gmail.com[1]*

What is a Mycotoxin?

Mycotoxin is a convenient generic term describing the toxic secondary metabolites produced by fungi. "Myco" means fungal (mold) and "toxin" represents poison. They encompass a considerable variety of low molecular weight compounds with diverse chemical structures and biological activities. Some mycotoxins could also be toxic to plants or other microorganisms; but these compounds are not classified as antibiotics of fungal origin. Like most microbial secondary metabolites, the benefit of mycotoxins for the fungi themselves is still not clearly defined. Due to their diverse chemical structures, mycotoxins may exhibit a number of biological effects, including both acute and chronic toxic effects as well as carcinogenic, mutagenic, geno-toxic, and immuno-toxic effects. **Diseases caused by mycotoxins in human being are known as mycotoxicosis.** The interaction of mycotoxins with cellular macromolecules plays a dominant role in their toxic actions. Recent studies on the effect of mycotoxins on apoptosis have further revealed their mode of action at the cellular level.

History of Mycotoxins

- Mycotoxin contamination has affected humans for thousands of years.
- Modern mycotoxicology was not developed until the discovery of aflatoxins in the early 1960s as the causative agent in the peanut meal causing the "Turkey X" disease that killed more than 10 thousand turkeys fed with the contaminated meal.
- Only in last 30-40 years have scientists been able to isolate specific toxins from their fungal source.
- Because aflatoxins are a series of highly potent carcinogens produced by commonly occurring *Aspergillus flavus* and *A. parasiticus*, research has focused new attention on mycotoxins.
- In the last 40 years, many new mycotoxins have been identified and characterized, and their biosynthetic origin in various fungi elucidated. It has been estimated that at least 25% of the world's agricultural product is contaminated with mycotoxins and certain diseases have been linked to ingestion of food and feed contaminated with mycotoxins.

Impact of Mycotoxin

The most obvious negative economic impact of mycotoxins is loss of crops and affected animals. Also, humans may encounter severe health hazard or high mortality rates in countries with less regulation or monitoring programs.

Mycotoxin Health Hazards

- Generally lower risk in well developed countries due to improved standards of living.
- High intake of affected product, usually in conjunction with limited amounts of other food sources.
- Greatest threat comes from long term exposure due to eating spoiled food or meat from animals fed contaminated feed.

Mycotoxin Effects on Humans

- Economic loss due to impaired health of stock animals.
- Illness: symptoms can include cold/flu-like symptoms, sore throats, headaches, nose bleeds, fatigue, diarrhea, dermatitis, and immune suppression, and vary by species.
- Death.

Mycotoxin Effects on Animals

- Feed refusal.
- Impaired animal health, resulting in reduced production of eggs, milk, weight gain, etc.
- Metabolites are passed through the milk in cheese, dry milk, and yogurt.
- Diseases.
- Death in animals.

Symptoms of Mycotoxicosis

- Drugs and antibiotics are not effective in treatment.
- The symptoms can be traced to foodstuffs or feed.
- Testing of said foodstuffs or feed reveals fungal contamination.
- The symptoms are not transmissible person to person.
- The degree of toxicity is subject to person's age (more often in very young and very old), sex (more often in females than males) and nutritional status.
- Outbreaks of symptoms appear seasonally.

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Factors Affecting Mycotoxin Production

- Genetics and environmental and nutritional factors greatly affect the formation of mycotoxins.
- Depending on the susceptibility of the crop, geographic and seasonal factors, as well as cultivation, harvesting, storage, and transportation practices, mycotoxins are found worldwide.
- In the field, weather conditions, plant stress, invertebrate vectors, species and spore load of infective fungi, variations within plant and fungal species, and microbial competition all significantly affect mycotoxin production.
- Physical factors such as time of exposure, temperature during exposure, humidity, and extent of insect or other damage to the commodity prior to exposure determine mycotoxin contamination in the field or during storage.
- Chemical factors including the nutritional status of the crops or chemicals (such as fungicides) used in crop management could affect fungal populations, and consequently toxin production
- In general, mycotoxins are optimally produced at 24–28°C, but some toxins such as T-2 toxin is maximally produced at 15°C.
- Contamination during crop storage may be affected by changes in temperature and water activity that allow ecological succession of different fungi as water activity and temperature of stored grain changes.
- During storage and transportation, water activity, temperature, crop damage, and a number of physical and chemical factors, such as aeration (O_2, CO_2 levels), types of grains, pH, and presence or absence of specific nutrients and inhibitors are important.

Production of mycotoxins by toxicogenic fungi

- Invasion by fungi and production of mycotoxins in commodities can occur under favorable conditions in the field, at harvest, and during processing, transportation and storage
- Fungi that are frequently found in the field include: *A. flavus, Alternaria longipes, A. alternata, Claviceps purpura, Fusarium verticillioides* (previously called *moniliforme), F. graminearum*, and a number of other *Fusarium* spp.
- Species most likely introduced at harvest include: *F. sporotrichioides, Stachybotrys atra, Cladosporium sp., Myrothecium verrucaria, Trichothecium roseum,* as well as *A. alternata.*
- Most penicillia are storage fungi. These include: *Penicillium citrinum, P. cyclopium, P. citrinoviride, P. islandicum, P. rubrum, P. viridicatum, P. urticae, P. verruculosum, P. palitans, P. puberulum, P. expansum, and P. roqueforti.*
- All of which are capable of producing mycotoxins in grains and foods.
- Other toxicogenic storage fungi are: *Aspergillus parasiticus, A. flavus, A. versicolor, A. ochraceus, A. clavatus, A. fumigatus, A. rubrum, A. chevalieri, Fusarium verticillioides, F. tricinctum, F. nivale, and several other Fusarium spp.*
- It is apparent most of the mycotoxin producing fungi belongs to three genera: *Aspergillus, Fusarium*, and *Penicillium*. However, not all species in these genera are toxicogenic.
- Mushroom toxins includes: *amanita* toxins, orellanine, gyromitrin, muscarine, muscimol and ibatonic acid.

69. PLANT PATHOLOGY 15295

Role of ß-Aminobutyric Acid (BABA) in Management of Plant Diseases

Chirag Gautam

Department of Plant Pathology, University of Agricultural Sciences, Bengaluru-560065
**Corresponding Author Email: chirag19111911@gmail.com*

What is BABA?

BABA is a simple, nonprotein amino acid which induces resistance (thus plant defence activator) against a large number of plant parasites when applied. It operates via a variety of defence mechanisms, including physical barriers and biochemical changes leading to resistance. So it is an amino acid which mediates induced resistance. In 1960, Oort and Van Andel first noted induced resistance to tomato late blight following DL-β-aminobutyric (BABA) treatment. In 1963, Papavizas and Davey reported high activity of BABA against *Aphanomyces euteiches*

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causing root rot in peas.

Spectrum of Activity of BABA

Host plants include annual as well as perennial plants, monocots and dicots belonging to Solanaceae, Cucurbitaceae Compositae, Leguminaceae, Cruciferaceae, Gramineae, Malvaceae, Rosaceae, and Viniferaceae. Pathogens include oomycetes, fungi, bacteria, TMV and nematodes. BABA protect against diseases of foliage, roots and fruits (Table 1).

Modes of BABA application include foliar sprays, soil (root) drenches and seed soakage. BABA is also effective when incorporated (as a powder) into the soil, injected into the stem or applied as a solution to bare roots, cut stems, or cut leaves.

The concentration of BABA required to achieve effective (~90%) resistance under controlled conditions depends on the host, the pathogen and the mode of application. Normally, higher doses are required in foliar sprays (250 to 1,000 μg ml–1) than in soil drenches (20 to 100 μg ml^{-1}), probably because of a more efficient uptake through the root. Highest concentrations (0.5 to 1% solutions) are needed in seed soaking. Persistence (duration) of resistance induced by BABA also depends on the pathosystem and mode of application. Unlike other plant activators (*e.g.*, SA, INA, BTH), which provide resistance only when applied before pathogen infection (8), BABA exhibit post-inflectional activity when applied 1 to 3 days after inoculation. This was true in tomato against *Phytophthora infestans* (2), tobacco against *Peronospora tabacina* (1), grapes against *Plasmopara viticola* (3), and cauliflower against *Peronospora parasitica* (7).

Synergistic interaction: - Cohen (2002) observed that BABA was not effective in inducing resistance against powdery mildews. However, when mixed with triazole fungicides, it greatly enhanced their effectiveness.

TABLE: 1. Pathosystems in which resistance were induced by β-aminobutyric acid

Plant	pathogen/s
Potato	*Phytophthora infestans, Alternaria solani, Fusarium sambucinum.*
Tomato	*Phytophthora infestans, Botrytis cinerea, Xanthomonas vesicatoria, Fusarium oxysporum f. sp. lycopersici, Clavibacter michiganensis, Meloidogyne javanicum.*
Pepper	*Colletotrichum coccodes, Phytophthora capsici.*
Cucumber	*Pseudoperonospora cubensis, Sphaerotheca fuliginea, Colletotrichum lagenarium, Pseudomonas sp., Meloidogyne javanicum, Botrytis cinerea.*
Broccoli, kohlrabi	*Alternaria brassicicola*
Pea	*Aphanomyces euteiches*
Grapes	*Plasmopara viticola*
Apple fruit	*Alternaria alternata*
Melon	*Pseudoperonospora cubensis*, *Fusarium oxysporum* f. sp. *melonis*, *Monosporascus cannonballus*.
Watermelon	*Fusarium oxysporum* f. sp. *niveum*
Cauliflower	*Peronospora parasitica*, *Pseudomonas marginalis*, *Pseudomonas fluorescens*, *Erwinia carotovora* subsp. *carotovora*

Mode of Action of BABA

Physical barriers

When BABA is applied as a foliar spray, BABA induces the formation of pinpoint necrotic spots which are considered by some researchers to be involved in SAR. Trailing necrosis (*i.e.*, necrosis surrounding the developing hyphae), enhanced callose formation, and papillae are observed in Arabidopsis plants treated with BABA after a challenge inoculation with *Peronospora parasitica*.

- Hypersensitive reaction and reactive oxygen species
- Accumulation of Pathogenesis-related proteins
- Accumulation of Phytoalexins

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70. PLANT PATHOLOGY 15331

Pleurotus ostreatus – Forthcoming Earth Saver

Subramanian R.[1], Rageshwari S.[2]

[1] PG Scholar and [2] Ph.D. Student, Tamil Nadu Agricultural University, Coimbatore – 641003

INTRODUCTION: Synthetic polymers started to substitute natural materials and nowadays plastics have become an indispensable part of our life. Synthetic plastics are extensively used in packaging of Products like food, pharmaceuticals, cosmetics, detergents and chemicals. Approximately 30% of the plastics are used worldwide for packaging applications. This utilization is still expanding at a high rate of 12% per annum. Improperly disposed plastic materials act as the significant source of environmental pollution, potentially harming life. In addition, the burning of polyvinylchloride (PVC) plastics produces persistent organic pollutants (POPs) known as furans and dioxins (Jayasekara *et al.*, 2009). Hence microbial biodegradation of the plastic waste is consider to be need of the hour in the current scenario.

Biodegradation by Microorganisms

Several organisms are possessing enzymatic machinery to degrade the different types of plastics.

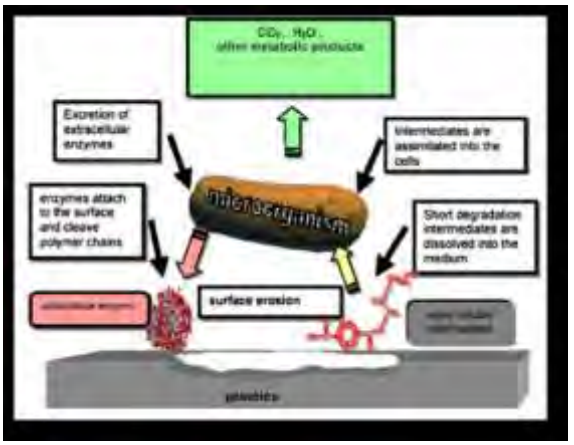
- Polyethylene - *Brevibacillus borstelensis*
- Polyurethane - *Comamonas acidovorans* TB-35
- Polyvinyl chloride – *Aureobasidium pullulans*
- BTA- co-polyester - *Thermomonospora fusca*
- Poly Caprolactone - *Clostridium botulinum*
- Polylactic acid - *Penicillium Roquefort*
- Starch/polyethylene - *Aspergillus niger*
- Starch/polyester - *Streptomyces*
- Poly(3-hydroxybutyrate) - *Schlegelella*

Biodegradation also for hunger elimination

P. ostreatus effectively uses the plastic waste as a carbon source for biomass and metabolite production. Microbial decomposition by the *P. ostreatus* can modify the fragile nature, tensile strength and Elastic modulus of plastic and leads to formation of (–OH) and carbon oxygen bonds. Increased laccase activities results in oxidation of polyethylene hydrocarbon of the plastic waste (Luz *et al.*, 2013). The degradation of oxo-biodegradable waste was evidenced by the formation of cracks and holes in the plastic surface after 45 days of incubation and by the formation of (−OH) and Carbon Oxygen bonds.

After 45 days of incubation, the factors like maximum load of break, Energy at break, Tensile extension at break, Load at tensile strength, Elastic modulus shows reduction in their physical strength and become easily prone for degradation. Plastic waste incubated under the 18°C by *P. ostreatus* induces fruiting body formation and thus fruiting body can be commercially exploited for feeding the hunger for some extent.

Polymer	Before incubation	After 45 days of incubation
Physical and Mechanical properties		
Maximum load of break (N)	4.362	2.260
Energy at break (J)	0.069	0.013
Tensile extension at break (CM)	0.532	0.300
Load at tensile strength (N)	2.820	1.850
Elastic modulus (MPa)	33.341	17.417



Conclusion: *P. ostreatus* is capable of degrading oxo-biodegradable plastic and producing mushrooms using the plastic waste without any prior physical treatment. Hence the P. ostreatus can be commercially used for edible mushroom production and it forms a new alternative for the proper treatment of plastic pollutants

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71. PLANT PATHOLOGY 15343

Genome Editing in Plant Disease Management

Rageshwari S[1] and Subramanian R[2]

[1]Ph.D. Scholar, [2]M.Sc. Student, Dept. of Plant Pathology, TNAU, Coimbatore

Genome editing is an emerging technology for crop genome management which allows targeted sequence editing. They rely on engineered endonucleases (EENs) that cleave DNA in a sequence specific manner due to the presence of sequence specific DNA binding domain or RNA sequence. The nucleases recognize the specific sequence and efficiently cleave the target site (Carroll, D. 2014). The newly discovered nucleases like Zinc Finger nucleases (ZFNs), Transcription Activator-Like Effector Nucleases (TALENs), Meganucleases and CRISPR/ Cas9 system collectively called as Site directed nucleases (SDN) enable targeted double stranded breaks creating a site-specific gene modifications. This results in cellular DNA repair mechanisms like HDR (homologous directed repair) and NHEJ (error prone non-homologous end joining) in plant cells leading to a heritable genome modifications (Wyman *et al.*, 2006).

The first report of diseases resistance mediated by these nucleases especially TALENs were reported in rice against rice bacterial blight susceptibility gene. This rice gene encodes a member of the SWEET sucrose-efflux transporter family and is hijacked by *X. oryzae pv. oryzae*, using its endogenous TAL effectors AvrXa7 or PthXo3, to activate the gene and thus divert sugars from the plant cell so as to satisfy the pathogen's nutritional needs and enhance its persistence. The TAL effectors of *Xanthomonas oryzae pv oryzae* (Xoo) contribute to pathogen virulence by activating specific rice disease-susceptibility (S) genes. The rice sucrose-efflux transporter gene (OsS called as SWEET14) is required for the virulence and survival of the bacterial pathogen *Xanthomonas oryzae.* This resulted in silencing of the gene, resulting in resistance to *X. oryzae* (Li *et al.*, 2012).

The CRISPR/Cas9 could be used in plants to confer molecular immunity against DNA viruses like *Tomato yellow leaf curl virus* (TYLCV) in *Nicotiana benthamiana* plants (Zahir Ali *et al.*, 2015). The CRISPR/Cas9 system targeted TYLCV for degradation and induces mutation in the targeted sequences. The most effective method is to target the Origin of replication or Intergenic region exhibiting delayed or reduced accumulation of viral DNA, or reducing the symptoms of infection. This method can be effectively used against DNA viruses also.

The efficacy of CRIPR/Cas9 system against plant virus extends the utility of this technology to produce resistant plants to multiple viral infections. The efficiency of mutation and regeneration has been reported to be high over 90 per cent. Researches related to ZFNs and meganucleases regarding plant disease management have not been reported yet.

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72. PLANT PATHOLOGY 15369

Biological Control: Mechanisms and Approaches

Raina Bajpai[1*], Rahul Singh Rajput[1], Jyoti Singh[2]

[1]Ph.D. Scholar, Department of Mycology and Plant Pathology, Institute of Agricultural, Sciences, BHU, Varanasi – 221005

[2]Ph.D. Scholar, Department of Botany, Institute of Sciences, BHU, Varanasi – 221005

*Corresponding Author Email: rainabajpai03@gmail.com

INTRODUCTION: Reduction of inoculum amount or disease producing agents or activities of a pathogen either in active or its resting stage by any other organism in natural condition or by manipulating its environment, host or by introduction of any antagonists is basically defined as "**Biocontrol**". Biocontrol is an advancing, environmental friendly and economically sound method to control pest attack because it restricts the use of chemical as

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chemical residues have harmful impact on humans or other organisms, if biocontrol method is practiced efficiently, it will provide essentially widespread control with a very favorable cost-benefit ratio. Certainly, each and every control method has potential to impair non-target native species, and the biocontrol agents themselves can harm to non-target species if they are left unmanaged. Therefore, before release of a biocontrol agent, it is necessary to maintain its potential to benefit conservation targets and controlling goals against its ability to cause harm. There are many diseases and insects that can be successfully controlled using biological agents including pathogens of wounds and other cut surfaces, crown gall, diseases of leaves and flowers, such as powdery mildew, diseases of fruits and vegetables, such as Botrytis, and fungal pathogens in the soil (disease suppressive soils).

Mechanisms of biocontrol method

There are many mechanism followed by biocontrol agents such as parasitism, predation, competition, induced resistance and the production of antimicrobial substances. These several mechanisms may act together.

1. **Competition**-Competition exists between organisms for the requirement of the same resource for growth and survival. Use of the resource by one organism they reduces the availability of resources for the other organism. Competition for space or food is the most important among them; it mostly exits between closely related species. Therefore, it is very effective to treat plants or seeds with a non-pathogenic strain of a related species that can compete with the pathogenic organism. It is not always needed that they should be closely related to the pathogen until it consumes the same resources. For example, Competition for nutrients is observed in case of bacteria and yeasts against fungal spore germination on the leaves surface. Some micro-organisms also produce secondary metabolites that have anti- microbial properties
2. **Parasitism**- Parasitism of one microorganism by another (hyperparasitism) is studied well and is influenced by environmental factors together with nutrient availability. In recent days formulations of some parasitic organisms are also available commercially for the management of various plant pathogens present in the soil and on the plant surface. Different bacteria and fungi act as biocontrol agent. The parasitic fungi penetrate the pathogen with hyphae, wall-degrading enzymes also play role in parasitism. Some nematodes too consume large numbers of bacteria in the soil as well as amoebae are reported to attack yeasts, spores and fungal hyphae, even though these non-specific predators in nature and their respective role in biological control is still not clearly understood. Mycoparasitism is a phenomenon in which parasitism of a fungus (host) by another fungus (mycoparasite). *Trichoderma harzianum* used as seed treatment against pathogenic fungus (*Sclerotium rolfsii*) on Chickpea and Sugar beet.
3. **Antibiosis**: an association between organisms that is injurious to one of them. Antibiosis is provided by marigold (Tagetes species) roots, which release terthienyls, chemicals that are toxic to several species of nematodes and fungi.

