A Monthly Magazine of Agriculture and Biological Sciences

Volume XVIII | Issue No. 02 | 01 July, 2019 | Pages: 148 | ₹ 85.00

AGROBIOS

NEWSLETTER

ISSN 972-7027X

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Harnessing Plant Biotechnology and Physiology to Stimulate Agricultural Growth

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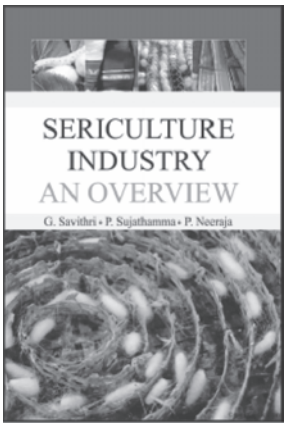

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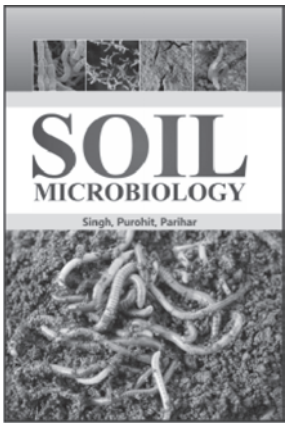

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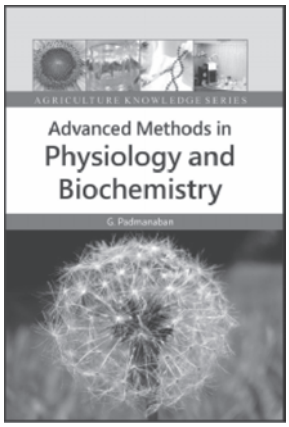

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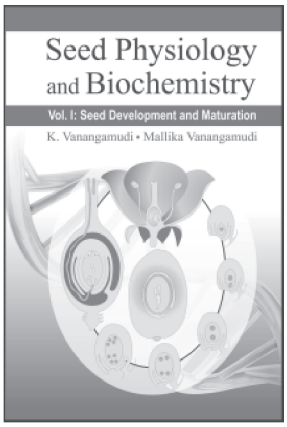

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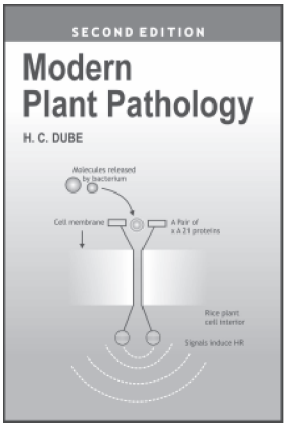

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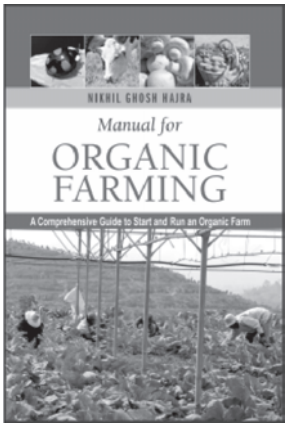

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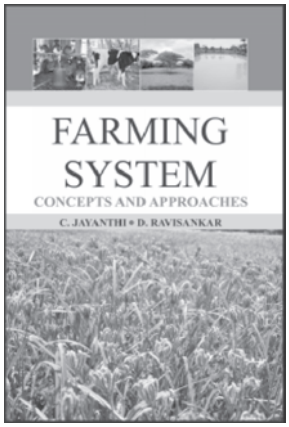

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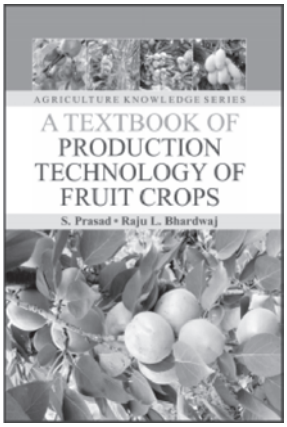