FIG. 1: Competition for nutrient and space between Trichorderma Sp.and Sclerotium rolfssi in PDS plate.

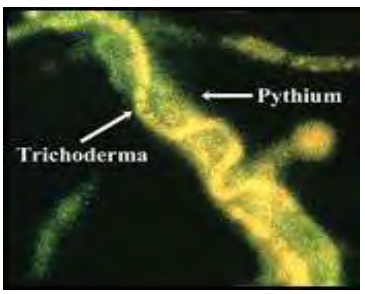

FIG 2: Mycoparasitism between *Trichoderma sp.* and *Pythium*

Approaches of biocontrol

1. Classical biocontrol approach- it focuses a non-native pest with one or more species of

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biocontrol agents from the pest's native range.
2. New Association or 'Neoclassical' approach - it targets native pests with non-native biological control agents.
3. 3.'Conservation', 'Augmentation' and 'Inundation' approaches maintain or increase the abundance and impact of biocontrol agents that are already present, and in many cases native to the area.

Classical biocontrol is by far the most widespread used approach for plant pests. Conservation and augmentation approaches also secure a specific role and especially for enhancing the impacts of classical biocontrol and other control measures.

Examples

- **Predator**- *e.g.* **Mantids**-The praying mantid (Mantidae) is a non-specific predator.
- **Spiders** -Spiders (nearly 4000 species) are basically predators, and 99% of their diet is fulfilled by. Lady beetle-feed voraciously on aphids.
- **Parasitoids**-It include different wasp and flies, *e.g.* ichneumonid wasps and tachinid flies
- **Pathogen**-It consists of various bacteria, fungus and viruses.

E.g. Ampelomyces quisqualis - application of its spores on leaf surface to controls powdery mildew.

Coniothyrium minitans - application of its spores on soil destroys pathogenic structures of the *Sclerotinia sclerotiorum*.

Problems on commercial use of biological control

Due to variation in its efficacy under various abiotic stresses commercial application and its acceptance has been slow to develop. This problem could be resolved by enhancing understanding of the environmental parameters that limit biological control. Another limitation is small investment in the development of commercialization of biocontrol products, may be due to the cost of developing, testing efficacy and risk, registering and marketing such a product.

73. PLANT PROTECTION 14940

Safety Precaution for Pesticides Application and use of Plant Protection Equipments

Kalpana Gairola, Akansha Singh and Pooja Upadhyay

Department of Plant Pathology, GBPUA&T, Pantnagar-263145, Uttarakhand, India.
**Corresponding Author Email: kgairola123@g mail.com*

Pesticides are mainly used to prevent pests and diseases in agriculture production in order to eliminate yield losses and to maintain high quality product. Although Pesticides are developed under very strict regulation to function with reasonable certainty and minimum impact on human health and environment. Serious concern have been raised in farmers field regarding the adverse effects of pesticides on the environment *i.e.*, water, soil, air, contamination from leaching, runoff, and spray drift, and detrimental effects on non-target organisms, all these effects depend on the toxicity of the pesticide, therefore measures should be taken by the farmers while mixing, during application and after application. Moreover, the use of appropriate plant protection equipment along with precautions that are required in all stages of pesticide handling can minimize exposure of pesticides to human and their adverse effects on the environment.

Pesticides are useful for crop production but it can be dangerous when handled improperly. Safe application of pesticides depends on many things such as appropriate selection of pesticides and uses it according to label direction. Safety precautions are labeled in pesticide packaging to minimize the risk and health hazard. Here are some points for safer pesticide application.

Before Applying Pesticide

1. Know the pest, and how much damage is really being done.
2. Use pesticide only when really needed.
3. Seek advice on the proper method of control.
4. Use only the recommended pesticide for the problem. If several pesticides are recommended; choose the least toxic to mammals and if possible the least persistent.
5. Read the label, including the small print.
6. Make sure the appropriate protective clothing is available, and is used; and all concerned with the application also understand the recommendations.
7. Commercial operators using large quantities of extremely toxic or highly toxic pesticides should visit their doctor and have a blood test, and have repeat checks during the season.
8. Check application equipment for leaks,

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calibrate with water and ensure it is in proper working order.
9. Check that plenty of water is available with soap and towel and that a change of clean clothing is available.
10. Check that pesticides on the farm are in a dry locked store. Avoid inhaling pesticide mists or dusts, especially in confined spaces such as the pesticide store.
11. Take only sufficient pesticide for the days of application from the store to the site of applications. Do not transfer pesticides into another container; especially bear cans and soft drink bottles.

While Mixing Pesticides and during Application

1. Wear protective clothing. If it is contaminated, remove and replace with clean clothing.
2. Never work alone when handling the extremely highly toxic pesticides.
3. Never allow children or unauthorized persons near the mixing.
4. Re-check the label.
5. Avoid contamination of the skin, especially the eyes and the mouth. Liquid formulations should be poured carefully to avoid splashing. Avoid powder formulations puffing into face. If contaminated with the concentrate, wash immediately.
6. Always have plenty water available for washing.
7. Always stand upwind while mixing.
8. Never eat, drink or smoke when mixing or applying pesticide.
9. Make sure pesticides are mixed in the correct quantities.
10. Avoid inhalation of chemical, dust or fumes.
11. Start spraying near the downwind edge of the field and proceed upwind so that operators move onto unsprayed areas.
12. Never blow out clogged nozzles or hoses with your mouth.

Avoid Spray Drift

1. Do not spray if wind conditions cause drift, as birds, bees and wildlife may be endangered. Never spray if the wind is blowing towards grazing livestock or regularly used pastures
2. Never leave pesticides unattended in the field.
3. Provide proper supervision of those assisting with pesticide application, and have adequate rest periods.
4. When blood tests are being conducted, does not work with pesticides if your cholinesterase level is blew normal.

After Application

1. Return unused pesticide to the store.
2. Safely dispose all empty containers. As it may be difficult to burn empty containers after each days during spraying operations, they should be kept in the pesticide store until convenient numbers are ready for disposal. It is absolutely impossible to clean out a container sufficiently well to make it safe for use storage of food, water or as a cooking utensil. If any containers are burnt, never stand in the smoke.
3. Never leave pesticides in application equipment. Clean equipment and return to store.
4. Wash well and put clean clothing. Where there is considerable amount of spraying, the operators should be provided with a shower room.
5. Keep a record of the use of pesticides.
6. Do not allow other persons to enter the treated area for the required period, if restrictions apply to the pesticide used.

Uses of Plant Protection Equipments

Spraying: This is the most commonly adopted method. Spraying of fungicides is done on leaves, stems and fruits. Spraying is of two types; viz, high volume and low volume. When sprays involve large quantities of liquid per unit area, they are termed as high volume *i.e.,* 600 liters per hectare. With low volume, it is usually possible to cover one hectare with about 60 liters. In convential high volumes; spray apply at the rate of 600-1000 liters/ha; drop size is likely to be of the order of (0.5-3mm). On the other hand, in low volume sprays as little as (15-60 liters) of liquid per hectare may be used to distribute the same amount of chemical. When air blast equipment is used; optimum radius of the droplets would be 15-35 microns, while for aircraft application. It is about 35-70 microns.

Sprayers: Depending on the source energy for operation of sprays, they may be broadly divided into two categories.

1. Manually operated sprayers
   a) Hydraulic energy sprayers
   b) Compression pneumatic or Air sprayers
   c) Hydraulic energy sprayers
   d) Bucket pump sprayer
   e) Knapsack sprayers
   f) Rocking sprayers
   g) Foot sprayers (Pedal pump)
2. (B) Compression pneumatic or Air sprayers
   a) Compression hand sprayers
   b) Compression knapsack sprayers
3. (C) Power operated sprayers which are commonly termed as power sprayers.
   a) Gaseous energy sprayers *e.g.* Motorized knapsack sprayers
   b) Centrifugal energy sprayers *e.g.* Mist sprayers

Dusting: For dusting purposes dusting machines are used on standing crops. The

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machines are;

1. Manually operated Dusters
   a) Hand dusters
   b) Rotary hand dusters
2. Power operated dusters
   a) Tractor dusters
   b) Engine operated power dusters.

Water requirement for spraying

	Liters per hectare or trees and shrub	Liters per hectare for field crops
High volume	over 1200l/ha	over 600l/ha
Medium	600-1200 l/ha	250-700l/ha
volume		
Low volume	250-600 or 120/ha	60-250 or 601/ha
Very low volume	under 250 l/ha	under 60l/ha
Ultra low volume		1-2l/ha

All above precautionary measures about handling of pesticides and pesticide equipments will help in risk free and safe pest control.

74. PLANT PROTECTION 15277

Different Methods to Minimize Crop Damage by Wildboars in Groundnut

R. Prasanna lakshmi*, P. Ganesh kumar and P. Swarna

Krishi Vigyan Kendra, Kalikiri, Chittoor dt, Andhra Pradesh
Acharya N G Ranga Agricultural University, Andhra Pradesh
**Corresponding Author Email: pras.agrico@gmail.com*

Wildboar (*Sus scrofa*) is a native mammalian species of Western Europe as well as of Northern Africa. Damage to agricultural crops like groundnut, maize, jowar *etc* by wildboars is enormous and widespread. Earlier the damage by wildboars was high in crop fields nearer to forest areas now they are damaging crops in roadside villages also. Among the field crops, groundnut is severely damaged by wildboars *i.e.* during sowing and from pod formation stage to harvesting stage. In Chittoor district of Andhra Pradesh where 1.3lakh hectares of groundnut is being cultivated during *kharif*, wildboars are the major havoc than any other pest in most of the areas. The basic reason for unexpected abrupt raise in their populations can be attributed to degradation of natural habitats, non-availability of preferred dietary items in natural habitats. Deforestation resulted in the decline of the natural predators for wild boars like tigers, wolf, jackal etc there by indirectly contributing to the phenomenal raise in the wildboar populations. Over exploitation of forest resources by the mankind forced wildboars out of their natural habitat and compelled them to depend on cultivated crops such as groundnut, paddy, maize, sorghum, fruits & vegetables.

The intensity of damage depends on population density, cropping pattern, extent of crop area, season and stage of the crop. The damage caused by wildboar is more alarming than their actual feeding in the crop. Farmers have developed antagonistic attitude towards wildboar and pushes towards retributive killings that have a substantial impact on the wildboar population undermining the conservation efforts. Therefore, reducing antagonism caused mortality is an important strategy for conservation of wildboars.

1. ITKs used by farmers to minimize wildboar damage

1. **Sarees method:** This is generally followed by farmers, which has a behavioral background with respect to wildboars. By arranging different colored old sarees around the crop, the animal may not able to push through soft cloth when the snout comes into contact as it is the most sensitive part of its body.
2. **Tying of empty glass bottles along with bolt/stone around the field:** Farmers in KVK operational area also follow this method to restrict wildboar movement. In this method, empty glass bottles are tied around the field to which a small bolt or stone is attached. When wind movement is there, stone/bolt touches the glass bottle and produces sound which scares away the wildboars from damaging the crops.

2. Technologies Recommended by AINP on Vertebrate Pest Management

1. **Arrangement of three rows of cotton nawar soaked in kerosene:** Wooden poles are planted around the field at a distance of 1m. Cotton nawar soaked in kerosene solution tied to these wooden poles in 3 rows by keeping 1ft distance between the rows. Kerosene smell restricts wildboar movement entering crop fields. On an average an amount of Rs.5000/- is required to tie kerosene soaked cotton nawar in 3 rows

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around 1 acre field.

2. **Arranging three rows of coconut rope smeared with sulphur and pig oil:** Coconut coir rope is arranged in three rows around the field with the support of wooden poles which are placed at 1-2m distance. Sulphur is mixed in oil at certain proportion that make into semi solid suspension. Then sulphur and oil mixture is smeared on already tied coconut rope. This mixture smell will act as a repellent to wildboars which unable them to enter crop field. On an average an amount of Rs.4000/- is required to tie coconut rope in 3 rows around 1 acre field.
3. **Tying of GI wire in three rows around the field:** Wooden poles were arranged around the crop field at 1m distance then GI wire is tied in three rows from base to top. This acts as a fence and restricts wildboar movement into the crop field. An amount of Rs.1500/- is required to tie GI wire in 3 rows around 1 acre field.
4. **Arranging phorate granules around crop field:** Wooden poles should be planted around crop field at 1-2m distance. Phorate granules and sand must be mixed in 1:5 ratio and 50-60g of mixture should be kept in perforated cloth and tied to wooden poles at 60-70cm height. This works on the principle of strong smell of phorate granules which is more concentrated than crop smell and wildboars cannot detect the crop.
5. **Growing of safflower around groundnut:** Safflower crop may be grown as guard crop or border crop in 3-4 rows with 30×15cm spacing around groundnut to restrict wildboars entering field. Due to its thorny nature it causes inconvenience to wildboars. Because of this extent of damage is minimized by 60-70%.

75. NEMATOLOGY 15345

Entomopathogenic Nematodes (EPNs): An Indispensable Biopesticide

Satyapriya Singh

Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi - 12, India.
**Corresponding Author Email: satyapriya_10797@iari.res.in, satyachintu25@gmail.com*

INTRODUCTION: Biopesticides are developed from naturally occurring living organisms such as animals, plants, and microorganisms (*e.g.* nematode, bacteria, fungi, and viruses) that can control serious plant- damaging insect pests by their nontoxic ecofriendly mode of actions, therefore reaching importance all over the world. In this context, entomopathogenic nematodes (EPNs) held greater potential in insect pest management. These are beneficial organisms that attack and kill a wide variety of insect pests and have been described from 23 nematode families (Koppenhöfer, 2007). These are highly diverse, complex and specialized in nature. The most commonly studied EPNs are those that can be used in the biological control of harmful insects are from the members of Steinernematidae and Heterorhabditidae (Gaugler, 2006). They can be considered good candidates for integrated pest management and sustainable agriculture.

Concept and Utility

They infect many different types of insects like the larval forms of moths, butterflies, flies and beetles as well as adult forms of beetles, grasshoppers and crickets. *Steinernema carpocapsae*, one of the first EPN species to be commercialized, was originally isolated from cocooned codling moth larvae (Dutky & Hough 1955). Selection of an EPN for control of a particular pest insect is based on several factors that include the nematode's host range, host finding or foraging strategy, tolerance of environmental factors and their effects on survival and efficacy (temperature, moisture, soil type, exposure to ultraviolet light, salinity and organic content of soil, means of application, agrochemicals, and others).

TABLE: EPNs used in India

Scientific name	Common name	Crops	EPN species
Agrotis ipsilon, A. segetum	Black cutworm	Potato	*Steinernema feltiae*
Anomala sp.	Potato chaffer beetle	Vegetable	S. *carpocapsae*
Amsacta albistriga	Red hairy caterpillar	Groundnut	S. *carpocapsae*, *Heterorhabditis bacteriophora*
Chilo sacchariphagus indicus	Sugarcane internode borer	Sugarcane	*H. indica*, S. *carpocapsae*
Chilo partellus	Stem borer	Maize	*H. indica*, S. *carpocapsae*
Earias vittella	Spotted	Okra	*Steinernema*

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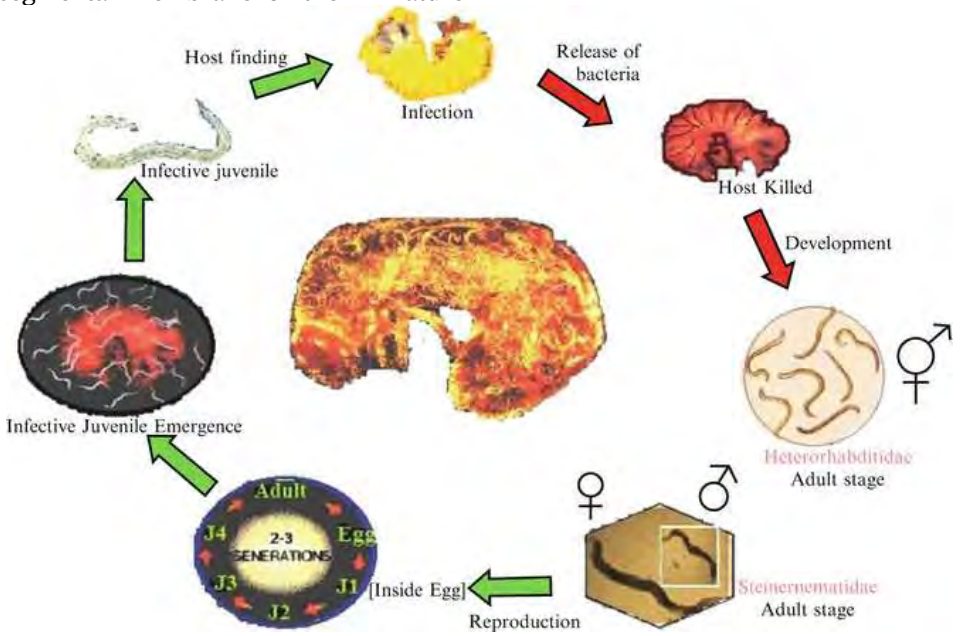
Scientific name	Common name	Crops	EPN species
	bollworm		*feltiae, Heterorhabditis* sp.
Holotrichia sp.	White grub	Sugarcane	*H. indica*
Helicoverpa armigera	Pod borer	Pulses, cotton	*Steinernema feltiae,* S. *carpocapsae*
Phthorimaea operculella	Potato tuber moth	Potato	*H. indica*

Mode of action

When the infective juveniles of EPNs are applied they start searching for their insect hosts. Once insect larvae have been located, the nematode infective juveniles penetrate into the larval cavity via natural opening such as mouth, anus and spiracles (Poinar, 1990). Infective juveniles of Heterorhabditis nematode can also enter through the intersegmental membrane of the immature cuticles. The IJ_3 is the only stage which present outside and all other stages of nematode present inside the body. Once in the body cavity, infective juveniles release symbiotic bacteria (*Xenorhabdus spp.* for Steinernematidae and *Photorhabdus spp.* for Heterorhabditidae) from their gut in insect blood. In the blood, multiplying nematode-bacterium complex causes septicaemia and kill their insect host usually within 48 hours after infection. Nematode feed in the insect body, mature in to adults, reproduce and then emerge as infective juveniles from the host cadaver to seek new larvae in the soil. Insects feed by Heterorhabditidae are stiff, turn beef red in colour and emit fluorescent light in dark where as in Steinernematidae insects are lumpy, sticky, greenish to black without emit light. Major advantages of EPNs are that the infected body do not produce foul smell and the bacteria prevent the growth of the micro-organisms.



Application

EPNs application is very simple and can be done with water canisters or ordinary sprayers. Depending on environmental conditions, target pests and substrate, surfactants and humectants (eg. Xanthan) may be used to improve their effectiveness. EPNs have been applied successfully against soil inhabiting insects (as soil application) as well as above-ground insects (foliar spray) in cryptic habitats (Shapiro-Ilan et al. 2006). Recommended dose is 2.5 billion IJ_3. Formulations are available in WDG, WP form which contain infective stage in anhydr0obiotic stage.

Potential in pest management

The great advantages of using entomopathogenic nematodes as biopesticides for insect pest control are in operator and end-user safety, absence of withholding periods, the advantage of minimizing the treated area by monitoring insect populations, minimal harm to natural enemies and lack of environmental pollution. It has also many disadvantages like high cost of production, limited self-life and required refrigerated storage and environmental limitations requirements for adequate moisture and temperature, sensitivity to UV radiation, lethal effect of several pesticides

Conclusion: Conservation and augmentation of natural nematode populations through proper management practices and periodic nematode releases offer exciting possibilities for insect-pest suppression. Finally, these fascinating animals may contribute more to science than their use

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solely as biological control agents. With EPN's impressive attributes, which make them an excellent alternative tool for control of insect pests, EPN has sparked heightened interests amongst the biocontrol workers and lead to immense opportunities to test them against a wide variety of insect pests. Finally, these fascinating organisms may contribute more to science than their use solely as biological control agents. They can be used on a large-scale in integrated pest management, organic farming and sustainable agricultural systems to control insect pests.

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76. DISEASE MANAGEMENT 15381

Toxin-Antitoxin Systems: Role in Plant Disease Management

[*1]Gurudevi, V. Navali, [2]Jabbar Sab and [3]Jayappa

[1, 2 &3]Ph.D. Scholar, Department of Plant Pathology, UAS, GKVK, Bengaluru-65
**Corresponding Author Email: gvnavali5017@gmail.com*

INTRODUCTION: Bacteria have evolved a treasure trove of antibacterial toxins. Some toxins are used as competitive weaponry and are neutralized in the cell until they are secreted, to the detriment of neighbouring bacteria. Other toxins, such as those encoded in toxin-antitoxin (TA) systems, are self-poisoning agents. TA systems are gene modules that encode a protein toxin and a neutralizing antitoxin. These modules are functionally diverse, found in virtually all free-living bacteria and archaea, and are numerous in many genomes. Antitoxins typically have shorter half-lives than toxins, when antitoxins are degraded, the toxins are free to inhibit a variety of essential processes and halt bacterial growth. Although self-poisoning might not seem intuitively beneficial, there is growing evidence that TA systems provide important stress tolerance and virulence advantages to human pathogenic bacteria. For example, toxin activities might rid a population of bacterial cells that have lost a mobile genetic element or that have been infected by phage, or they may induce a metabolically dormant state that confers tolerance to stress. TA systems are abundant among plant-pathogenic and-symbiotic bacteria, and the very few studies investigating these systems suggest that they may play an important role in plant-associated lifestyles.

Biology of TA Modules

The toxins of all characterized bacterial TA systems are proteins, while the antitoxins are either proteins or small RNAs (sRNAs). In general, the toxin is more stable than the antitoxin. Currently, TA systems are assigned to six classes (I–VI) according to their genetic structure and regulation. In type I and III TA modules the antitoxins are small noncoding RNAs, while the antitoxins of the other TA classes are small proteins.

Types of Toxin-Antitoxin Systems

TA systems are organized into six proposed types based on the nature and mechanism of the antitoxin. The best-characterized group is Type II TA systems, which encode a protein antitoxin that directly binds and inhibits the protein toxin. Type II antitoxins often have a second function as transcriptional repressors of the toxin-antitoxin operon. Antitoxins may also take the form of antisense RNAs that bind toxin-encoding mRNA (Type I systems) or RNAs that bind directly to the toxin (Type III systems). Protein antitoxins may suppress toxin activity by competitively binding the toxin's target (Type IV), directly cleaving them RNA encoding the toxin (Type V), or triggering another protein to cleave the toxin (Type VI). The majority of known TA systems are Types I and II; only one or a few TA systems of Types III–VI have been validated experimentally thus far.

Type I TA systems have a noncoding RNA antitoxin and a protein toxin. In these systems, small regulatory antisense RNAs (sRNAs) base-pair to the mRNA of the toxin to inhibit its

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translation. Under normal growth conditions, this duplexing inhibits ribosome binding and the RNA duplex is rapidly degraded by RNase III. However, under conditions of stress, the pool of antitoxin sRNA is reduced, resulting in the translation of the now non-duplexed toxin mRNA. The toxins themselves are short hydrophobic peptides that insert and disrupt membranes, leading to a loss of membrane potential and, in turn, growth arrest (Fig. 1). The hok/sok (parB locus) gene pair on plasmid R1 was the first type I TA system discovered12. Multiple hok/sok homologs have since been identified on chromosomes throughout the bacterial kingdom, including that of *E. coli*.

Type II TA systems are the largest and best-studied TA system class, with thousands of type II TA loci identified in most free-living bacteria, such as *E. coli*. Unlike the type I antitoxins, the type II antitoxins are proteins. They typically have two domains, one that binds DNA and a second that binds and inhibits the activity of the cognate protein toxin (Fig. 1). The antitoxins also often bind the promoters of their own operon in order to repress transcription; in most, but not all cases, the toxins function as co-repressors. In some cases, they bind the promoters of other genes. Type II TA systems are regulated by distinct differences in the cellular lifetimes of the antitoxins and toxins. Namely, the antitoxins are highly susceptible to proteolysis, whereas their cognate toxins are comparatively stable. Thus, in response to stress, the antitoxins are selectively degraded. This leads to growth arrest due to the cellular effects of the now free toxins. Type II toxins function by inhibiting replication (*i.e.*, by inhibiting DNA gyrase) or translation (*i.e.*, by cleaving mRNA, inactivating ribosome elongation factors or inactivating glutamyl-tRNA synthetase (GltX), among other processes).

The majority of type II toxins are endoribonucleases (RNases), which often adopt a microbial RNase fold (similar to those of RNase T1 and RNase SA). The ribosome-dependent RNase toxins bind directly to the A site of the ribosome, where they cleave ribosome-associated mRNA. Other RNase toxins are ribosome independent, including MqsR, which also adopts a microbial RNase fold, and MazF, a functional dimer with a unique fold. Unlike those of their highly similar RNase toxin counterparts, the structures of both the cognate antitoxins and the oligomeric toxin–antitoxin complexes differ considerably from one another.

In type III systems, as in type I systems, the antitoxin is a small RNA. However, instead of duplexing with toxin mRNA to prevent toxin synthesis, the antitoxin forms pseudo knots that bind directly to the toxin (Fig. 1). The founding and best-studied member of the type III class is toxIN. The toxN toxin gene is preceded by a short palindromic repeat, which is itself preceded by a tandem array of nucleotide repeats. ToxN, an RNase, cleaves not only the toxIN transcript—into the active 36-nucleotide antitoxin sRNAs but also other mRNAs. Its activity is inhibited when it associates with toxI sRNA, which blocks its active site.

The most recently identified TA systems are types IV–VI. In type IV, as in type II, both the antitoxin and toxin are proteins. However, whereas in type II systems antitoxins and toxins bind to form a tight complex, the antitoxin and toxin of the type IV system never interact. Instead, the toxin prevents growth by binding and inhibiting the polymerization of the bacterial cytoskeletal proteins MreB and FtsZ, thereby blocking cell division. The antitoxin antagonizes toxin activity by promoting and stabilizing MreB and FtsZ cytoskeletal filament bundling (Fig. 1).

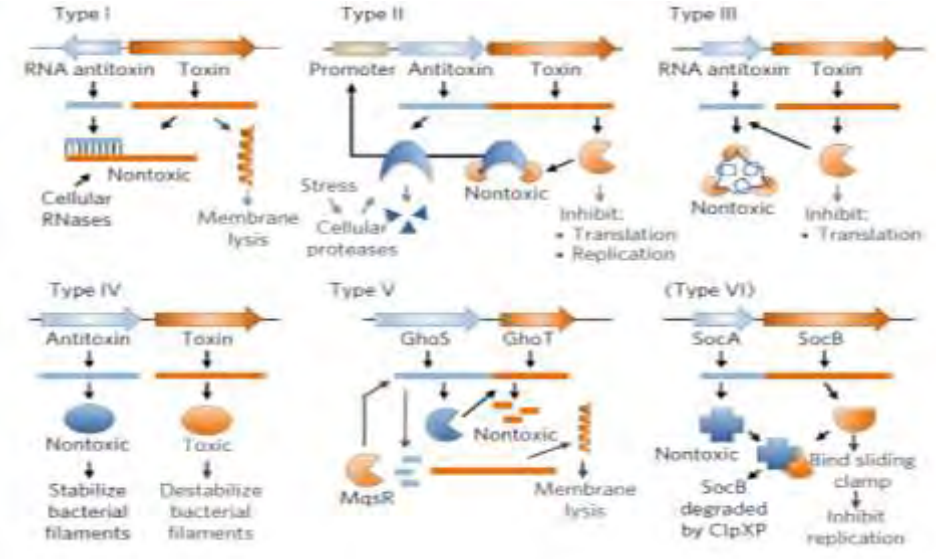

FIG. 1: Different types of Toxin-antitoxin systems

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In the only known type V system, the antitoxin (GhoS) is an RNase that, under growth conditions, cleaves the toxin (GhoT) mRNA. However, under conditions of stress, the mRNA of GhoS is degraded by the type II toxin MqsR. This results in the translation of GhoT, a small hydrophobic peptide that, like the toxins from type I systems, damages the cell membrane (Fig. 1). Thus, this is an example of one TA system (ghoST) that is directly regulated by that of another (mqsRA). The most recently discovered TA system (type VI) is composed of a protein toxin, SocB, and a protein antitoxin, SocA. The toxin blocks replication elongation by binding directly to the β sliding clamp DnaN and outcompeting other clamp-binding proteins. The antitoxin SocA is a proteolytic adaptor protein that neutralizes SocB toxicity by promoting its degradation by ClpXP (Fig. 1).

Possible Functions of Toxin-Antitoxin Systems

1. **Junk:** they have been acquired from plasmids and retained due to their addictive nature.
2. **Stabilisation of genomic parasites** – chromosomal remnants from transposons and bacteriophages.
3. **Selfish alleles:** non-addictive alleles are unable to replace addictive alleles during recombination but the opposite is able to occur.
4. **Gene regulation:** some toxins act as a means of general repression of gene expression while others are more specific.
5. **Growth control:** bacteriostatic toxins, as mentioned above, restrict growth rather than killing the host cell.
6. **Persisters:** some bacterial populations contain a subpopulation of 'persisters' controlled by toxin-antitoxin systems that are slow growing, hardy individuals, which potentially insure the population against catastrophic loss. At least with regard to endoribonuclease encoding Type II TA systems, their role in persistence is highly debated.
7. **Programmed cell arrest and the preservation of the commons:** the altruistic explanation as demonstrated by MazEF.
8. **Programmed cell death:** similar to the above function, although individuals must have variable stress survival level to prevent entire population destruction.
9. **Antiphage mechanism:** when bacteriophage interrupt the host cell's transcription and translation, a toxin-antitoxin system may be activated that limits the phage's replication.

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77. BIOCONTROL 15378

Mass Production of Entomopathogenic Fungi

S. Hemalatha

Senior Research Fellow, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Success of any microbial control programmes depends on production of sufficient quantity of inoculum for field application. Efficient production technologies have been developed for laboratory and commercial use of entomopathogenic fungi. Most of the entomopathogenic fungi are facultative pathogens and can be mass produced in synthetic, semisynthetic or natural media containing suitable nutrient source. Selection of strains of fungi having high virulence, good growth and sporulation is considered important in mass culturing.

Media used production and maintenance of fungal pathogens

Culturing can be done in variety of media containing sugar and salts as sources of carbon and nitrogen respectively. Specific media have been identified for culturing different types of fungi (Table 1).

TABLE 1. Synthetic/Semisynthetic media used for culturing entomopathogenic fungi

	Medium	Composition	Fungal pathogen
1.	Sabouraud's dextrose agar with yeast extract (SDAY)	Dextrose 40g; peptone 10g; yeast extract 2g; agar 15g; distilled water 1000 ml	*Beauveria bassiana* *B. brongniartii* *Verticillium lecanii*
2.	Subouraud's maltose agar with yeast extract (SMAY)	Maltose 40g; peptone 10g;; yeast extract 5g; agar 15g; distilled water 1000 ml	*Nomuraea rileyi* *Zoophthora radicans* *Paecilomyces farinosus*
3.	Potato dextrose	Peeled potato 200g;	*B. bassiana*

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	Medium	Composition	Fungal pathogen
	agar (PDA)	dextrose 20g; agar 15g; distilled water 1000 ml	*V. lecanii*
4.	Emerson's YpSs agar	Soluble starch 15g; K_2HPO_4 1g, Mg SO_4, $7H_2O$ 0.5g, yeast extract 4g, agar 15g, distilled water 1000 ml	*Metarhizium anisopliae* *M. flavoviride*
5.	Nutrient agar	Beef extract 3.0g; peptone 5.0 g, NaCl 5g; agar 15g; distilled water 1000 ml	*Paecilomyces fumosoroseus*
6.	Oat meal agar	Oats 100g, agar 15g, distilled water 1000 ml	*P. fumosoroseus*
7.	Czapek - Dox agar (CDA)	Sodium nitrate 2g; K_2HPO_4 1g, $MgSO_4$ 0.5g; KCl 0.5g, $FeSO_4$ 0.01g; sucrose 30g; agar 15g; distilled water 1000 ml	*B. bassiana*

Natural Media

Different types of cereals, pulses, brans and vegetables have been reported to be suitable for mass production of entomopathogenic fungi (Table 2).

TABLE 2. Natural media for culturing entomopathogenic fungi

	Medium	Fungal pathogen
1.	Sorghum grains	Verticillium lecanii *(Easwaramoorthy and Jayaraj, 1977);* Paecilomyces farinosus *(Gopalakrishnan* et al., *1999);* Beauveria bassiana *(Devaprasad, 1989)*
2.	Rice	Nomuraea rileyi *(Silva and Loch, 1987)*
3.	Carrot	B. bassiana *(Sivasankaran* et al., *1990);* Metarhizium anisopliae *(Sundarababu, 1980)*
4.	Crushed sorghum grains with yeast extract	N. rileyi *(Vimala Devi, 1994)*
5.	Jack seeds	V. lecanii *(Easwaramoorthy and Jayaraj, 1977)*
6.	Cooked rice	B. bassiana; M. anisopliae *(Jenkins* et al., *1998)*
7.	Wheat bran	B. bassiana *(Rombach* et al., *1988)*
8.	Oats	M. anisopliae *(Villacorta, 1976)*
9.	Coconut water	M. anisopliae *(Chandrika Mohan, 2001)*
10.	Cassava chips + rice bran + fish meal	M. anisopliae *(Chandrika Mohan, 2001)*

Culturing of Fungal Pathogens

Preparation of synthetic media: For preparing solid agar media like SDAY, SMAY, Emerson's YpSs agar, Nutrient agar and CDA half the quantity of water is used to dissolve the chemicals by slight heating / boiling. The agar is melted in the other half of water by slow heating and constant stirring. The melted agar is added to the other half of medium containing chemicals and mixed thoroughly. Usually pH is adjusted to 6.5 – 6.8 before mixing with agar. The medium is then dispensed in test tubes (5 ml/tube) or 250 ml Erlenmeyor flask (50 – 100 ml/flask). The mouth of the test tube or flask is plugged with non-absorbent cotton, covered with paper and autoclaved at 15 PSI for 20 min. The tubes are allowed to cool in slanted position for getting agar slants. The flask is allowed to stand until they can be held by hand and the medium is poured asceptically into sterile Petridishes to produce agar plates.

Preparation of Semi-Synthetic Medium

Potato dextrose agar: Washed and peeled potato is made into thin chips, boiled in 500 ml of water and filtered through muslin cloth. To the extract weighed quantity of glucose is added and mixed. The agar is melted in another half of water and mixed with potato extract containing glucose.

Oat meal agar: The oats is first cooked in 500 ml of water and filtered through muslin. The agar is melted in another 500 ml of water, added to the extract of oats and final volume is made upto one litre. Dispensing and autoclaving are done as described earlier.

Preparation of Natural Medium

Sorghum medium: A quantity of 100g of sorghum grains is thoroughly washed, cooked in 500 ml of distilled water and extract is strained through muslin. Extract is dispensed in Erlenmeyer flasks at the rate of 100 ml/flask and autoclaved.

Carrot medium: A quantity of 100g of carrot is washed well in tap water, cut into small bits and cooked in 500 ml distilled water. The extract was filtered through muslin cloth dispensed in 250 ml Erlenmeyer flask at the rate 100 ml/ flask and autoclaved. If solid medium is needed of agar can be added. Otherwise the cut pieces of carrot are transferred to 250 ml Erlenmeyer flasks containing 100 ml of water at the rate of 40 g per flask. Autoclaving is done as described elsewhere.

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78. ENTOMOLOGY 15034

Genetic Improvement of Predator and Parasitoids

Ashrith K. N. Narayana Swamy K. C. and Indhushri Chavan

Ph.D. Scholar, Department of Agricultural Entomology, College of Agriculture, Naville, UAHS Shivamogga, Karnataka, India.
**Corresponding Author Email: kn.ashrith@gmail.com*

Successful integration of biological and chemical control strategies in insect pest control programs is a major challenge facing applied entomologists. The frequent incompatibility of these two keystones of Integrated Pest Management (IPM) has resulted in widespread target-pest resurgences, secondary pest outbreaks and accelerated evolution of pesticide resistance, thereby incurring significant economic and environmental costs (Metcalf, 1986). Genetic improvement of predators and parasitoids is an important trait in the field of biological control. It involves direct purposeful genetic alterations to enhance the efficacy of natural enemies of crop pests. Genetic improvement can be achieved through artificial selection, hybridization or recombinant DNA techniques. Generally, two implementation strategies are used with genetically improved natural enemies. First one is the improved natural enemies can be deployed by 'inoculation' where in the new strain is released one or more times into an environment where it is expected to establish and persist. Second one is by 'augmentation', which involves mass rearing of the new strain and releasing it periodically as it is not expected to persist in the environment (Routray *et al.,* 2016). An endosulfan tolerant strain of *Trichogramma chilonis* (Endogram) has been developed by National Bureau of Agriculturally Important Insect Resources (NBAIR) Bengaluru, for the first time in the world. *T. chilonis,* an egg parasitoid of lepidopteran pest tolerant to endosulfan was developed in the laboratory. The genetical study showed that F_1 crosses exhibited semi-dominant response to endosulfan (Jalali *et al.,* 2006).

Charles *et al.* (2011) studied insecticide tolerance level and the kind of inheritance in a strain of *T. chilonis* Ishii, strain. Tolerant and susceptible strains of endosulfan, spinosad and lamda cyhalothrin were selected to carry out the crossing experiments. The result revealed that endosulfan tolerance appeared to be recessive for the cross involving tolerant male parent and semi dominant for the tolerant female parent. Spinosad tolerance appeared to be semi dominant and lamda cyhalothrin tolerance was found to be completely dominant for crosses with the male and female tolerant parents. Host searching range of genetically improved High Temperature Tolerant (HTT) strains and Ludhiana strain of *T. chilonis* was up to 10 and 8 meters from the release point, respectively. Parasitization of factitious host *Corcyra cephalonica* egg was found to decrease with increase in distance from point of parasitoid release. The parasitization efficiency of both the strains showed negative and positive correlation with temperature and relative humidity, respectively (Singh and Shenhmar, 2008). Naka *et al.* (2005) conducted laboratory hybridization between the indigenous *Chrysoperla nipponensis* and its close relative *C. carnea*, interspecific hybrids were obtained, fully viable and fertile F_1 and F_2 generations were produced. Crosses between *C. carnea* females and *C. nipponensis* males showed 41.3% fertility, but the reciprocal cross showed only 9.5% fertility. The absence of change in hatchability, adult emergence rate, total developmental period or deviation from the sex ratio from parents to the F_2 generation of hybrids suggests that there is no genetic incompatibility between *C. carnea* and *C. nipponensis* resulting from hybrid breakdown. Maternal microinjection was adopted to deliver DNA to the eggs of *Cardiochiles diaphaniae*. The results of microinjection with the plasmid pJKP2 followed by slot blot analysis suggested that the method could be used to deliver injected DNA to the ovaries of this wasp. The plasmid phsopd, containing the parathion hydrolase gene (opd) of *Pseudomonas diminuta* was injected to this wasp. The results indicated that the maternal microinjection can result in transformation of this parasitoid (Presnail and Hoy, 1996).