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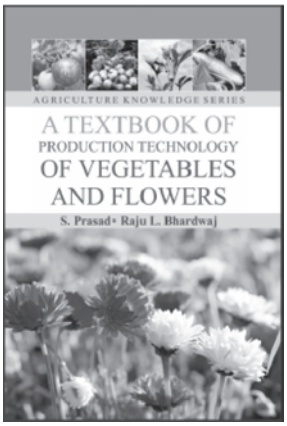

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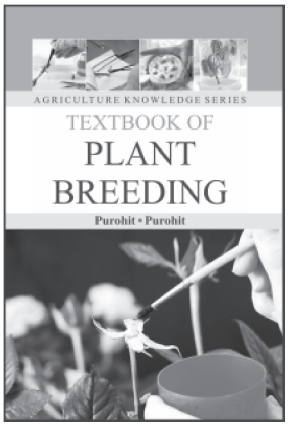

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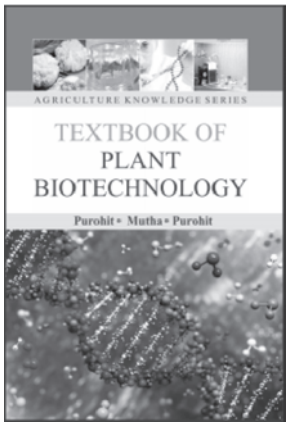

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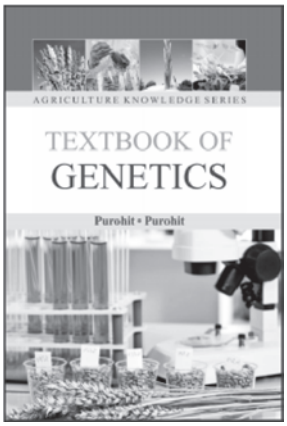

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AGROBIOS NEWSLETTER

July, 2019 / VOLUME XVIII / ISSUE NO. 02

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TYPESETTING
Yashee Computers, Jodhpur

PRINTED BY
Manish Kumar, Chopra Offset, Jodhpur

PUBLISHED BY
Dr. Updesh Purohit, for Agrobios (India),
Behind Nasrani, Cinema, Chopasani Road, Jodhpur

RNI No.: RAJENG/2002/8649
ISSN: 0972-7027

SUBSCRIPTION RATES
SINGLE COPY: ₹ 85.00
ANNUAL INDIVIDUAL: ₹ 1000.00
ANNUAL INSTITUTIONAL: ₹ 2000.00

DATE OF PUBLISHING: 01 July, 2019
DATE OF POSTING
07-08 OF EVERY MONTH AT RMS POST OFFICE

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BIOTECHNOLOGY

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1. Padlock Probes Based Detection of Plant Pathogens

KEERTHANA, U.* AND PRABHUKARTHIKEYAN, S. R.

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The accurate identification and the detection of pathogenic microorganisms or other targets of interest have become increasingly important in pest management strategies. Padlock probes (PLPs) offer a means of combining pathogen-specific molecular recognition and universal amplification, thereby increasing sensitivity and multiplexing capabilities without limiting the range of potential target organisms. Padlock probes are circularizing oligonucleotide probes which detect target sequences with very high specificity and selectivity (Nilsson *et al.* 1994). These linear oligonucleotide probes have target recognition sequences situated at both the 5'- and 3'-ends, connected by an intervening sequence that can include sequence elements useful for detection (Figure 1). When hybridized to a target molecule the two ends are brought adjacent to each other, and by the use of a ligase they are covalently joined (intra-molecular ligation). The circularized probe is wound around the target strand in a manner similar to padlocks, driven by the helical nature of double-stranded DNA. Reacted probes are not removed from long target sequences such as genomic DNA even by superstringent washes (*i.e.* washes performed above the melting temperature of the probe–target hybrids) and can be detected via reporter molecules attached to the linker.

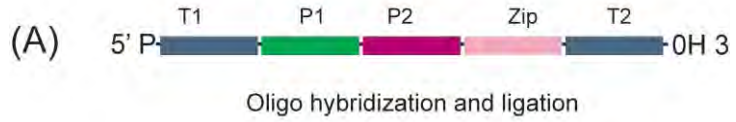

FIGURE 1: Padlock probe

Detection of pathogen is based on the following amplification mechanism.