The development of molecular methods for genetic manipulation of arthropods has created exciting new opportunities for altering the genomes of beneficial arthropods. A little work on the genetic improvement of parasitoids and predators has been done so far and there is tremendous scope to strengthen the area of biological control by improving genetic basis. To

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overcome the limitations of selection pressure, emphasis should be given to improve the natural enemies of pest through hybridization or molecular changes that are more persistent. Maintenance of biodiversity should be primarily important concern to be created among the farmers to enhance natural hybridization. So gene mapping for each species of parasitoid or predator is prior necessity that could enhance further improvement.

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79. ENTOMOLOGY 15325

Silicon in Plant Defense

S. Tripathy and L. K. Rath

Department of Entomology, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha -751003

Silicon (Si) an element abundantly available on earth's crust is the second only to oxygen (Ehrlich, 1981). Uptake of Si by plants (mostly monocots) enhances the defensive power of the plants against the phytophagous insects, fungal pathogens, nematodes etc. This development of defensive power in plants is called induced resistance. Induced resistance is nothing but the qualitative or quantitative enhancement of plants' defense against the invading organisms in response to pest related injury or extrinsic physical or chemical stimuli.

Plants can uptake silica exclusively as monosilicic acid by diffusion process. A number of advantages are attained by the plant due to silicon uptake. Uptake of silica strengthens the epidermal cell wall in the leaves and stems. Si deficiency causes deficiency of protein and chlorophyll. Si also regulates plants' uptake of iron, magnesium and aluminium. The rate of photosynthesis also increases due to Si uptake as it helps in producing more erect leaves exposing their more surface areas towards capture of sunlight.

Sources of Silicon

Si is made available to the plants both from organic and inorganic sources. While the organic sources are crop residues especially of silicon accumulating plants, diatomaceous earth; the inorganic sources are many like calcium silicate, Potassium silicate, Silica gel, Silicate hydrate, Ortho silicic acid, Fly ash, Paper mill sludge, Steel slag etc.

Silica Uptake by the Plant

Various sources of Si applied to soil or the Si present in the soil has to be converted to the available form, monosilicic acid which is absorbed by the plant roots through a passive process regulated by transpiration stream activated by the transporters located in the plasma membrane of the root cells. The absorbed Si accumulates in the old tissue mainly in the walls of epidermal cell walls resulting in cell wall thickening, cell wall hardening and tissue rigidity. Silicon accumulation occurs in the region of maximum transpiration such as leaf epidermis near the stomatal guard cell, trichomes and thorns.

Gene responsible for Si transportation was first described in rice crop and the genes identified are LSi1, LSi2 and LSi6. Ma *et al* (2004) have studied the transporter SiT1 helps in transportation of Si from soil through root epidermis to the cortical zone of the plants while SiT2 helps in further transportation of Si from cortical zone to the xylem. Thus, through the xylem vessel Si can reach to different parts of the rice plants like leaf sheath, leaf lamina, inflorescence and developing grains.

Role of Silicon in Plants

Silicon though is not considered as an essential element but has been considered as a functional element in the monocots in particular. Si accumulation helps in photo-assimilation of

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carbon and promotes assimilated carbon to panicles in rice and causes higher grain yield. Si in plants filter the harmful ultra-violet radiation receiving leaf surface with leaf cells acting as 'windows' transmitting light energy to photosynthetic mesophyll and cortical tissue beneath epidermis.

Silicon is an important constituent of DNA and RNA *i.e.* silica deficiency decreases the synthesis of protein and chlorophyll. Si also reduces the toxicity of heavy metals in acid soils particularly. In rice, Si application causes cell wall thickening, increases the size of vascular bundles, thus, improved the rigidity of stem with decreased stem width and increased stem hardiness as well as enhances the efficiency of N, P, K for higher grain yield.

Induced Defensive Role of Silicon in Plants

It has been observed that high Si deposition in the stem of rice plant causes erosion of mandibles of larvae of yellow stem borer and larval penetration is highly impaired. A number of scientist have opined in a similar way to describe the non-preference mechanism of resistance developed in rice plants due to Si application. Thus, it is proved that Si uptake by rice plants and its ultimate deposition in stem, leaf sheath acts as a mechanical barrier to the stem borer larvae feeding on rice.

Induced antibiosis effect of Si in rice also has been studied by many scientists. Si uptake by rice causes lower larval weight and high larval mortality in first instar larvae of yellow stem borer and this mortality may be due to improper starch assimilation leading to mal-digestibility. Si in rice causes defensive reaction through production of phenolic compounds that are detrimental to rice stem borer. Not only the effect of Si has been studied on stem borer but also on brown plant hopper, white backed plant hopper, leaf hopper and leaf folder as well.

It has been found that Si deposition in sugarcane leaf sheath causes lower incidence of early shoot borer and also wheat varieties containing high Si are not severely infested by hessian fly. It has also been witnessed that a high Si level contributed towards resistance in maize to stalk borer.

Increase level of Si has been shown to influence the plant defensive enzymes leading to increased accumulation of phenolics, phytoalexins, and momilactones with increased activities of peroxidase, polyphenol oxidase and phenyl alanine ammonia lyase. Studies on these biochemicals on the defensive mechanism in plant against the fungus are wider as compared to insects. However, recent studies shows that hydrogen peroxide which is produced as a by-product in octadecanoid pathway due to silicon uptake, causes pores in cellular layer of the mid gut of many insects which causes their death. It has been reported that Si is able to prime jasmonate mediated defensive response in rice against leaf folder.

Conclusion: Recent advances in molecular approach of plant defense mechanism have opened new avenues to study the role of Si in plant defense against herbivores at gene level. Identification of Si transporter genes in rice is the example to suggest that induced resistance is under genetic control. However, further elaborate study in relation to various micronutrient linked gene isolation and sequencing in different crops and their major pests need to be geared up. While before 2000AD we were not aware about the involvement of gene in induced resistance, but today scientists have demonstrated the role of genes in induced resistance. It is not only Si, rather plants' defensive role under the action of several abiotic elicitors will come into picture to mitigate herbivory.

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80. ENTOMOLOGY 15342

Impact of Neonicotinoide on Honey bee

Konkani Pratibhaben P.

Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari
**Corresponding Author Email: pratibhakonkani1993@gmail.com*

INTRODUCTION: In India about 80% or more of the crop plants depends or stand beneficial from insect pollination. About 750 to 1000 be floral plants are estimated to be growing in India of the 160 million hectares of cropped area, more than 55 million is under bees dependent crops. Approximately 90 percent of all flowering plants require pollinators to survive. In agriculture, nearly a third of pollination is accomplished by honeybees. Cucumbers, almonds, carrots, melons, apricots, cherries, pears, apples, prunes, plums, cantaloupe, onions, avocados, kiwi,

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blueberries, cranberries and more depend on honeybee pollination.

Of all living beings on the planet, honey bee is the most fascinating. They are probably the only species to live in perfect harmony in the most organized social structure that civilizations can ever imagine. Honey bees are god's greatest natural gift to mankind. The vast evolution of biodiversity in nature can be credited to the enormous pollinating efforts of the 20,000 bee species over the millions of years. Without doubt, bees are god's anointed plant breeders. Albert Einstein is said to have remarked that "if the bee disappeared off the surface of the globe, man would have only four years to live". There are seven recognized species of honey bees across the world. Honey bees are presumed to have originated in South and Southeast Asia. Across the world, two honey bee species the European, *Apis mellifera* and the Asiatic, *Apis cerana indica* are commonly cultured for commercial honey production, it is interesting that all the seven species are known to possess similar social and communication skills. Mankind owes a lot to bees. It is not just the honey and wax, but honey bees actually have been the most ancient natural plant breeders. Bees are considered as nature's greatest gifts which foster the continuous expansion of biodiversity on the planet. Nature's plant bio-diversity is largely accelerated over millions of years due to the constant cross pollination carried out by pollinator insects, mainly the bees. The bees and the flowers have co-evolved in a manner that flowers provide pollen and nectar to bees so that the bees can help them in cross pollination.

Pesticides, alone and in combination with other factors, have had a devastating effect on honeybees and wild pollinators. A wide range of insecticide molecules of the 'Organo-phosphate' and 'Carbamate' groups are known to have a broad spectrum toxicity to several insects including the bees. Among all the insecticide groups neonicotinoide group is very harmful to the honeybee. These are Imidacloprid, Acetamiprid, Thiamethoxam, Thiacloprid, Clothianidin, Nitenpyram and Dinotefuran. The neonicotinoids act strongly as oral and contact poisons. Of the six neonicotinoid insecticides, acetamiprid and thiacloprid were found to be relatively less toxic to honey bees. Insecticides such as imidacloprid, clothianidin, thiomethoxam and binotefuran showed high toxicity to honey bees at very low concentrations.

Mode of Action of Neonicotinoide

The neonicotinoid insecticides are highly toxic to sap-sucking insects on a wide range of crops and fruit trees. Insecticides of this group are more toxic to insects as compared to mammals because the binding affinity of the neonicotinoids to the receptor sites 'nicotinic acetyl choline receptor nAChR' in the central nervous system is much stronger in insects compared to the receptors in mammals. Binding of the neonicotinoid molecules to the nicotinic receptors is similar to the binding of nicotine, but in such a strong manner that the nervous system gets over-stimulated, the receptor get blocked thereby resulting in paralysis and death.

The neonicotinoid insecticides act at very low doses of 7 to 50 grams of active ingredient per hectare. Imidacloprid and Thimethoxam are also used extensively in seed treatment. When the treated seeds germinate or when the neonicotinoids are applied to the soil, these insecticides are absorbed by the seedlings through the roots and stem and translocated inside the plant through 'systemic' action. The seedlings thus contain the insecticide inside its leaves, stems, vascular tissues, buds, flowers, pollen, nectar and fruits and thus are protected from sap-sucking insects generally upto two months. Imidacloprid was introduced in 1991 globally by Bayer and registered in India in 1993. Subsequently, Acetamiprid and Thimethoxam were registered in India in 1999, Thiacloprid and Clothianidine in 2002, Dinotefuran in 2006 and Nitenpyram in 2012. Neonicotinoids are approved for use in 120 countries and command a global market worth Rs 16,000 crores. Across the world, imidacloprid alone is estimated to have a market share of Rs 6,500 crores. As oral poison, a dose as low as 3.7 to 7.6 nano grams per bee of any of these insecticides would be sufficient to kill at least 50% of the honey bee populations. To explain further, for example, 7.4 grams of imidacloprid can kill one billion honey bees.

Impact on Honey Bee

Colony Collapse Disorder is unlike other ailments that have affected honeybees in the past because worker bees simply disappear rapidly, never returning to the hive where the queen still lives with a small cluster of bees amidst pollen and honey stores in the presence of immature bees (brood). It has been reported that losses of honeybee colonies across 21 states in the winter of 2007-8 averaged 35%. A sub-lethal dose far less than this can still have detrimental effects on the general health of the bees, their vigour, energy and working capabilities. When exposed to sub lethal doses of imidacloprid, honey bees suffer from impaired memory, altered learning, reduction in immunity, motor activity, sucrose sensitivity, foraging, brood production and track return. The bees lose their normal capacities to fly, dance, forage, maintain hive temperatures and communicate properly through round and waggle dance. They also lose their navigation skills to return back to their hives, thus leading

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to colony collapses. These chemicals accumulate in the hives over repeated use and cause harmful effects, such as reduction in activity and longevity of young larvae and the queen and nursing behaviour of young worker bees.

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81. ENTOMOLOGY 15371

Embryonic Development of an Insect

***Ms. Chauhan, R. C.**

Department of Entomology, N. M. C. A., N. A. U., Navsari- 396450
**Corresponding Author Email: crinky246@gmail.com*

EMBRYOLOGY

Embryology is the branch of biology which deals with the growth and development of an embryo of an organism, commencing with the union of male and female gametes. Embryology includes the development of the fertilized egg and embryo and the growth of the organ system.

Embryonic Development in Insects

Development of an insect from egg to adult can be divided into two parts

1. Early embryonic development - takes place inside the egg and
2. Post embryonic development – occurring outside the egg.

Insect Eggs

1. Mature insect eggs are oval, elongate, may be spherical, disc or barrel like.
2. The eggs are covered by two shells, a tough outer shell called the chorion, and a thinner inner shell called the vitelline membrane.
3. There is an opening called micropyle at the chorion for the entrance of sperm.
4. The two membranes surround a large nucleus and a mass of cytoplasm.
5. The cytoplasm consists of a large central area of yolk and a peripheral bounding layer, the periplasm, beneath the vitelline membrane.
6. The egg nucleus lies in a central position and embedded in cytoplasm.

Fertilization of Egg

The production of male (sperm) and female (ovum) gametes is commonly considered to be the first phase in insect development. The union of gametes (spermatozoon and ovum) is the second phase of development, and creates a diploid zygote with the potential to form an entire organism and this process occurs through the fertilization of ovum with sperms.

Early embryonic development

The early embryonic development is started immediately after fertilization of the eggs by sperms and it is occurred through a series of events that includes

1. Cleavage
2. Formation of blastoderm
3. Vitello phages
4. Formation of germ band and
5. Gastrulation
6. Formation of embryonic membrane
7. Blastokinesis
8. Formation of organ system
9. Appendages

a. Cleavage

- Cleavage is the repeated mitotic divisions of a fertilized ovum zygote. After fertilization, the zygote nucleus of an egg starts to divide.
- After fertilization, the egg and sperm nuclei fuse together at the periphery of the egg to form the diploid fused- nucleus (zygote) and then the zygote migrates to the centre of the egg. The zygote nucleus divides repeatedly, thus, one cell divides into two daughter cells called blastomeres, then cleave into four; these cleave into eight, and so on. Ultimately produces large number of daughter nuclei.
- Then the daughter nuclei are accompanied by a hollow mass of cytoplasm forming nucleo-cytoplasm units called energids or cleavage cells.

b. Formation of Blastoderm

- The energids move and migrate towards the periphery (periplasm) of the egg and arrange in a layer of circlet within the yolk.
- The energids may undergo further, one or more mitotic divisions and retain the distinct cell walls and subsequently form a layer of cells, called the blastoderm.
- The blastoderm, in true sense, is the primary germinal epithelium. It lies just beneath the vitelline membrane.

c. Vitellophages

- In some species of insects, all energids do

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not migrate to the periphery to form the blastoderm but some of them lie behind within the yolk are called the yolk cells, merocytes or vitellophages.
- The vitellophages carry out breakdown of the yolk and are incorporated in the midgut epithelium.

d. Formation of Germ Band

- Initially Blastoderm forms a thin layer of cuboid cells subsequently they become columnar and thicker in the ventral region. This thickening is called embryonic primordia or germ band which develops ***future embryo***. The rest blastoderm remains as extra-embryonic membrane called serosa.

e. Gastrulation

Gastrulation is the process by which the mesoderm and endoderm are invaginated within the ectoderm. The germ band becomes differentiated into a median area called middle plates and two lateral areas called lateral plates. The gastrulation stage begins when the mesoderm is formed from the middle in one of the three ways

1. by an invagination of the middle plates,
2. by growing lateral plates over middle plate or
3. by proliferation of cells from the inner surface.

Cells proliferation from each end of the mesoderm (derived from middle plate) and eventually grow around the yolk. These represent the beginning of the endoderm (derived from vitellophages), and they form the lining of what will be the future mid gut of the insect.

f. Formation of the Embryonic Membrane

- The germ band becomes covered by one or more embryonic membranes. Soon after formation of germ band, the serosa from either side extend until both extensions meet and fuse in the ventral mid line.
- Small cavity forms on the ventral surface of the germ band called amniotic cavity. The amniotic cavity is bound by a membrane is called amnion.

g. Blastokinesis

- The ***embryo*** begins to move within the yolk, undergoing rotation, revolutions and marked displacement, the phenomenon is called blastokinesis.
- The movements taking place from the posterior to anterior pole of egg are termed as the ***anatrepsis***, whereas those from ventral to dorsal surface of the egg are called ***anatripsis***.

82. ENTOMOLOGY 15390

Management of Stored Insects in Relation to Climate Change

Roomi Rawal*

Department of Entomology, CCS Haryana Agricultural University, Hisar, 125004
**Corresponding Author Email: roomi.rawal78@gmail.com*

In the past, the effects of climate change were projected in connection with alterations in land and in the evolution of different forms of life. Although there are other contributing factors, of late climate change is related to global warming as the outcome of human activities. As a growing concern, prediction of climate change and its effects have demanded attention in several global Summits. Changing climate trends have also shown direct and indirect relationships to agriculture and global food production (Dinar *et al.*, 2012). In recent years, droughts and other harsh weather events explained as a result of the changing climate trends are becoming common. Numerous mitigation strategies are being developed to handle the crisis. Safe food grain storages by themselves are considered as a measure to adapt to the changing global climates and as a channel to food security, particularly in periods when agriculture fails (Jayas, 2012).

Stored grain is a man-made ecosystem undergoing incessant interactions between several abiotic (for example temperature, relative humidity, inter-granular CO_2 levels and moisture content) and biotic factors (such as insect pests, fungi, rodents and mites). Continuous interactions occur with time and unfavourable interactions cause grain deterioration. Changing seasonal patterns would promote favourable conditions for the growth and multiplication of insect pests in new geographical regions. For example, *Rhyzopertha dominica* (Lesser grain borer) which is native to the tropics is feared to develop as a serious pest in the UK (Cook *et al.*, 2004). Immediate storage of harvested grain (in warm condition), however, it would result in threats due to moisture condensation; an issue that needs to be dealt with caution. Studies indicate that storage conditions in the African continent are expected to improve with the

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changing climate and to some extent in Asia (Parry *et al.*, 2005). This is possibly because of earlier summers, higher temperatures, quicker crop growth cycles, earlier harvest, following storage of sufficiently low moisture grain and reduced need for subsequent drying operations. But in Europe, risks are estimated due to severe weather events, such as the European heat wave of 2003 that had antagonistic effects on the agricultural production of Europe (Beniston *et al.*, 2007). From a different viewpoint, higher levels of precipitation, floods and storms are also predicted with higher frequency during winter. This would in turn affect drying potential, consequent storage quality and allied expenses.

In general, delayed winters and rising seasonal temperatures would permit shorter periods for pests to complete their developmental cycles, thereby resulting in a much rapid built up in their populations. With respect to the insect type, diverse stages of its life cycle will show different levels of tolerance to climate change. For instance, eggs of *Tribolium confusum* are the most sensitive to increasing temperature and those of *Sitotroga cerealella* to CO_2. However, it is the larvae stage in case of *Oryzaephilus surinamensis* and the adult stage in case of *Lasioderma serricorne* and *S. paniceum* that are the least tolerant to increasing levels of CO_2 (Campolo *et al.*, 2013).