1. **Rolling Circle Amplification (RCA) mechanism:** RCA is based on rolling replication of short single-stranded DNA circular molecules. This process requires DNA polymerase, a primer to initiate the replication, DNTPs and DNA binding and unwinding proteins. Most of the groups are using the RCA reaction for signals' amplification, where the small circular probes serve as the template (Figure 2). In RCA reaction, primer has dual functions, both as RCA signal amplifier and discriminator by being complementary to the DNA-targeted sequence. RCA technology is a robust and simple method that can make available a universal platform for the localization of a wide variety of molecules such as nucleic acid sequence (Kuhn et al. 2002).

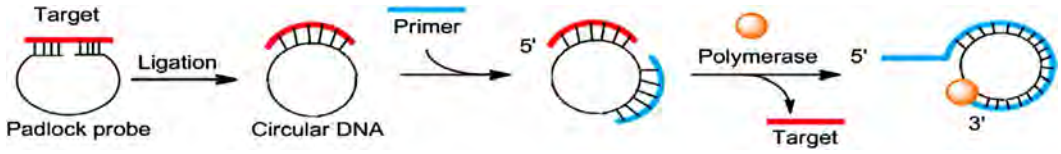

FIGURE 2: Padlock probe-based detection using RCA mechanism

2. **Ramification amplification (RAM) or hyperbranched rolling circle amplification method:** RAM is a novel isothermal nucleic acid amplification method. This technique is termed as RAM because the amplification power is derived from primer extension, strand displacement and multiple ramification (branching) points (Zhang et al., 1998). This method uses a specially designed circular probe (C-probe) in which the 3' and 5' ends are brought together in juxtaposition by hybridization to a target. The two ends are then covalently linked by a T4 DNA ligase in a target-dependent manner, producing a closed DNA circle. In the presence of an excess of primers (forward and reverse primers),

bacteriophage Ø29 DNA polymerase extends the bound forward primer along the C-probe and displaces the downstream strand, thus generating a multimeric ssDNA by continuously rolling over the closed circular DNA, analogous to the "rolling circle" replication of bacteriophages in vivo. The multimeric ssDNA generated then serves as a template where multiple reverse primers hybridize, extend and displace downstream DNA and generate a large ramified (branching) DNA complex. This ramification process continues until all ssDNAs become double-stranded, resulting in an exponential amplification that distinguishes itself from the previously described nonexponential RCA.

Thus, Padlock probes are well suited for parallel gene analysis because cross-reactive ligation events between different probes, which may arise when a large number of probes are combined, generate linear products that can easily be distinguished from circularized probes. The combination of padlock probes and localized signal amplification via RCR should allow detection of large sets of target DNA sequences. In addition to detection these mechanisms will provide more sensitive and specific detection of pathogen even at SNPs level.

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2. DNA Barcoding: Fantasy to Reality in Species Identification

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INTRODUCTION: DNA barcoding is a technology that involves using gene sequences to differentiate species, similar to the standardized barcodes system used in retail stores to differentiate the hundreds and thousands of items they sell. Dr Paul D.N. Hebert from the University of Guelph is called as Father of DNA barcoding. DNA barcodes are short DNA sequences from a uniform location on the genome which distinguishes Earth's changing biodiversity. Thus, by establishing a shared community resource of DNA sequence, organismal identification and taxonomic classification will become easier.

Significant Limitations of the Traditional Approach

In the case of the traditional approach, phenotypic plasticity and genetic variability in the traits used for species recognition can lead to incorrect identifications. Second, this approach overlooks morphologically cryptic taxa, which are common in many groups. Third, since morphological traits often show variation depending on the gender or particular life stage, many individuals cannot be identified. Finally, although there has been major advance in the recent interactive version, it still demands a high level of expertise lack of which often leads to misdiagnoses.