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83. PEST MANAGEMENT 15234

Pesticide Resistance in Insect Pests

Rishikesh Mandloi[1]*

Ph.D. (Ag.) Scholar, [1]Department of Entomology, College of Agriculture Jabalpur, JNKVV, Jabalpur-482004 (Madhya Pradesh) India*

**Corresponding Author Email: rkm.jnkvv@yahoo.com*

Pesticide Resistance

Meaning

- **Pesticide Resistance** is the ability of a life form to develop a tolerance to a **pesticide**. Pests (weeds, insects, mites, diseases, etc.) that become **resistant** to a **pesticide** will not be affected by the **pesticide**. When pests are **resistant**, it is more difficult to control the pest.
- **Definition:** the development of an ability in a strain of insects to tolerates dose of toxicant which would prove lethal to majority of the individuals in a normal population of a same species.

Types of Resistance

1. **Simple resistance**: resistance is limited to only one insecticide and not to the related ones.
2. **Cross resistence**: an insect resistance to one insecticide is also resistance to the related ones.
3. **Multiple resistance**: the co-existence of different defense mechanism in the same strain
4. **Monogenic resistance**: single gene is involved in development of resistance.
5. **Polygenic resistance**: several genes are involved in the development of resistance.

Factors of Pesticide Resistance

Propensity of pest populations to evolve resistance is probably caused by a number of factors. First, pest species are usually capable of producing large number of offspring. This increases the probability of random mutations and ensures the rapid build-up in numbers of resistant mutants once such mutations have occurred.

Secondly, pest species have been exposed to natural toxins for a long time before the onset of human civilization. For example, many plants produce phytotoxins to protect them from herbivores. As a result, co evolution of herbivores and their host plants required development of the physiological capability to detoxify or tolerate poisons.

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Thirdly, humans often rely almost exclusively on insecticides for pest control. This increases selection pressure towards resistance. Pesticides that fail to break down quickly and remain in the area contribute to selection for resistant organisms even after they are no longer being applied

Example

Resistance has evolved in a variety of different pest species: Resistance to insecticides was first documented by A. L. Melander in 1914 when scale insects demonstrated resistance to an inorganic insecticide.

Between 1914 and 1946, 11 additional cases of resistance to inorganic insecticides were recorded. The development of organic insecticides, such as DDT, gave hope that insecticide resistance was an issue of the past.

Unfortunately, by 1947 housefly resistance to DDT was documented. With the introduction of every new insecticide class – cyclodienes, carbamates, formamidines, organophosphates, pyrethroids, even *Bacillus thuringiensis* – cases of resistance surfaced within two to 20 years.

Management of Insecticide Resistance

Insecticide resistance management (IRM): The strategies used to delay to onset of resistance to manage resistance population are known as insecticide resistance management

Managing Strategies of Resistance

Pesticide resistance develops when pesticides are used too often and when the same pesticide or similar pesticides are used over and over again. Reduce the development of pesticide resistance by:

- Only using pesticides when necessary
- Using pest tolerant or resistant plant varieties
- Using cultural controls
- Using biological controls
- Monitoring to make sure pesticides are applied at the most effective time
- Using selective pesticides that break down quickly
- Only using tank mixtures of pesticides that have different sites of action
- Using the recommended application rate
- Getting complete coverage so all plant parts receive the proper pesticide dose
- Avoiding use of low rates with marginal pest control
- If there is more than one generation of pest, alternate different pesticide groups
- If the pesticide doesn't work, do not re-treat with a pesticide in the same group
- Alternating pesticides or pesticides in different groups

Pesticides have been grouped according to how they work (site of action). Reduce the development of pesticide resistance by alternating pesticides from the different groups.

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84. PEST MANAGEMENT 15346

Essential Oils in Insect Pest Management

Satyapriya Singh

Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi - 12, India.
**Corresponding Author Email: satyapriya_10797@iari.res.in, satyachintu25@gmail.com*

INTRODUCTION: Injudicious use of synthetic chemicals leads to pesticide treadmills. For instance, negative impact of these pesticides on non-target organisms including natural predators and parasitoids of different insect pests, their high toxicity to environment and human beings and the rapid development of pesticide resistance in insect pests and disease pathogens are the most peculiar scenarios. A necessary implementation of an IPM strategy is the only solution for alleviating these negative impacts of synthetic pesticides on environment and non-target organisms. In this context, biopesticides hold the premise for an increased reliability of in insect pests control and a successful integration of integrated pest management. Biopesticides encompass a large number of technologies, from microbial to botanicals. Among the botanicals, essential oils (EOs) are the major category. In recent years, the use of EOs derived from aromatic plants as low-risk insecticides have increased considerably owing to their popularity with organic growers and environmentally conscious consumers.

CONCEPT: Essential oils are defined as the products obtained from hydro distillation, steam

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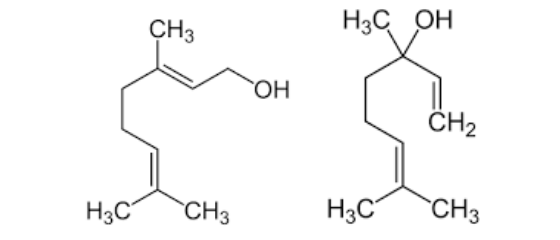
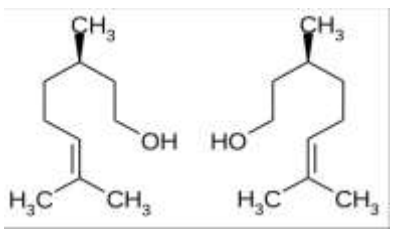
distillation, dry distillation, or mechanical cold pressing of plants (Regnault-Roger *et. al.,* 2012)). It contains many volatile, low-molecular-weight terpenes and phenolics. The major plant families from which EOs are extracted include Myrtaceae, Lauraceae, Lamiaceae, and Asteraceae. EOs have repellent, insecticidal, and growth-reducing effects on a variety of insects. They have been used effectively to control preharvest and postharvest phytophagous insects and as insect repellents for biting flies and for home and garden insects. The compounds exert their activities on insects through neurotoxic effects involving several mechanisms, notably through GABA, octopamine synapses, and the inhibition of acetyl cholinesterase. With a few exceptions, their mammalian toxicity is low and environmental persistence is short.

Phytochemistry of Essential oils

Plant EOs has been used since antiquity. The synthesis and accumulation of EOs are associated with the presence of complex secretory structures such as glandular trichomes (Lamiaceae), secretory cavities (Myrtaceae, Rutaceae), and resin ducts (Asteraceae, Apiaceae). Depending on the species considered, EOs are stored in various plant organs, *e.g.*, flowers (bergamot orange, *Citrus bergamia*), leaves (lemon grass, *Citronella* spp.; eucalyptus, *Eucalyptus* spp.), wood (sandalwood, *Santalum* spp.), roots (vetiver grass, *Chrysopogon zizanioides*), rhizomes (ginger, *Zingiber officinale*; turmeric, *Curcuma longa*), fruits (anise, *Pimpinella anisum*), and seeds (nutmeg, *Myristica fragrans*). EOs constituents belong mainly to two phytochemical groups: terpenoids (monoterpenes and sesquiterpenes of low molecular weight) and, to a lesser extent, phenylpropanoids.



Geraniol Linalool



Citronellol Citral

The sesquiterpenes (15-carbon) are formed via the mevalonate pathway in the cytosol. Monoterpenes present in EOs may contain terpenes that are hydrocarbons (-pinene), alcohols (menthol, geraniol, linalool, terpinen-4-ol, *p*-menthane-3,8-diol), aldehydes (cinnamaldehyde, cuminaldehyde), ketones (thujone), ethers [1,8-cineole (=eucalyptol)], and lactones (nepetalactone). Aromatic compounds are less common and are derived mainly from the shikimate pathway, for example, the phenylpropanoid dillapiole. A typical EO may contain 20 to 80 phytochemicals.

Uses

EOs and their constituents exert insecticidal effects or reduce and disrupt insect growth at several life stages. Eugenol, abundant in cloves (*Eugenia caryophyllata*), or cinnamaldehyde, abundant in cinnamon (*Cinnamomum verum*), exerts ovicidal, larvicidal, and adulticidal toxicity on the bean weevil, *A. obtectus*, and inhibits its reproduction. The oil of citronella (*Cymbopogon nardus*) repels mosquitoes and flies, and garlic (*Allium sativum*) oil is a deterrent to many insect herbivores (Regnault-Roger, 1997). EOs has several characteristics that improve their efficacy as insecticides. They are both phytochemically diverse (containing many biosynthetically different compounds) and redundant (containing many analogs of one class). Zhu et al. conducted a series of experiments to assess the repellency and toxicity of patchouli oil and its main constituent, patchouli alcohol, against the Formosan subterranean termite, *Coptotermes formosanus*. They demonstrated repellency and that paper filters treated with patchouli oil were less consumed by worker termites. The acaricidal activity of *Chenopodium ambrosioides* var. *ambrosioides* against adult mites *Tetranychus urticae* and *Panonychus ulmi* is the notable evidence in recent study. Extracts of some other varieties of *Chenopodium* were assayed and shown to have insecticidal properties against the western flower thrips (*Frankliniella occidentalis*), green peach aphid, and the greenhouse whitefly (*Trialeurodes vaporariorum*) (Chiasson *et. al.,* 2004). EOs also offers untapped potential in medical entomology.

Conclusion: One of the most attractive features of EOs is that they are, in general, low-risk products. Their mammalian toxicity is low and they are relatively well-studied experimentally and clinically because of their use as medicinal products. In terms of ecotoxicology, EOs are safe to use but not without potential problems. The development of EOs as plant protection products is especially suited to organic farming as well as to integrated pest management. They are natural in origin and biodegradable, have diverse physiological targets

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within insects, and, consequently, may delay the evolution of insect resistance. As a result, EOs has been embraced by the public and organic growers as an alternative or complementary approach to synthetic pesticides.

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85. AGRICULTURAL ENGINEERING AND TECHNOLOGY 15339

Current Research Trends in Probiotic Beverage from Small Millets: A Review

Ramya K. G., Farheen Taj and Veena R.

AICRP on Post Harvest Engineering and Technology, UAS, GKVK, Bengaluru-65

Millet is the staple food of millions inhabiting the arid and semi-arid tropics of the world and is considered a food security crop. Millet grains are nutritionally comparable and even superior to major cereals with respect to protein, energy, vitamins and minerals. Besides, they are a rich source of dietary fibre, Phytochemicals and micronutrients and hence they are rightly termed as 'nutricereals'. Rapid urbanization involving changes in occupation patterns, life styles, family structures and value system are reflected as changes in practices and in the level of physical activity. A large shift from consumption of coarse grains such as sorghum, barley, rye, maize and millet to more refined cereals, like polished rice and wheat is seen especially among the urban population and higher income groups. Probiotics are live microorganisms that are similar to beneficial microorganisms found in the human gut. Probiotics are available to consumers mainly in the form of dietary supplements and foods. Probiotics dramatically increase overall nutrition and enhance rapid cellular growth and development. The application of probiotic cultures in non-dairy products and environments represents a great challenge and needs to be researched at the industrial level for commercial production of these healthy products.

INTRODUCTION: Millet is the staple food of millions inhabiting the arid and semi-arid tropics of the world and is considered a food security crop (Rao; 1986). In India, large areas in different parts of the country are cultivated with millet. Millet grains are nutritionally comparable and even superior to major cereals with respect to protein, energy, vitamins and minerals. Besides, they are a rich source of dietary fibre, Phytochemicals and micronutrients and hence they are rightly termed as 'nutricereals'. Millets contain water soluble gum and β -glucan that is useful in improving glucose metabolism (Vijaya-Lakshmi & Radha; 2006). Studies show that individuals on a millet -based diet suffer less from degenerative diseases such as heart disease, diabetes, hypertension etc. Low glycemic index nutritious food products prepared from millet can be used as an effective support therapy in the treatment of diabetes mellitus (Arora & Srivastava; 2002).

Rapid urbanization involving changes in occupation patterns, life styles, family structures and value system are reflected as changes in practices and in the level of physical activity. A large shift from consumption of coarse grains such as sorghum, barley, rye, maize and millet to more refined cereals, like polished rice and wheat is seen especially among the urban population and higher income groups. These changes could result in a significant decrease in the overall fiber content of the diet (Popkin *et al.*, 2001) and associated with rising affluence induced by developmental transition contributed to increasing prevalence of overweight/obesity (Sindhi R & Jain S; 2006).

One viable strategy for improving public health is appropriate modification of the food supply to give products that deliver substantiated health benefits while retaining consumer appeal.

Cereals are prime targets in this regard. As dietary staples, relatively small improvements in grain composition (especially in starch and fiber) have the potential to translate into significant health gains at the population level when they are incorporated into food (Regina *et al.*, 2007). Although millets are nutritionally superior to cereals, yet their utilization in the country is not widespread. They are mostly used in preparation of traditional dishes. One possible way of

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extending their utilization could be by developing health beverages.

Need for Probiotic Beverages from Small Millets

Probiotics are live microorganisms that are similar to beneficial microorganisms found in the human gut. Probiotics are available to consumers mainly in the form of dietary supplements and foods. Probiotics dramatically increase overall nutrition and enhance rapid cellular growth and development. Probiotics also produce many important enzymes and increase the availability of vitamins and nutrients, especially vitamin B, vitamin K, lactase, fatty acids and calcium. They help to kill viruses and parasites thus providing benefits of increased health. People taking probiotics have experienced lowered cholesterol. Yeast and fungal infections are prevented, and sometimes eliminated with supplements of probiotics. In rural areas, people generally do not consume probiotics rich foods, thus making them prone to diseases such as diarrhea, dysentery and similar other stomach disorders. Probiotics have been used for centuries in fermented dairy products. However, the potential applications of probiotics in nondairy food products and agriculture have not received formal recognition. In recent times, there has been an increased interest to food and agricultural applications of probiotics, the selection of new probiotic strains and the development of new application has gained much importance (Shah; 2000). L. acidophilus, Bifidobacterium spp. and L. casei species are the most used probiotic cultures with established human health in dairy products, whereas the yeast Saccharomyces cerevisiae and some E. coli and Bacillus species are also used as probiotics. Probiotics products available in the markets today are mainly milk based; however, the increase in consumer vegetarianism and demand for cholesterol free probiotics has encouraged scientists and researchers to explore newer matrices as vehicles for probiotics.

Studies on Development of Probiotic Beverages

Probiotification of millet malt slurry viz pearl millet, foxtail millet, little millet by yeast and lactic bacteria was studied for the development of millet based probiotic beverages by Pampangouda (2014). The result revealed that millet malt slurry fermented by S. boulardii showed more reduction in pH (3.8), TSS (10.3 Brix) and highest titrable acidity (2.24 %). The malt slurry fermented by L. acidophilus showed highest score (8.5/9.0) with respect to overall acceptability and highest microbial population of 7.91×10^8 cfu/ml. After 30 days of storage at 40°C microbial population was slightly decreased and chemical properties was slightly changed.

Vasudha and Mishra (2013) reviewed the non- dairy probiotic beverages and reported that there is a demand for the vegetarian probiotic products owing to health consideration from the perspective of cholesterol in dairy products. These non- dairy probiotic beverages can serve as a healthy alternative for dairy probiotics and also favor consumption by lactose intolerant consumers.

Amal *et al* (2012) developed rice and millet probiotic beverage products using commercial probiotic starter culture of *Streptococcus thermophilus* (ABT-2), L. acidophilus and Bifidobacterium BB-12. They also reported that fermentation of cereal based substrates with ABT-2 culture improved the colour, flavour, texture and overall acceptability of the beverages. The slight changes in the counts of probiotic, pH and acidity during storage at 4°C did not influenced on shelf life up to 15 days of storage period.

Srikanth Samrat *et al* (2011) carried out a study to make a millet based probiotics drink by isolating Lactobacillus from curd and growing in lactose medium and incubated for 24 hrs. Fifty microlitres of this broth was inoculated into aqueous extracts of *Zea mays* (corn), *Oryza sativa* (rice) and *Eleusine coracana* (finger millet) and the growth of Lactobacillus after 48 h was quantified. They reported that the best growth was observed on rice extracts. Antimicrobial activity of the probiotics extract was evaluated against pathogens such as *Salmonella typhi*, *Shigella dysenterica* and *Mycobacterium smegmatis*. The zone of inhibition was maximum for Lactobacillus isolated from Oryza sativa. They concluded that the present study gives scope for administering Lactobacillus inoculated rice extract as probiotic supplement especially for the economical weaker sections.

The application of probiotic cultures in non-dairy products and environments represents a great challenge and needs to be researched at the industrial level for commercial production of these healthy products (Mattila- Sandholm *et al*., 2002).

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86. AGRICULTURAL ENGINEERING AND TECHNOLOGY 15340

Alternative Food Processing Methods to Enhance Microbial Safety and Quality

Ramya K. G., Veena R and Farheen Taj

AICRP on Post Harvest Engineering and Technology, UAS, GKVK, Bengaluru-65

Traditional food processing relies on heat to kill food borne pathogens, (bacteria, viruses, and parasites) to make food safe to eat. For many foods, heating is an effective way to treat foods. However, there are many foods that pose a risk for bacterial or viral food borne disease for which heat is either undesirable or cannot be used *e.g.* raw oysters. There has been a consumer demand for minimally processed food, such as pre-cut greens or fruit, or oysters that also has an extended shelf-life and is safe to eat. Researchers have been studying on non-thermal processing methods (methods that do not use heat) that will destroy pathogens and keep foods safe to eat, while retaining the sensory attributes and nutrient content similar to raw or fresh products. These alternative processing methods are at various stages of development and have the potential to destroy pathogens and retain desired food quality. Foods treated with non-thermal process are safer to eat then untreated products (*e.g.* oysters, sprouts) but still require refrigeration to delay spoilage. These non-thermal or alternative processing methods include high pressure, different forms of ionizing radiation, gases, light and chemical sanitizers.

The kinds of non-thermal processing methods that are currently being explored for a variety of ready-to-eat products to retain fresh attributes of food while ensuring safety are: High Pressure Processing (HPP) Gases (ozone, chlorine dioxide, cold plasma) Light (ultraviolet, pulsed light) Chemical (chlorine, surfactants) Ionizing radiation (gamma irradiation, electron beam).

Pulsed light (PL) is a non-thermal technology that uses short, intense pulses of white light which includes ultraviolet, infrared and visible light. Treatment of foods with PL has been approved by the FDA. PL is the same as the light seen outside, but it is much more intense. It is like a camera flash that is used to take pictures but far more intense. When this light is flashed on a food, it kills microorganisms but has minimal impact on the food. Short flashes of this intense light are used to prevent the temperature of the food from increasing. Within PL, there is ultraviolet light (UV) – the same light that causes sunburns in people. The UV light kills pathogens by disrupting the DNA. There are companies commercially using pulsed light for the UV germicidal component to disinfect food contact surfaces but not for produce or seafood applications.

Applications - Pulsed Light Treatment given to Eggs for Surface Decontamination

Eggs and egg-based products were frequently associated with salmonellosis outbreaks caused by *Salmonella Enteritidis* in the United States of America (U.S.A.), as well as in the European Union (E.U.) (Braden, 2006; EFSA, 2007). Eggs were treated with pulsed light of flashes of 2.1 Joule/cm^2 and 10.5 Joule/cm^2. Exposure to 2.1 Joule/cm^2 leads to death of Salmonella cells (5 log colony-forming units (CFU) per egg shell) on the egg surface with slight increase in temperature. Increase to 10.5 Joule/cm^2 did not cause penetration of Salmonella cells to the egg contents from the shell. No adverse effect on quality of egg albumin was observed. No effect on sensory and functional properties (Lasagabster *et al.*, 2011).