Features of DNA Barcode Gene

1. Low intra species variability
2. Species-level genetic variability and divergence
3. Short sequence length
4. Size of sequence: 600 – 700 bp
5. Universality
6. Short enough to be quickly sequenced
7. Easily identified in all species of organisms
8. Variable enough to provide a unique sequence for each species

Barcoding of Animals

DNA barcoding study evaluates the potential of COI as a taxonomic tool. A COI profile for the seven most diverse animal phyla was created based on the analysis of 100 representative species was able to assign 96% of newly analysed taxa to their proper phylum. Similarly, a COI profile for eight of the most diverse insect orders was created based on a single representative from each of 100 different families, was used to assign each of 50 newly analysed taxa to its correct order. Using COI profile for lepidopterans, low sequence divergence among families, provide to be a challenging case for species diagnosis, especially since this is one of the most speciose orders of insects. Fortunately, the 'COI profile' created for 200 closely allied species was able to assign 150 newly analyzed individuals to species with 100% success.

DNA Barcoding in Plants

Large scale standardized sequencing of the

mitochondrial gene COI has made DNA barcoding an efficient species identification tool in many animal groups. In plants, mitochondrial DNA has low substitution rates, which led to the search for alternative barcoding regions. From initial investigations of plastid regions, seven leading candidates have emerged. Four are portions of coding genes (matK, rbcL, rpoB, and rpoC1), and 3 are noncoding spacers (atpF–atpH, trnH–psbA, and psbK–psbI). Various combinations of these loci have been proposed as preferred plant barcodes, but no consensus has emerged. Since there is a lack of an agreed standard, its progress in plant barcoding has been slowed down. To identify a standard barcode for plants, data (sequence data from 907 samples, representing 445 angiosperm, 38 gymnosperms, and 67 cryptogam species) from different laboratories have been pooled. Further research on this might overcome the current issues and aid in the development of good DNA barcodes for plants.

Ten Reasons: Why to go for Barcode of Life?

1. **Works with fragments**. Barcoding can identify a species from any piece of the organism that is available. Thus, it can be used in food quality control as it can quickly identify the undesirable animal or plant material in processed foodstuff. It can also be used in identifying roots sampled from soil layers.
2. **Works for all stages of life**. Barcoding can identify a species in its many forms, from eggs and seed, through larvae and seedlings, to adults and flowers.
3. **Unmasks look-alikes**. Barcoding can identify differences in look-alikes among species thus can guide in identifying dangerous organisms masquerading as harmless ones and also enables to view biodiversity with accuracy.
4. **Reduces ambiguity**. Written as a sequence of four discrete nucleotides, ATGC – along with a uniform locality on genomes, a barcode of life provides a digital identifying feature. A library of digital barcodes will help in reducing the ambiguity in identifying species found in different parts of the earth.
5. **Makes expertise go further**. The bewildering diversity of about 2 million already known species confines even an expert to morphological identification of only a small part of the plant and animal kingdoms. With the view that lot more species to be identified, the barcoding system could speed up the process of identification of known organisms as well as to detect unknown species.
6. **Democratizes access**. It will make possible identification of species, whether abundant or rare, native or invasive, engendering appreciation of biodiversity locally and globally.
7. **Opens the way for an electronic handheld field guide, the Life Barcoder**. Barcoding makes it possible to link the biological identification to DNA sequencing, miniaturization in electronics, and computerized information storage. Integrating those links will lead to portable desktop devices and ultimately to hand-held barcoders. Imagine the promise of a school child with a barcoder in hand learning to read wild biodiversity, the power granted to a field ecologist surveying with a barcoder and global positioning system, or the security imparted by a port inspector with a barcoder linked to a central computer.
8. **Sprouts new leaves on the tree of life.** Already barcoded 2 million species will pave the way to draw the tree of life on Earth. Barcoding newly discovered species will provide sprouting new leaves on the tree of life.
9. **Demonstrates value of collections**. Barcode library will strengthen to preserve Earth's biodiversity.
10. **Speeds writing the encyclopedia of life**. Barcode library linked to vouchered specimens and their binomial names will enhance public access to biological knowledge, thus paves way to create an on-line encyclopedia of life on Earth.