Pulsed Light Treatment for Freshly Cut Mushroom

Fresh slices of mushrooms were exposed to pulsed light treatment by flashing at 4.8, 12 and 28 Joules/cm^2 and it was found to increase the shelf life by 2-3 days in comparison to untreated

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samples. The native microflora reduction ranged from 0.6-2.2 log after 15 days of refrigeration. 12 and 28 Joule/ cm^2 treatments affected the texture due to thermal damage. It induced enzymatic browning due to increase in polyphenoloxidase activity. Some phenolic compounds and vitamin C content were found to be reduced. But 4.8 Joule/cm^2 increased shelf-life without affecting the texture and antioxidant. (Oms-Oliu *et al.*, 2010).

Continuous Flow Pulsed Light System for Bacterial Inactivation in Fruit Juices and Milk

Apple juice (pH of 3.49) and orange juice (pH of 3.78) were inoculated with gram positive (*Listeria innocua* 11288) and gram negative (*Escherichia coli* DH5-) bacteria. These were then subjected to continuous pulsed light system. Xenon-flash lamp emitting light in the range of 100-110 nanometer (nm) and with the flashes at constant frequency of 3 Hz and lasting for 360 microseconds (μs) was used. It was concluded that the lethal effect of pulsed light processing depends on the type of microorganism and the absorption properties of the liquid food. With treatment of 4 Joule/cm^2, the microbial load reductions in apple and orange juices for *Escherichia coli* were 4.00 and 2.90 Log-cycle respectively and for *Listeria innocua* were 2.98 and 0.93 Log-cycles respectively (Pataro *et al.*, 2011).

Decontamination of Packaging Material

Paper-polyethylene was artificially inoculated with spores such as *Cladosporium herbarum*, *Aspergillus niger*, *Aspergillus repens* and *Aspergillus cinnamomeus* and then exposed to pulsed light with fluence ranging from 0.244 to 0.977 Joule/cm^2. The highest level of inactivation of 2.7 log reduction was achieved. The colour of the spores affected their resistance to pulsed light. Different spores required different fluences for their inactivation (Turtoi and Nicolau, 2007).

The pulsed light processing is a new concept and has many applications in the food industry as a non-thermal technique of food preservation. While developing the applications of pulsed light processing, it is to be taken into consideration that the food to be processed, the microbial type and load affect the efficacy of the treatment. Though with some limitations, if complemented with other processing techniques this technology can help in better food preservation with minimal effects on the food quality. There are some microbial species resistant to the pulsed light processing technique and so such species should be studied and also the foods they contaminate be considered separately for processing. This technique has showed potent in reducing peanut allergy. It can be further studied to reduce other allergies associated with food. This technique being still new and hardly commercialized should be researched for economization.

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87. AGRIBUSINESS 15060

Practical Applications of Warehouse Receipt Financing and Key Issues

[1]Mahesh. M. Kadam and [2]Ranjit Patil

[1]Lovely Professional University, Punjab, [2]Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444 104

Warehouse receipt finance can be provided under different warehousing arrangements:

In a **private warehouse**, manufacturing and warehousing take place under the same roof, and both activities are controlled by the same company. The warehouse is just a part of the overall company operations, which may be manufacturing, wholesaling or retailing. It is very

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risky to use commodities in private warehouses as collateral for loans: other than spot checks by the bank, there is little to ensure that the goods are really present. • A field warehouse is an arrangement where a collateral management or credit support company takes over the warehouse of a depositor (producer/ customer) or a public warehouse by leasing it (or part of it) for a nominal fee, and becomes responsible for the control of the commodities to be used as collateral. • A **public warehouse** is normally a large storage area that serves many businesses, for example in a port or major transit centre. It is owned (or rented for a long period) and operated by a warehouse operator, which stores commodities for third parties for a fee and acts as the commodities' custodian.

Public warehouse operators often issue warehouse receipts that are acceptable as collateral by banks. However, the quality of the receipt as collateral depends on many factors, particularly the legal and regulatory regime in the country, and the financial status and integrity of the warehouse operator. The comparative advantages of different warehousing arrangements depend on several factors such as: i) the availability and integrity of public warehouses in rural areas; ii) cost structures; iii) types and sizes of transactions; and iv) quality of the legal and regulatory environment. Especially in countries where no well-functioning legal and regulatory framework is in place and where reliable public warehouses are in short supply in rural areas, field warehousing can be an attractive instrument for collateralized commodity financing. As the field warehouse is on or near the premises of the firm depositing the commodities, there is little disruption in the firm's day-to-day business; in effect, instead of the goods being moved to the warehouse, the warehouse is moved to the goods.

This form of **warehouse receipt finance** is therefore particularly useful where the borrower needs ready access to the commodities, such as for processing operations. Nevertheless, the existence of a network of reliable public warehouses in rural areas has substantial benefits: Whereas financing against the security of field warehousing is a bespoke transaction, with relatively high banking charges (and little possibility for a commodity firm to make banks compete with each other), public warehouses that are acceptable to banks can be used by a wide range of commodity owners to obtain ready access to finance. A well-developed public warehousing system also contributes to broader commodity and rural financial market development. For example, the use of public warehouses involves independent grading and quality certification of stored goods by the warehouse operator, enhancing transparency in commodity marketing. With tradable warehouse receipts, commodity transactions become easier and faster. A good system of **warehouse receipts** also facilitates the development of commodity exchanges, which require quality certification and delivery points. For financial institutions, warehouse receipts constitute at least a possessory pledge, which is superior to the pledging of assets in the borrower's possession. Elements of a warehouse receipt financing system A well-functioning warehouse receipt financing system based on public warehouses therefore has the potential to reduce risks and transaction costs in collateralized financing, which may result in broad-based access to such financing and low costs. A well-functioning mechanism for the control and oversight of public warehouses helps to ensure that the warehouse receipts they issue are acceptable collateral for the financial community. This is commonly accomplished through the creation of a government regulatory agency in charge of licensing and inspecting public warehouses. Public warehouses are required to maintain high levels of technical and financial performance, which needs to be monitored by a regulatory agency (which can be a self-regulatory structure). In addition, a public warehouse has to meet several technical standards and must prove its financial stability. Insurance is critical for all warehouse receipt finance. If warehouse receipts are not issued by reputed, international warehousing companies or collateral managers, the credit quality of the local warehouse operator can be upgraded by using insurance bonds or letters of guarantee, or by developing indemnity funds. The choice of the most appropriate method should be based on analysis of the local market infrastructure, evaluation of the risks, and the availability of financial and insurance services and products.

Conclusions: Finally, warehouse receipt financing requires a stable and predictable market and policy environment that preserves the incentives for private storage and financing. A certain level of seasonal price fluctuation is needed to attract commodity market participants and enable them to recover storage and financing costs. To nurture trust in the system, governments should therefore refrain from heavy market intervention and ad hoc and erratic policy measures. A good market information system reduces uncertainties regarding the value of the stored goods.

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88. AGRIBUSINESS 15320

The Innovative and Unique Business Model of ICT is "e-Choupal"

Netravathi G.[1] and Sumith R. Solunkhe[2]

Assistant Professor, Dept. of Extension Education, College of Agriculture, Navsari Agriculture University, Bharuch, Gujarat

Assistant Professor Dept. of Agriculture Extension, Polytechnic in Agriculture, NAU, Vyari, Gujarat

e-choupal is a Hindi word which means **"village meeting place"**. Market is a meeting place where vendors and customers come together to do transactions. e-choupal is a **virtual** market place where farmers can transact directly with a processor and can realize better price for their produce. e-choupal has the advantages of the market but spans very large varieties of vendors and customers. Geographical distances do not restrict participation in the e-choupal.

The main disadvantage of conventional market is that information asymmetry is inherent in the market where as e-choupal provides for transparent transactions. This enables the participation of smaller as well as larger players. Elimination of some layers of intermediaries allows for larger share of profits to reach the lower end of value chain. The main attractiveness of e-choupal is that it can be used for connecting large producers/small producers and small users/large users, thereby eliminating the need for hierarchy of brokers. Internet is used as a low transaction cost backbone for communication. Physical delivery of produce to the processor is still done through the existing intermediaries. e-choupal does not attempt total elimination of intermediaries, as intermediaries are indispensable in economy like India where intermediaries are adding value to the every step of value chain at a low cost.

Intermediaries have the expertise in storage, transportation, quality assessment and counter party risk reduction, which are difficult to replicate. e-Choupal provides farmers with all the market information and this helps them to become market oriented. In e-choupal intermediaries are leveraged but they are disinter mediated from the market information flowing to the farmers.

Idea Generation

The idea of creating and leveraging an electronic market place came from the brainstorming session done by senior executives of ITC-IBD. ITC believes in using a business model that does good to society and helps in improving the standard of living of stakeholders as well as add value to the shareholder wealth. He also believed that to tap the Indian rural market opportunity, and to reach across a wide range in rural India, the leaders have to understand and unleash the power of the small-scale entrepreneur in village communities.

ITC is the major exporter of soya bean. It used to buy soya bean mainly from the local markets. This created the problem of poor quality produce; need to handle a large variety and high cost of intermediation. Indian market has inadequate physical, social and institutional infrastructure that is substituted by intermediaries and they also add value to the chain on every step. ITC was looking for a solution that doesn't eliminate the intermediaries entirely but at the same time leverage their strengths.

IDENTIFYING THE PROJECT GOALS: The project was initiated with the objective of achieving a win-win situation for both farmers and the company. So on the one hand more profits and larger share of commodity exports were ensured for the company and on the other hand farmers realized better prices for their produce and improved the productivity of their farms.

Goals of ITC under e-Choupal

1. Helps enhance farm productivity by
   a) Disseminating latest information on district level weather forecasts for short & medium terms.
   b) Best practices in farming (generic as well as specific).
   c) Supply of quality inputs (seed, herbicide, fertilizer, pesticides etc) in the village itself.
2. Helps improve price realization for farm produce by
   a) Making available live data on markets viz. Location / Buyer wise prices offered.
   b) International market prices of relevant agri-commodities.
   c) Historical & Up-to-date information on supply & demand.
   d) Expert opinion on expected future price movements.

Working Model of e-Choupal

The e-Choupal model has been specifically designed to tackle the challenges posed by the

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unique features of Indian agriculture, characterized by fragmented farms, weak infrastructure and the involvement of numerous intermediaries, who block critical market information from passing to the farmers and use that information for getting a big margin for themselves. The intermediaries capitalized on the economies of information and economies of physical things, which are tied together in a bundle. Due to this, the farmer's does not get the proper price of its product & they continue to live below the poverty line. But e-Choupal sets things in order as it smoothens the flow of information to the farmers by disinter mediating intermediaries from the chain of information flow and at the same time leverages the physical transmission capabilities of the them as they deliver critical value at every link for a very low cost in a weak infrastructure environment. The structure of e-choupal is shown in **Fig 1**.

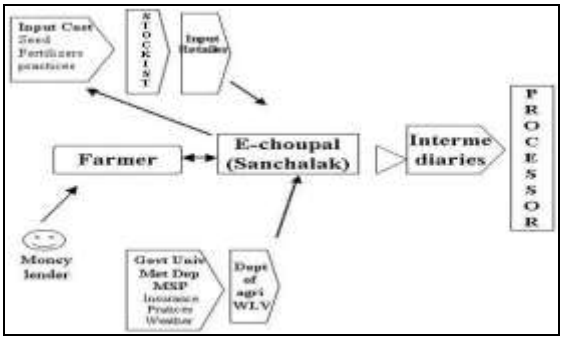

FIG. 1: e-Choupal, a new business model

e-Choupal is an ICT platform that facilitates flow of information and knowledge, and supports market transactions on line.

- It transmits **Information** (weather, prices, news).
- It transfers **Knowledge** (farm management, risk management).
- It facilitates sales of **Farm Inputs** (screened for quality).
- It offers the choice of an alternative **Output**-marketing channel (convenience, lower transaction costs) to the farmer right at his doorstep
- It is an interlocking network of partnerships (ITC + Met Dept + Universities + Input COs + Sanyojaks, the erstwhile Commission Agents) bringing the "best-in-class" in information, knowledge and inputs.
- e-choupal is, thus, distributed transaction platform that brings together sellers, buyers
- along with information and service providers.

Advantages of e-Choupal Model

- Customer centric.
- Capable of being used for many commodities and multiple transactions.
- Easily scalable once it is verified.
- Uses local talent and local people and develops local leaders.
- Can be extended to local as well as global procurers.
- Stimulates local entrepreneurs to extend their innovativeness.
- Uses all the existing institutions and legal frameworks.
- Many others can join the market as transaction time is low.

89. AGRIBUSINESS 15351

Agmarknet

Dr. Ingle Suchita Ganeshrao

Assistant Professor, Department of Agriculture Economics,
Rajiv Gandhi College of Agriculture, Parbhani, Maharashtra

The regulated Markets all over the country are collecting and disseminating the market information on arrivals and prices of notified agricultural commodities but there is need to accord priority to its dissemination after meaningful analysis. This is partially being done through AGMARKNET.

During the ninth Five year plan (1997-2002), the directorate of marketing and inspection (DMI), Government of India embarked on an ICT project named AGMARKET with the help of national Information Centre (NIC). AGMARKET has been started for linking all-important APMCs, SAMBs, state directorates and DMI Regional offices located throughout the country for effective exchange of information on market prices and arrivals of important commodities. AGMARKET is expected to play a catalytic role in market led agriculture extension in India. The AGMARKET scheme was started in October, 2000 and more than 2700 wholesale markets have been provided electronic connectivity under the scheme.

The major aim of the scheme is to collect and disseminate price and market related information in respect of agricultural commodities. Price related information in respect of agricultural commodities. Price related information in respect of agricultural commodities. Price related information on the

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portal includes maximum, minimum and modal price of the commodity and quantity of arrivals of more than 300 commodities and 2000varieties. Apart from the prices and arrivals, information related to standards and grade; labeling, sanitary and phyto-sanitary requirements; physical infrastructure of storage and warehousing and market laws and regulations is also provided in the portal of AGMARKET.

The scheme of AGMARKET is fully funded by the government of India. The scheme has also been given boost by Prasar Bharati (Doordarshan and All India Radio). Users can access website of AGMARKNET (www.agmarknet.nic.in) at any time. Future development involves linking all the agricultural wholesale markets in the country and establishing strategic alliance with government and non-government organization to disseminate information to the farmers who operate in these markets. The database developed under AGMARKET would also be linked to other agricultural database, for instance, on area, production, yield of crops, land use, cost of cultivation, agricultural exports and imports. This would provide sound base of planning demand driven agriculture production. AGMARKET is also expected to play a crucial role in embalming e-commerce in agricultural marketing.

The information being disseminated through the AGMARKET portal includes:

- Prices and arrivals (Daily Max., Min., Model, MSP, Weekly/Monthly prices and arrivals trends, future prices from three National commodity exchange)
- Grades and standards
- Commodity profiles
- Market Profiles
- Other Reports
- Research Studies
- Companies involved in contract Farming
- Schemes of DMI for strengthening Agricultural Marketing infrastructure

90. ECONOMICS 15364

Pradhan Mantri Fasal Bima Yojana

Tulika Kumari[1]*, Binita Kumari[2] and Priyanka Lal[3]

Ph.D. scholar, ICAR-National Dairy Research Institute
**Corresponding Author Email: tulikakumari42@gmail.com*

INTRODUCTION: A major portion of Indian citizen, mostly in rural areas depends on agriculture and farming. So it is very necessary to strengthen their crop insurance scheme so as to prevent them incur heavy losses, if crop gets damaged due to natural calamities and other unavoidable circumstances. Therefore, the prime minister of India, Shree Narendra Modi, has launched a new crop insurance scheme on 13th January, 2016. This crop insurance scheme is called "Pradhan Mantri Fasal Bima Yojana" which will be implemented in every states of India, with association with the respective state governments. The main motto of this scheme is to provide more efficient insurance support to the farmers of country and become a financial support to thousands of farmers. Government has decided to provide low premium insurance cover to farmers so they can sustain even if the yield is damaged.

Objectives

- To provide insurance coverage and financial support to the farmers in the event of failure of any of the notified crop as a result of natural calamities, pests & diseases.
- To stabilize the income of farmers to ensure their continuance in farming.
- To encourage farmers to adopt innovative and modern agricultural practices.
- To ensure flow of credit to the agriculture sector. This will contribute to food security, crop diversification and enhancing growth and competitiveness of agriculture sector besides protecting farmers from production risks.

Key Features

- Under this scheme if the farmer loses the crop due to any natural activity, then the 25% of the total loss will be provided instantly. The remaining amount will be paid after proper assessment of the situation.
- There will be a uniform premium of only 2% to be paid by farmers for all Kharif crops and 1.5% for all Rabi crops. In case of annual commercial and horticultural crops, the premium to be paid by farmers will be only 5%. The premium rates to be paid by farmers are very low and balance premium will be paid by the Government to provide full insured amount to the farmers against crop loss on account of natural calamities.
- There is no upper limit on Government subsidy. Even if balance premium is 90%, it will be borne by the Government.
- Earlier, there was a provision of capping the premium rate which resulted in low claims being paid to farmers. This capping was done to limit Government outgo on the

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premium subsidy. This capping has now been removed and farmers will get claim against full sum insured without any reduction.

- The use of technology will be encouraged to a great extent. Smart phones will be used to capture and upload data of crop cutting to reduce the delays in claim payment to farmers. Remote sensing will be used to reduce the number of crop cutting experiments.
- PMFBY is a replacement scheme of NAIS / MNAIS, there will be exemption from Service Tax liability of all the services involved in the implementation of the scheme. It is estimated that the new scheme will ensure about 75-80 per cent of subsidy for the farmers in insurance premium.
- The Scheme can cover all the Crops for which past yield data is available and grown during the notified season, in a Notified Area and for which yield estimation at the Notified Area level will be available based on requisite number of Crop Cutting Experiments (CCEs) being a part of the General Crop Estimation Survey (GCES).

Risk to be covered and exclusion: Following risks leading to crop loss are to be covered under the scheme:-

Yield losses (standing crops, on notified area basis), Prevented sowing (on notified area basis), Post-harvest losses (individual farm basis, Localized calamities (individual farm basis)

General Exclusion: Losses arising out of war and nuclear risks, malicious damage and other preventable risks shall be excluded.

Procedure for Assessment, Processing and Approval of Claims

- **Yield losses at Notified Area level:** Once the Yield Data is received from the State/UT Government as per the prescribed cut-off dates, claims will be processed, approved and settled by IA.
- **Claim Pay-outs** based on Yield losses shall be calculated as per the following formula:

$$\text{Claims Payout} = \frac{\text{Shortfall in Yield}}{\text{Threshold Yield}} \text{ X Sum Insured}$$

Where,

$$\text{Shortfall Yield} = (\text{Threshold Yield} - \text{Actual Yield})$$

- **Assessment of prevented Sowing:** The adverse weather conditions shall be defined in the notification and shall be captured by notified weather station/s in the district. The extent of claims payable will be decided on the basis of weather data recorded at the notified weather station/s for the purpose.
- **Localized Calamity Loss Assessment:** Loss assessment and modified indemnity procedures in case of occurrence of localized perils, such as hailstorm, landslide, flood, and inundation shall be for a cluster of affected farms or affected village and the settlement of claims, if any, will be each insured farmer covered under assessment.
- **Post-Harvest Loss Assessment:** Loss assessment and indemnity procedures in case of occurrence of Post-Harvest Loss shall be for a cluster of affected farms or affected village and the settlement of claims, if any, will be each insured farmer covered under assessment. The District Administration will assist IA in assessing the extent of loss.

Procedure for Settlement of Claims

- **For coverage through Banks:-**The claim amount along with particulars will be released to the individual Nodal Banks. The Banks at the grass-root level, in turn, shall credit the accounts of the individual farmers and display the particulars of beneficiaries on their notice board. The Banks shall provide individual farmer wise details claim credit details to IA and shall be incorporated in the centralized data repository.
- **For coverage through other insurance intermediaries**: The claim amount will be released electronically to the individual Insured Bank Account.

91. EXTENSION EDUCATION 15302

RAAKS - Rapid Appraisal of Agricultural Knowledge Systems: An Innovative Methodology

Suganthi N and Sujeetha T. N.

Post-Doctoral Fellow, Department of Agricultural Extension & Rural Sociology, TNAU, Coimbatore

INTRODUCTION: Project design for rural poverty reduction has shifted from top-down interventions to a more stakeholder-based innovation system perspective. **RAAKS** (Rapid Appraisal of Agricultural Knowledge Systems) is a methodology for facilitating agricultural innovation and rural development from this new perspective. It uses the agricultural knowledge and information systems (AKIS) perspective to look at the social organization of innovation.

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RAAKS action-research study is carried out in 3 phases: (A) problem definition; (B) analysis of constraints and opportunities; and (C) strategy development and action planning. **RAAKS** is methodology to help stakeholders gain a better understanding of their performance as innovators. It can be used to focus on the present and potential social organization of actors (groups or individuals) in a situation where innovation is desirable.

RAAKS provides a way to improve the generation, exchange and utilization of knowledge and information for innovation. Men or women villagers, researchers, policymakers, extension workers, consumers, producers of inputs or services, industrialists and/or traders, guided by a team of specialists, can all be involved in a **RAAKS** study. Central elements of **RAAKS** are teamwork, focused collection of information, qualitative analysis, and strategic decision-making.

RAAKS differs from participatory Rapid Rural Appraisal (RRA) and Participatory Technology Development (PTD) by its focus on the social organization of innovation, which is the way actors (individuals and organizations) build and maintain relationships with each other to foster innovation. Participatory Rural Appraisal focuses more on analyzing local farming and livelihood systems and general conditions enabling and/or constraining their development. PTD helps to create a process of creative interaction between local community members and outside facilitators, to experiment with and develop technologies. **RAAKS** complements both PRA and PTD. In practice, **RAAKS** teams often combine techniques from these and other participatory approaches

Applicability

1. Governmental, non-governmental and private organizations who feel pressed to improve their performance with respect to innovation. They include extension, research or development agencies, exporters of agricultural products, agro-industries, and national or international policymaking bodies;
2. Organizations or institutions that intervene on behalf of particular developments;
3. Managers of agricultural development programmes, extension managers, researchers, and development professionals in general. To them **RAAKS** is a way of facilitating inquiry into the constraints and opportunities that affect networking, cooperation and communication for innovation.

RAAKS can be used by

1. Field workers to chart out the knowledge and information networks in which you operate;
2. Trainers to encourage trainees to take a comprehensive, critical look at their performance as facilitators of innovation in agriculture;
3. Managers to encourage teamwork, self-monitoring and the generation of ideas on how to improve collective performance related to innovation, with built-in feedback and follow-up;
4. Researchers to develop an understanding of the social organization of innovation as a basis for proposals for action and/or further analysis; and
5. Consultants to facilitate a shared understanding among stakeholders, to define what can be done and by whom, and to improve the way stakeholders function together.

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92. EXTENSION EDUCATION 15344

Community Radio in India

Pratyusa Bakshi*

M.Sc.(Ag.), Department of Agricultural Extension, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, PIN- 741252

**Corresponding Author Email: pratyusa01@gmail.com*

INTRODUCTION: Community Radio implies a range of terms like “alternative”, “radical” or citizen radio. In sociology, a “community” is defined as a group of interacting people living in a common location. Community radio (CR) is a radio service offering a third model of radio broadcasting. Community stations serve geographic communities and communities of interest. They broadcast content that is popular and relevant to a local, audience. Community

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radio stations are operated, owned, and influenced by the communities they serve. They are generally non-profit. It has come to be known as the 'narrow casting' as opposed to 'broadcasting'. The introduction of the community radio is a milestone not only in reaching out to the remotest area but also persuading the citizen to share in the vision and excitement of development.

IMPORTANCE: In India, this concept can be effectively harnessed keeping in view the variety in region, culture, language, education and economic status. Community radio stations can be used to project and reflect the needs, desires, and problems of the common people. For example, the need to construct a new road, remove stagnant water, put down gang warfare or whatever problem is being faced by the people in a specific area, could be dealt with in a meaningful way, Fruitful negotiations could be held by the affected people with area development workers, local authorities and voluntary agencies. Similar background of, the people facilitates problem solving, and imparting instructions on various development related issues.

History of Community Radio in India: In India, the campaign of Community radio started in the mid-1990s, soon after the Supreme Court of India approved the idea, passed on its judgment in the month of February 1995, and declared "airwaves are public property".

Pioneering organizations such as Voices and Drishti Media therefore chose a concept called narrow casting to circumvent the policy restrictions. They worked with NGOs Myrada in Bangalore and Kutch Mahila Vikas Sangathan (a women collective) in Gujarat to train rural community reporters to produce audio programs just like it would be done in a radio studio.

Namma Dhwani (meaning, our voices), the setup at the village of Buddikote near Bangalore, even pioneered a new concept called cable casting where they used the cable TV network in the village for broadcast.

Anna FM is India's first campus 'community' radio that was launched on 1 February 2004, controlled by Education and Multimedia Research Centre and the students of Media Sciences at Anna University produce all programmes.

On 16 November 2006, the government of India advised a set of new Community Radio Guidelines that allowed the NGOs and other civil society organizations to possess and operate community radio stations. According to government sources, about 4,000 community radio licenses had been on offer across India.

Best Examples of Operating Community Radio in India

1. Radio Namaskar, based in Konark (Orissa) and established by Young India NGO with the support of UNESCO, which provided the transmitter;
2. Radio Dhadkan, based in Shivpuri (Madhya Pradesh) and run by Sambhav NGO in partnership with UNICEF.
3. Sangham Radio (Pastapur, Medak District, Andhra Pradesh).
4. Radio Bundelkhand (Orchha, Madhya Pradesh).
5. Mann Deshi Tarang (Satara, Maharashtra).
6. Namma Dhwani (Budhikote, Karnataka).
7. Radio Mattoli (Wayanad, Kerala).
8. Kalanjiam Samuga Vanoli (Nagapattinam, Tamil Nadu).
9. Barefoot (Tilonia, Rajasthan).
10. Kunjal Panchi Kutchji (Saras Crane of our Kutch), Gujarat State.
11. Mandakini Ki Awaaz (Voice of Mandakini), Uttarkhand State.
12. Kelu Sakhi (Listen, Friend), Karnataka State.
13. 'Chala Ho Gaon Mein' that is broadcast once a week on an AIR station in the Palamau district of Jharkhand

Basic Principles

An organisation desirous of operating a Community Radio Station (CRS) must be able to satisfy and adhere to the following principles:

1. It should be explicitly constituted as a 'non-profit' organisation and should have a proven record of at least three years of service to the local community.
2. The CRS to be operated by it should be designed to serve a specific well-defined local community.
3. It should have an ownership and management structure that is reflective of the community that the CRS seeks to serve.
4. Programmes for broadcast should be relevant to the educational, developmental, social and cultural needs of the community.
5. It must be a Legal Entity *i.e.* it should be registered (under the registration of Societies Act or any other such act relevant to the purpose).

Ministry of Information & Broadcasting, Government of India has come up with updated policy guidelines for setting up Community Radio Stations in India which has incorporated non-profit agencies, agricultural research institutes and schools in its ambit. According to the Ministry of Information & Broadcasting by November 2009 more than 40 community radio stations were operational in India.

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Components of Community Radio

Essential Technical Parameters	Manpower Requirement
The tower should be constructed to a maximum height of 30m which is allowed to prevent possibility of biological hazards of Radio Frequency (RF) radiation. Transmitter- should be Effective Radiated Power (ERP) specified is 100 W. Antenna with a feeder cable mounted on tower. Studio equipment comprising Recording and Playback equipment. Studio Console/ Mixer. Monitoring equipment.	Production in-charge Technician (studio operations) Researcher getting latest information from the community Several volunteers (for programme promotion) Monitor Maintenance Engineer (Contract)

Content Regulation and Monitoring

1. The programmes should be of immediate relevance to the community. The emphasis should be on developmental, agricultural, health, educational, environmental, social welfare, community development and cultural programmes. The programming should reflect the special interests and needs of the local community.
2. At least 50% of content shall be generated with the participation of the local community, for which the station has been set up.
3. Programmes should preferably be in the local language and dialect(s).
4. The Permission Holder shall have to adhere to the provisions of the Programme and Advertising Code as prescribed for All India Radio.
5. The Permission Holder shall preserve all programmes broadcast by the CRS for three months from the date of broadcast.
6. The Permission Holder shall not broadcast any programmes, which relate to news and current affairs and are otherwise political in nature.
7. The Permission Holder shall ensure that nothing is included in the programmes broadcast which: a. Offends against good taste or decency; b. Contains criticism of friendly countries; c. Contains attack on religions or communities or visuals or words contemptuous of religious groups or which either promote or result in promoting communal discontent or disharmony etc.

Funding

Government: Community Radio is a non-profit initiative by the members of the community but has its own operational costs. To start with, there needs to be an initial investment of Rs.2, 50,000 to Rs. 3, 00,000. An additional running cost of Rs. 20, 000 per month is required to pay for staff salaries, electricity, generator fuel, travel and other expenses. Hence, funds are of utmost importance. According to the new policy guidelines of the Ministry of Information & Broadcasting applicants are eligible to get funds from multilateral agencies.

UNESCO: Apart from initiatives on the part of the government, international bodies like UNESCO are also helping with funds for making community radio experience a success story in India. UNESCO's International Programme for the Development of Communication (UNESCO-IPDC) has approved funds in the amount USD 60,000 to help in the establishment of first 10 Community Radio Stations in India. The aim of the funds is to support CR stations in tribal areas in cooperation with organizations like Alternative India Development (AID).

SCOPE: In a country like India where there is diversity in all aspects, community radio can be used as a potent tool of development. It can be used to make communities aware of various social issues like dowry, forceful marriage of young girl child, birth control, nutrition and eco-balance, health issues like HIV. Community radio can be effectively used to provide information about weather conditions, train and bus timings in the locality.

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93. FOOD AND NUTRITION 15347

Food and Nutritional Requirements of Expectant Mother

Pratibha Thombare

M.Sc. Scholar, Dept. of Foods and Nutrition, Home science, VNMKV, Parbhani-431402
**Corresponding Author Email: pratibhathombare93@gmail.com*

Carrying an unborn child or foetus in the womb is known as pregnancy. The period of pregnancy is marked by high accumulation of nutrients in the form of during pregnancy is of great

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importance because foetus draws its nourishment from mother. It the nutrition of mother is inadequate then her body reserve are drawn up and depleted. Child bearing imposes a great strain, even though it is a normal physiological process. It increases considerably the nutritional requirements of the mother.

Reasons for Increased Food Intake

1. **Growth of foetus:** In Early stages and upto 12 week the embryo depend upon the surrounding tissues for its nourishment. Later on the embryo develops into foetus by increase in weight from a more 12 g around 12 week to a full grown baby about 3.2 kg around 40 week. In ordered to meet this rapid growth which includes formation of bone, production of blood and building muscles, brain and other tissues, the foetus need ready-made nutrients. These are slowly derived from the mother body through her blood stream. It is therefore necessary that thought pregnancy and particularly after 12th week till delivery mother should pay special attention to the kind ad quantity of food. She eats, since this the health of new born baby.
2. **Changes in mother:** In addition to meet the needs of the growing baby in the womb, nourishment is required for certain other purposes as well with development of baby, important changes take place in mothers body. There is an enlargement of child bearing organs, an increase in the breast tissues to meet the subsequent demand of lactation and increase in amount of circulating blood to the facilitate the supply of nourishment to the newly built tissues.
3. **Energy metabolism:** Energy metabolism increase during pregnancy by 5% during the first and second trimester and by about 12% during the third trimester.
4. **Role of placenta:** The placenta is the principle site of production for several hormones responsible for regulation of fetal growth and development of maternal support tissues. It is also involved for exchange of nutrients, oxygen and waste products.
5. **Blood composition:** The plasma volume increases on an average by about 50% and the red cell mass by about 20%.
6. **Increase in body weight:** The weight gain during first trimester is about 0.7 to 1.5kg. The weight gain during 2nd and 3rd trimester is about 350g/week. A full term total weight gain about 10-12kg.

ICMR Recommended Dietary Allowances of an expectant mother-2010

Sr. No.	Nutrient	Normal adult women	Pregnant women (For second and third trimester)
1	Energy kcals		
	Sedentary work	1900	+350
	Moderate work	2230	+350
	Heavy work	2850	+350
2	Protein (g)	55	82.2
3	Visible fat (g)		
	Sedentary work	20	
	Moderate work	25	30
	Heavy work	30	
4	Calcium (mg)	600	1200
5	Iron (mg)	21	35
6	Vitamin A		
	Retinol	600	800
	B-carotene	4800	6400
7	Thiamine		
	Sedentary work	1.0	
	Moderate work	1.1	+0.2
	Heavy work	1.4	
8	Riboflavin (mg)		
	Sedentary work	1.1	
	Moderate work	1.3	+0.3
	Heavy work	1.7	
9	Niacin (μg)		
	Sedentary work	12	
	Moderate work	14	+2
	Heavy work	16	
10	Pyridoxine (mg)	2.0	2.5
11	Ascorbic acid (mg)	40	60
12	Dietary folate (μg)	200	500
13	Vitamin B_{12} (μg)	1.0	1.2
14	Magnesium (mg)	310	310
15	Zink (mg)	10	12

Dietary Pattern

1. Small and frequent feedings should be taken. Avoid fasting or missing any meal.
2. More fiber should be included in the diet to prevent constipation which is common problem during pregnancy. 5-6 servings of fruits and vegetables should be included in the daily diet.
3. Diet should be rich in calcium to prevent osteomalacia, calcium supplements may also be taken.
4. Iron rich foods should be taken to prevent anemia and to build up iron stores in the foetal body. Iron supplements may be taken.
5. Diet should contain optimum amount of

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sodium in case of oedema or hypertension, sodium is restricted.
6. Inclusion of green leafy vegetables ensures minerals like calcium and Iron.
7. Plenty of water should be taken to keep the bowels regular.
8. Fatty rich foods, fried foods, excessive seasoning, strongly flavoured vegetable may be restricted in case of nausea and gastric distress.
9. Fluids should be taken between meal rather that along with the meals.
10. Adequate amount of calories should be taken so that enough fat is deposited during pregnancy which is required for lactation.

Dietary Problems

1. **Nausea and vomiting:** Nausea in pregnancy may be due to nervous disturbances, placental protein intoxication or due to derangement in carbohydrate metabolism. Morning sickness of early pregnancy can be improved by small and frequent meals liquids may be taken between meals instead of with food. Fatty rich foods, fried foods, excessive seasoning, coffee in large amount and strongly flavoured vegetables may be restricted.
2. **Anemia:** Iron deficiency anemia during pregnancy increases the likelihood of premature birth. The baby at birth is less well supplied with hemoglobin and thus is likely to become anemic during the first year of life. This anemia are prevented or treated by supplements of iron and folacin, respectively.
3. **Constipation:** Constipation is rather and common during the latter part of pregnancy. It can usually be avoided by placing more emphasis upon raw fruits and vegetables, some whole grain breads and cereals, a liberal intake of liquids and a regular program of exercise.
4. **Heart burn:** Heart burn is a common complaint during the latter part of pregnancy. In most cases, this is an effect of pressure of the enlarged uterus in the stomach results in occasional regurgitation of the stomach contents into the esophagus. This can usually be relieved by limiting the amount of food consumed at one time and drinking fluids between meals. Papaya and gingerly seeds are heat producing and should be avoided.
5. **Oedema and leg cramps:** Mild physiological edema is usually present in the extremities in the third trimester. The swelling of the lower extremities may be caused by the pressure of enlarging uterus on the veins returning fluid from the legs. This normal edema requires no sodium restriction or other dietary changes. The common occurrence of cramps during pregnancy. Prevention of these leg cramps has been reported with reduction of milk intake and supplementation with non-phosphate calcium salts. Magnesium is another mineral with the potential for relieving leg cramps.

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94. HUMAN HEALTH 15222

Eco-Friendly – Enzyme Based Biodetergent

Gajanan Deshmukh[1], Preeti Birwal[1], Rekha Menon, Saurabh Patel[1]

[1]Ph.D. Research Scholar, ICAR- National Dairy Research Institute, SRS, Bangalore
[2]Sr. Scientist, ICAR- National Dairy Research Institute, SRS, Bangalore
**Corresponding Author Email: gajanannnn@gmail.com*

INTRODUCTION: Cleanliness is said to be next to Godliness. In the dairy and food industry, cleaning is very important and it is imperative that all the food contact surfaces of processing and handling equipment be clean and hygienic, to prevent microbial contamination and to produce quality food products. To achieve this goal different types of detergents are being currently employed. Detergent is defined as a substance which when added to water increases the cleaning properties of that water. The use of current synthetic detergents has a drawback of creating environmental pollution problems, due to their non-biodegradability, corrosiveness and toxicity. Their prolonged use in larger dairy plants had led to the formation of slumps, resulting in unhygienic conditions in the surroundings. Further such compounds, even in small quantities, can cause considerable increase in the BOD levels thus disturbing the ecological balance of the area. These drawbacks of synthetic detergent leads to the development of novel enzymes based bio detergent.

Enzyme based Detergent Formulations

Bio detergents are enzyme-based detergents

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(also known as 'green chemicals') designed to break down protein, starches, and fat that occurred on equipment surface of food and dairy industry. Various enzymes such as proteases, amylases, lipases and cellulases are the indispensable ingredients used in these detergents. The cleaning ability of these formulations is mainly due to the synergistic action exhibited by the different detergent ingredients and the enzyme-preparations. Nowadays, enzyme-based detergents are very popular over the conventional synthetic ones in view of their better cleaning properties, ability to work effectively at lower temperature (30-50°C) and environment friendly nature. Presently, Proteases, Amylases, Lipases and celluloses make up the major portion of the market for industrial enzymes in cleaning applications.

TABLE 1: Commercial enzymes used in Detergent formulations.