Consortia

1. iBOL - International Barcode of Life.
2. CBOL – Consortium for the Barcode of Life
3. ECBOL - European Consortium for the Barcode of Life

Databases

1. BOLD – Barcode of Life Database
2. International Nucleotide Sequence Database Collaboration

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3. Small RNAs: Essential Regulator of Gene Expression in Plants

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Eukaryotic genomes produce thousands of diverse small RNAs (smRNAs), which play vital roles in regulating gene expression in all conditions, including in survival of biotic and abiotic environmental

stresses. As in other eukaryotes, regulation of gene expression in plants relies on a variety of molecular mechanisms that affect different steps in the life of a messenger RNA (mRNA), including transcription, splicing, processing, transport from the nucleus to the cytoplasm, translation, storage and mRNA decay. By regulating gene expression mainly through transcriptional and post-transcriptional gene silencing (PTGS), smRNAs function as major players controlling different steps of mRNA life. Small noncoding RNAs (smRNAs) are the important posttranscriptional regulatory factors in gene regulatory networks. They are involved in many important processes of plant development and stress responses.

Based on mechanism of action SmRNAs can be divided on different catagories begin with the effects of siRNAs on epigenetic regulation and TGS, including RNA-directed DNA methylation, and then examine the roles of smRNAs, including miRNAs, tasiRNAs, natural antisense siRNAs (nat-siRNAs), and long siRNAs (lsiRNAs), in PTGS, including the posttranscriptional degradation of mRNAs also, in the repair of DNA double-strand breaks (DSBs) and in the regulation of pre-mRNA splicing. These sRNAs are loaded into RNAinduced silencing complexes (RISC) and regulate the expression of their relative target genes negatively by affecting the mRNA levels, chromatin remodeling, and DNA methylation.

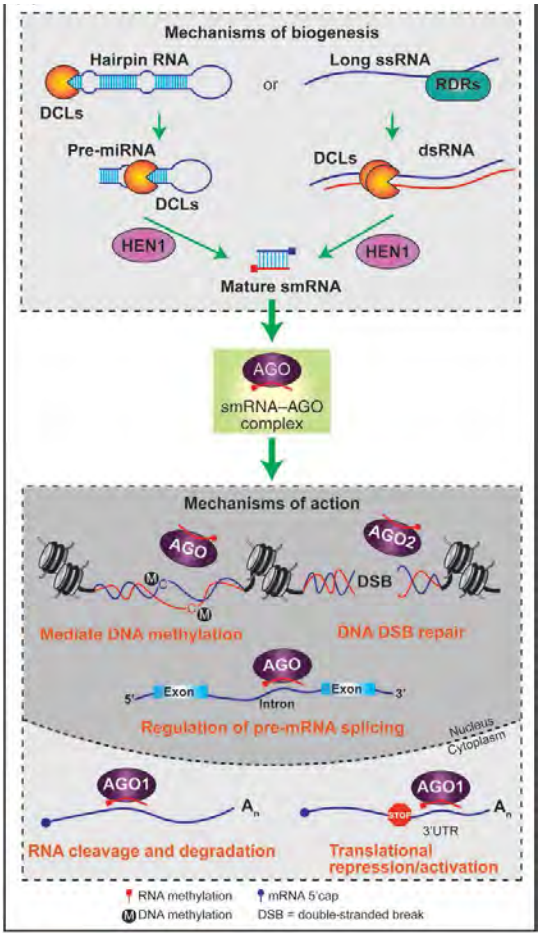
miRNA: 20–22 DsRNAs with hairpin-shaped secondary structure at miRNA loci which mediate gene silencing post-transcriptionally by mRNA cleavage or regulation of translation via perfect or near-perfect complementarities with target RNAs.

Long miRNAs (lmiRNA): Another class of plant miRNAs is 23–27-nt long, termed long miRNAs (lmiRNAs); these can be produced from the same MIR gene which give rise to normal miRNAs. lmiRNAs arise as a result of competition between DCL3 and DCL1 in processing of the double-stranded stem-loop precursors and associate with AGO49 Mediate DNA methylation in cis and trans, leading to transcriptional gene silencing.

Heterochromatic-siRNA (or hcsiRNA): Het-siRNAs are mostly derived from heterochromatin, silenced repetitive sequences and TEs. Function in heterochromatin formation to trigger DNA methylation and histone modifications resulting in transcriptional gene silencing. This process in plants, termed RdDM (RNA directed DNA Methylation).