Trade Names	Source organism	Manufacturer
Alkaline proteases/ subtilisins		
Alclase	Bacillus licheniformis	Novo Nordisk, Denmark
Savinase	Alkaliphilic Bacillus sp.	Novo Nordisk, Denmark
Esperase	Alkaliphilic Bacillus sp.	Novo Nordisk, Denmark
Liquanase		Novo Nordisk, Denmark
Everlase		Novo Nordisk, Denmark
Ovozyme		Novo Nordisk, Denmark
Polarzyme		Novo Nordisk, Denmark
Maxacal	Alkaliphilic Bacillus sp.	Gist-brocades, Delft, The Netherlands
Maxatase	Alkaliphilic Bacillus sp.	Gist-brocades, Delft, The Netherlands
Opticlean	Alkaliphilic Bacillus sp.	Solvay Enzymes GmbH, Hannover, Germany
Optimase	Alkaliphilic Bacillus sp.	Solvay Germany
Protosol	Alkaliphilic Bacillus sp.	Advanced Biochemicals Ltd., Thane, India
Alkaline protease "Wuxi"	Alkaliphilic Bacillus sp.	Wuxi Synder Bioproducers Ltd., China
Proleather	Alkaliphilic Bacillus sp.	Amano Pharmaceuticals Ltd., Nagoya, Japan
Protease P	Aspergillus sp.	Amano, Japan
Durazym	Protein engineered variant of Savinase	Novo Nordisk, Denmark
Maxapem	Bleach-resistant, protein engineered variant of Alkaliphilic Bacillus sp.	Solvay, Germany
Purafect	Recombinant enzyme donor Bacillus lentus Expressed in Bacillus sp.	Genecor International Inc., Rochestar, USA
Amylases		
BAN	Bacillus amyloliquefaciens Recombinant enzyme Donor- Humicola sp. Expressed in Aspergillus sp.	Novo Nordisk, Denmark
Termamyl		Novo Nordisk, Denmark
Stainzyme		Novo Nordisk, Denmark
Duramyl		Novo Nordisk, Denmark
Maxamyl	Alkaliphilic Bacillus sp.	Gist-brocades, Delft, The Netherlands
Solvay amylase	Thermostable Baculis licheniformis	Solvay, Germany
Lipases		
Lipolase	Recombinant enzyme Donor-Huicola lanuginosa Expressed in Aspergillus oryzae	Novo Nordisk, Denmark
Lumfast	Recombinant enzyme Donor-Pseudomonas mendocina Expressed in Bacillus sp.	Genencor, USA
Lipofast	NA	Advanced Biochemicals, India
Cellulases		
Celluzyme	Humicola insolens	Novo Nordisk, Denmark
Endolase		Novo Nordisk, Denmark
Mannanase		
Mannaway		Novo Nordisk, Denmark

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95. HUMAN HEALTH 15229

Health Benefits of Noni Plants

[1]Patre P. R., [2]Abuj B. B. and [3]Garje V. K.

[1]Ph. D. Scholar Department of Biotechnology, SRTMU Nanded
[2]Dept. of Biochemistry and Molecular Biology, [3]Dept. of Plant Biotechnology, Aditya College of Agricultural Biotechnology, Beed, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani-431122

INTRODUCTION: Fruits are generally acceptable as good source of nutrient and supplement for food in a world faced with problem of food scarcity. They are known to be excellent source of nutrients such as minerals and vitamins. Noni, commonly known as great morinda, Indian mulberry, Nunaa (in Tamil) is a drought tolerant tree and in any type of degraded and unfertile land, particularly performs better in sandy loamy soil. The tree has attained significant economic importance worldwide in recent years through a variety of health and cosmetic products made from its leaves and fruits. Fetid oil obtained from seeds is used as insecticide or insect repellent in Hawai.

The Morinda citrifolia plant especially its fruit, has been used for centuries in folk medicine. The most important compounds identified in noni fruit are phenolics, such as damnacanthal and scopoletin, organic acids (caproic and caprylic acid), vitamins (ascorbic acid and provitamin A), amino acids such as aspartic acid, and minerals. Another compound named xeronine, supposedly an alkaloid, has been reported.

Nutrional composition of noni

Among phytochemical compounds have been identified in the noni plant, and the major components are phenolic compounds, organic acids and alkaloids. Of the phenolic compounds, the most important reported are anthraquinones (damnacanthal, orindone, morindin, etc.), and also aucubin, asperuloside, and scopoletin. The main fatty acids are caproic and caprylic acids, while the principal alkaloid is xeronine.

The complete physico-chemical composition of the fruit has not yet been reported and only partial information is available on noni juice. The fruit contains 90% of water and the main components of the dry matter appear to be soluble solids, dietary fibers and proteins. Thefruit protein content is surprisingly high, representing 11.3% of the juice dry matter, and the main amino acids are aspartic acid, glutamic acid and isoleucine.

Biological activity of Noni

1. Anti-Microbial Effects: M. citrifolia antibacterial activity against certain infectious bacterial strains such as Pseudomonas aeruginosa, Proteus morgaii, Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Salmonella and Shigella. He accentuated that the antimicrobial effect observed may be due to the presence of phenolic compounds, such as acubin, L-asperuloside, and alizarin in the fruit, as well as some other anthraquinone compounds in roots. antimicrobial effect on different strains of Salmonella, Shigella, and E. coli. acetonitrile extract of the dried fruit inhibited the growth of P. aeruginosa, B. subtilis, E. coli, and Streptococcus pyrogene.

It also helps in stomach ulcer through inhibition of the bacteria, *H. pylori* (Duncan et al., 1998). aqueous crude extracts of the fruit against *E. coli*, *Streptococcus* species, *Vibrio alginolyticus,* and *Vibrio harveyi*. It has also been found that ethanol and hexane extract of this fruit provide protection against *Mycobacterium tuberculosis*.

Antimicrobial activity was tested against Gram positive (*Staphylococcus albus* and *B. subtilis*) and Gram negative (*P. aeruginosa* and *Klebsiella pneumonia*) bacteria using 37 crude drug samples from different parts of 24 plants. Most of them exhibited antibacterial activity only against Gram positive bacteria. Antitumor activities were screened in mice bearing sarcoma 180 cells.

2. Anti-Cancer Activity: It has been reported that methanol extract of the fruit at a concentration of 0.1 mg/ml exhibited cytotoxic activity against breast cancer (MCF7) and neuroblastoma (LAN5) cell lines at 29 and 36%, respectively in 3-(4,5- dimethythiazol-. 2-yl)-2,5-diphenyl tetrazolium bromide (MTT) assay. The ethanol precipitable fraction (ppt) of noni juice, corresponding to a polysaccharide- rich substance composed of glucuronic acid, galactose, arabinose, and rhamnose, has been found to have immunomodulatory and anti-tumor effects against Lewis lung carcinoma (LLC). Noni also appears to stimulate the release of several mediators from murine effector cells such as cytokines, which slow down the cell cycle in tumors, increase the response of cells to other immunized cells that fight tumor growth, and have a potent macrophage activator activity, suspected of playing a role in the death of tumors.

3. Anti-Oxidant Properties: The ethyl acetate

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extract of noni fruit have strong inhibition of lipid oxidation comparable to the same weight of pure *a*-tocopherol and butylated hydroxy toluene (BHT). The superoxide anion radicals (SAR) scavenging activity of noni juice was shown to be 2.8 times higher than that of vitamin C, 1.4 times that of pycnogenol (PYC).

4. Anti-Inflammatory Activity: The aqueous extract of the fruit was investigated for anti-inflammatory activity against bradykinin and carrageenan induced oedema in the rat paw. The results showed that the bradykinin-induced inflammatory response was inhibited and subsided rapidly in rats that were pretreated either orally or intraperitoneally with fruit juice extract, whereas a higher dose of extract was required to completely inhibit the inflammatory response to carrageenan. Noni juice has a selective inhibition effect on some cyclo-oxygenase enzymes (COX-1 and COX-2) involved in breast, colon and lung cancer, and also in anti-inflammatory activity. The inhibition of the activity of these enzymes by noni juice was comparable with that of commercial traditional non-steroidal inflammatory drugs such as aspirin, indomethacins and celebrexs.

5. Analgesic Activity: Noni root extract (1600 mg/kg) showed significant analgesic activity in the animals, similar to the effect of morphine (75% and 81% protection using noni extract and morphine, respectively), and it also proved to be non-toxic.

6. Cardiovascular Activity: Noni fruit preventing arteriosclerosis, a disease related to the oxidation of low density lipoproteins (LDL). This beneficial effect could be due to the presence of lignans, phenylpropanoid dimers. Oxidation of LDL has been recognized as playing an important role in the initiation and progression of atherosclerosis. Methanol and ethyl extract of fruit showed 88 and 96% inhibition, respectively of copper-induced oxidation of low density lipoprotein particles in vitro. Six lignans were isolated from ethyl extract of the fruit and has been showed to have inhibiting effect of copper induced LDL oxidation in a dose-dependent manner. M. citrifolia root extract are mediated through blockade of voltage-dependent calcium channels and it showed antidyslipidemic effects and it can be used as a potential medicine for cardiovascular diseases.

7. Anti-Obesity and Hypoglycemic Effects: In effect, noni juice reduced the rate at which food exited the stomach when taken as a juice for seven consecutive days. Although, the mechanism is not clear, it may mean that it acts like an appetite suppressant, useful for weight loss if future studies show a similar effect in humans. Noni juice reduced body weight by 40%, when a mice fed a control diet and whereas 25% in high-fat-diet (HFD). A Japanese research team has also studied more specifically the hypoglycemic effects of the anthraquinone damnacanthol-3-O-beta-D-primeveroside and lucidin 3- O-beta-D-primeveroside by roots on streptozotocin (STZ)-induced diabetic mice and result showed that these molecules are responsible for the hypoglycemic effects. The elucidate cellular and molecular mechanisms involved in anti-obesity and hypoglycemic effects.

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96. HUMAN HEALTH 15327

Amazing Benefits of Tender Coconut Water

G. Anupama[1] and N. Ashoka[2]

[1]Assistant Horticulture Officer, Horticulture Training Centre, Munirabad -583233
[2]Assistant Professor of Agricultural Economics, College of Horticulture, Munirabad -583233

Coconut water is the ultimate thirst quencher and offers a tasty alternative to water. This pure liquid is packed with nutrients that yield an array of health benefits. Coconut water refers to the liquid endosperm of a tender coconut at an age of approximately 9 months from time of pollination, the period before the solid endosperm or white meat forms. It is a pure and nutritious beverage in the natural state. The coconut husk is an excellent package for the water which contains sugars, minerals, amino acids and vitamins. Tender coconut water is a natural source of electrolytes, minerals, vitamins, complex carbohydrates, Amino acids and other nutrients. The natural carbohydrate content is between 4-5% of the liquid solution. This make coconut water particularly suitable for the burgeoning sports drink market. Isotonic and bacteriologically sterile properties of fresh coconut water, straight out of the nut, promoted its use as a direct plasma replacement by military forces in the Asian theatre of combat during World War II. It has caloric value of 17.4 per 100gm. "It is unctuous, sweet, increasing semen, promoting digestion and clearing the urinary path," says Ayurveda on tender coconut water.

Numerous medicinal properties of tender coconut water reported are:-

1. Aids in Weight-loss Efforts: The fat content in coconut water is extremely low, so generous quantities can be consumed without the fear of immediately packing on the pounds. It also suppresses the appetite and makes you feel full because of its rich nature.

2. Picture-Perfect Skin: For those with acne or other blemishes on the surface of the skin, topical application of coconut water can go a great distance as it has the ability to clear up and subsequently tone the skin. It also moisturizes the skin from within if ingested orally and eliminates large amounts of oil. This explains why products such as facial creams, shampoos, conditioners and lotions that contain traces of coconut extract are more effective.

3. The Ultimate Hangover Remedy: Next time you overdo it and drink more than your belly can handle, consume coconut water to settle your stomach. It will also replace those essential electrolytes that exit the body if you experience bouts of frequent urination and vomiting.

4. Facilitates Digestion: If you constantly encounter difficulty during the digestion process, coconut water may provide a source of relief. Because of its high concentration of fiber, it aids in the prevention of indigestion and reduces the occurrence of acid reflux.

5. Boosts Hydration: The ingredients in coconut water are way more effective at hydrating the human body than those of sports and energy drinks. During rigorous exercise or extended periods of physical activity, the human body loses mineral-rich fluids. However, coconut water serves as an excellent replacement medium with 294 mg of potassium and 5 mg of natural sugar per glass, unlike your favorite sports drink that only contains half of the potassium content and five times the amount of processed sugar. In addition, the sodium count is only 25 mg, which is relatively low compared to the 41 and 20 mg found in sports drinks and energy drinks respectively.

6. Reduces Blood Pressure: In many instances, a disproportionate level of electrolytes can result in high blood pressure. Because coconut water contains an adequate supply of each, it can be used as a balancing mechanism. In some instances, it is recommended that coconut water be consumed at the start of each day to foster the balance of these electrolytes.

7. Rich in Nutrients: Unlike any other beverage on the market, coconut water contains five essential electrolytes that are present in the human body. These include: calcium, magnesium, phosphorous, potassium and sodium. Because of its unique composition, coconut water can be enjoyed by individuals with varying medical conditions.

8. Compatible with Human Blood: Since it is isotonic to human plasma, coconut water can be used in extreme emergencies to quickly rehydrate the human body if administered intravenously. It is not uncommon for the drink to be used in poorer, third-world countries to save human lives.

Analysis of Mature and Tender Coconut Water

	Mature Coconut Water	Tender Coconut Water
Total solids%	5.4	6.5
Reducing sugars %	0.2	4.4
Minerals %	0.5	0.6
Protein %	0.1	0.01

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	Mature Coconut Water	Tender Coconut Water
Fat %	0.1	0.01
Acidity mg %	60.0	120.0
pH	5.2	4.5
Potassium mg%	247.0	290.0
Sodium mg%	48.0	42.0
Calcium mg%	40.0	44.0
Magnesium mg %	15.0	10.0
Phosphorous mg%	6.3	9.2
Iron mg%	79.0	106.0
Copper mg%	26.0	26.0

Source: Satyavati Krishnankutty (1987)

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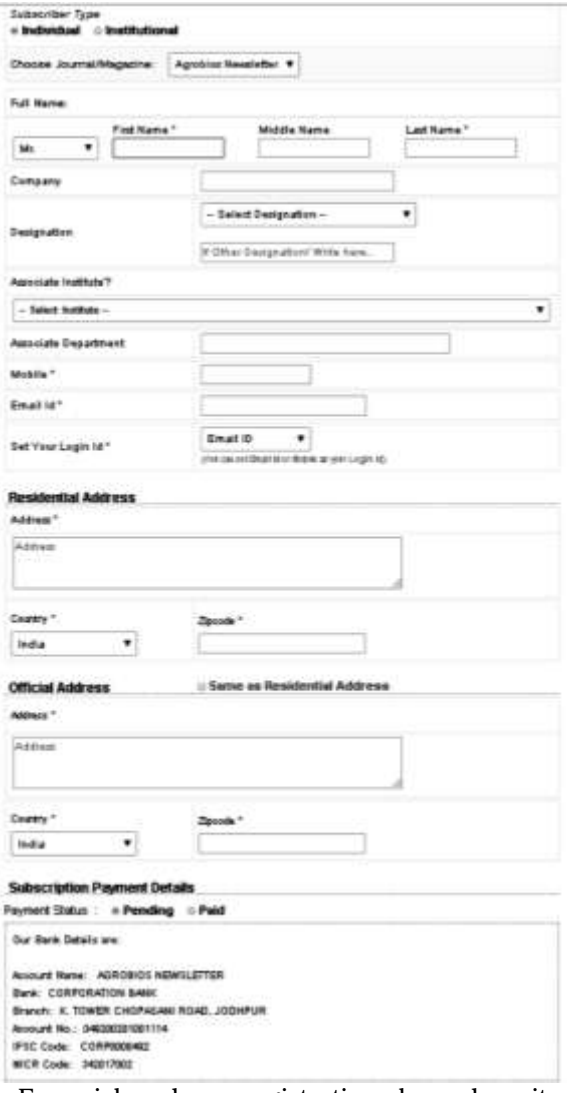

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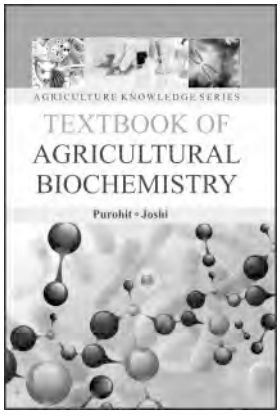

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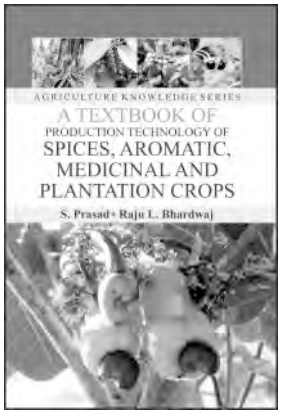

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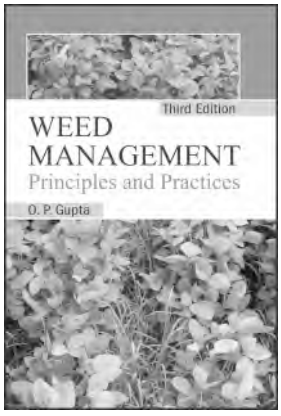

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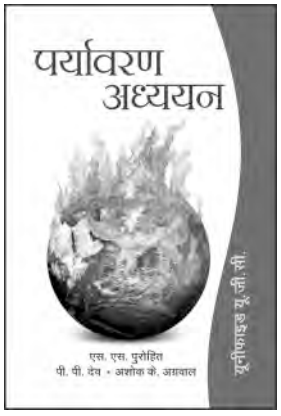

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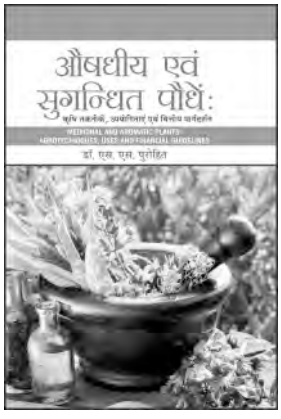

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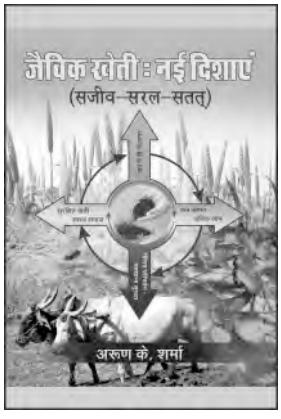

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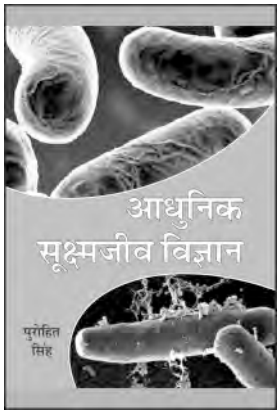

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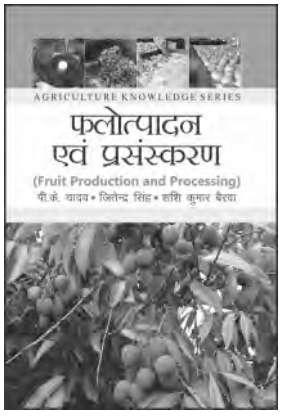

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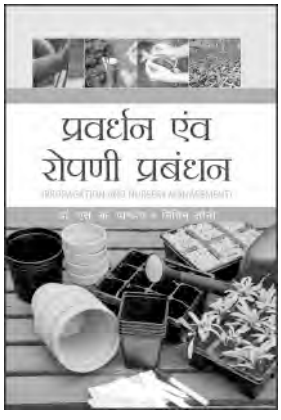

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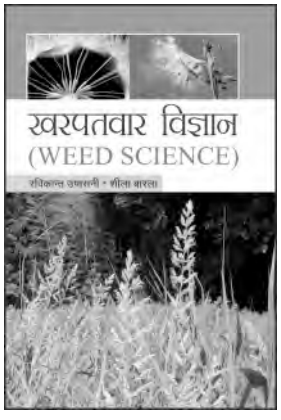

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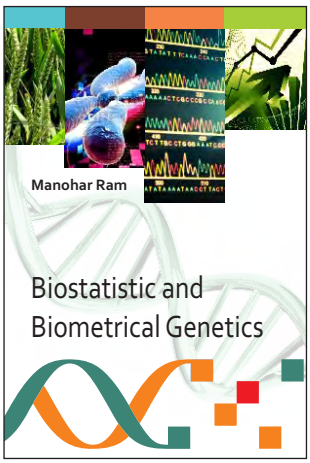

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