Transactivating-siRNA (tasiRNA): TasiRNAs belong to the group of secondary siRNAs generated in a phased pattern from noncoding tasiRNAs-generating loci (TAS genes), tasiRNAs control a much wider range of related mRNAs than individual miRNA, mediate post-transcriptional gene silencing, acting as morphogens by controlling expression gradients of the target mRNAs; can also mediate DNA methylation in cis.

Natural antisense si-RNA (nat-siRNA): Nat-siRNAs are a class of siRNAs produced from natural antisense transcripts that are encoded locally in cis (cis-NATs) or encoded in trans (trans-NATs). Mediate gene silencing mainly at the posttranscriptional level by mRNA cleavage in stress conditions or developmentally.



longsiRNA (lsi-RNA): Pathogen infection also induces lsiRNAs, which are 30–40-nt long and derived from protein-coding genes and/or NAT pairs. Down regulate mRNA expression by promoting mRNA decapping and 5′-3′ degradation.

Double strand breaks induced RNA (diRNA): Many stresses, including UV light and ionizing radiation, cause DNA DSBs, which lead to genomic instability and, if unrepaired, to cell death. This 21-nt diRNAs are generated in the vicinity of DSB sites, which function as guide molecules directing the recruitment of protein complexes to DSB sites to facilitate repair.

Plants have an incredibly rich variety of smRNAs, which do an outstanding job regulating gene expression and also, participate in protecting plants from dangerous external conditions. These diverse mechanisms of action of plant smRNAs provide plants with powerful tools to induce and suppress expression of key stress-response genes by epigenetically regulating transcription, mRNA stability, and translation during the global reprogramming of gene expression required to survive stresses.

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4. Role of Small RNAs in Regulating Gene Expression in Plants

KARMA LANDUP BHUTIA

TCA, Dholi, Dr. RPCAU (Pusa) Bihar

Eukaryotes have numerous sophisticated ways of controlling gene expression. In the complex environment of the cell, these mechanisms need to be precisely targeted. In the group of mechanisms that are involve in regulation of gene expression, there is special class of small RNA molecules which plays a crucial role in regulations of pre and especially post transcriptional gene expression. Inside the nucleus, genes that encode proteins and other forms of RNAs are transcribed by RNA polymerase. The primary RNA transcript is processed by splicing and other processing mechanisms and forms a mature mRNA to form polypeptide chain that folds into proteins. But this is where some small RNA molecules can have their silencing effects and this RNA mediated inhibition of gene expression is termed as RNA interference or in short RNAi. It is based on the ability of the small RNAs to trigger mRNA degradation, or inhibit mRNA translation or inhibit transcription of the gene coding for a particular mRNA.

Mechanisms of RNAi

Specially two classes of small RNA molecules are involved in RNA mediated inhibition of mRNA expression. They are microRNA (miRNA) and small interfering RNA (siRNA). Both classes of small RNA associated with the family of proteins known as argonautes, but they are different in their origin, processing pathways, target and mechanism of action. We'll first focus on micro RNA and then point out the differences and similarities with the siRNA.

MicroRNA (miRNA)

Micro-RNA is derived from actual genes found in genomes across all multicellular animals and plants. They are transcribed by RNA polymerase-II. The resulting transcripts are known as pri-miRNAs. The pri-miRNAs folds into stem loop structure which generally have some unpaired nucleotides and single stranded extension are found at both 5' and 3' ends. This pri-miRNA serves as the initial substrate for processing by a nuclear RNAse-3 enzyme. Nuclear RNAse-3 enzyme (DROSHA) interacts with the specialized RNA binding protein and forms a microprocessor complex. This complex performs a cleavage reaction that removes the 5' and 3' extension and liberates a 60-70 nucleotides long transcript known as pre-miRNA. The pre-miRNA is recognized by the nuclear export factor which transports the pre-miRNA to the cytoplasm for subsequent processing. In the cytoplasm, the second endonucleatic cleavage reaction generally refers to as dicing is catalyzed by DICER (in plants RNAse-3 enzyme). The product of the second cleavage is the miR:miR* duplex, it carries 5' monophosphate and 3' overhangs of two nucleotides which is not fully complementary. The two strands of this duplex are called as guide and the passenger strands. The duplex is then loaded into argonaute protein that is dedicated to miRNA mediated silencing reactions. Once the duplex is loaded in an appropriate orientation, one of the RNA strand called as miR guide strand is retained while the other strand, the miR* passenger strand is selectively removed. The guide strand retained will ultimately determine which RNA will be silenced. This process of retaining one strand and removing the other is called as sorting. Argonaute protein charged with the guide miRNA are referred as miRISC or micro RNA induced silencing complex. The complex is now ready to bind to its target RNA and promote gene silencing. Argonaute bound to miRNA typically identifies sequences within perfect complementary in the 3' UTR of target RNA. The most important pairing region of miRNA is called as seed sequence. The fate of the target mRNA is decided by sequence complementarity between miRNA and mRNA. If the miRNA is exactly complementary to mRNA, the miRISC complex will promote cleavage of mRNA which are then degraded by the cytoplasmic nucleases and if the miRNA is partially complementary to mRNA, the miRISC complex will inhibit the translation of mRNA, therby silenced the expression of target mRNA.

Small Interfering RNA (siRNA)

In contrast to miRNAs, siRNAs are not generally encoded in the genome as specific gene; instead siRNAs are derived from double stranded RNA that comes from several different sources like virus, artificially injected dsRNA and some other endogenous sources like aberrant RNA. Irrespective of their origins, duplex RNAs become substrate for an RNA processing reaction similar to miRNA but without the first nuclear RNAse-3 dependent cleavage, only dicing by cytoplasmic RNAse-3 enzyme is needed. The cytoplasmic RNAse-3 enzyme sequentially cleave the long duplex structure approximately every 20-25bp. The product of the dicing reaction are short duplex RNA similar to miR:miR* duplex but fully base paired along the length. Once the siR:siR* duplex has been generated, it also is loaded into the appropriate argonoute protein and the siR* passenger strand is selectively removed. The base pairing between siRISC and mRNA is more exact complimentary than that of miRISc, therefore, the binding of siRISC generally

results in the cleavage of target mRNA.

Other Pathways through which siRNA Generated

In plants, worms and some other eukaryotic organisms, the aberrant RNA that results from the RISC mediated cleavage can also serves as a template for RNA dependent RNA polymerase (RDRP). This process relies on unprimed RNA synthesis in which aberrant is used as a template. The resulting double stranded RNA is substrate for cytoplasmic RNAse-3 (DICER) activity and generates more siRNA. In another amplification process, the single stranded siRNA after the cleavage by cytoplasmic RNAse-3 (DICER), not associated with the RISC binds to the target mRNA in a sequence specific way and serves as a primer for RDRP to polymerize the antisense RNA strand. The double stranded RNA molecules serves as a substrate for cytoplasmic RNAse-3 (DICER) and generates more siRNA and inturn these can either unwind and primed RNA dependent RNA polymerization or together with RISC mediates the silencing of target mRNA.

Role in Plant System

Small RNAs plays crucial roles in plant system in terms of endogenous gene regulation, abiotic stress resistance like resistance to drought, salinity etc. biotic stress resistance like resistance of plants to bacterial diseases, fungal diseases, viral diseases, nematodes infection and insect pest attacks. Through transgenic approach, this RNAi mechanism can be used to study the function of targeted gene (functional genomics), to generate biotic stress resistant plants, abiotic stress resistant plants and also to enhance the nutritional quality of crop plants.

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5. Current Trends in Transgenic Crops

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There has been a growing realization that the future is going to be very crowded since there have been no successful attempts to control the ever-increasing global population and hence the foremost concern is focusing on feeding the population with increased quality nutrient profile under changing climatic condition. Our land areas and its potential are limited and so are the resources, so scientists came out with the idea of transgenic in late 1990s. However numerous researches and debates have been made in commercialisation of transgenic but the worldwide pace is slow owing to various social and political ideologies. For beginners it is important to know that transgenic crops are those which contain novel genes (transgenes) with improved quality traits, such as herbicide tolerance, and allow the developmental process to be dramatically accelerated (Gressey 2013). It removes the barrier of sexual incompatibility between plant species to be overcome and enormously increase the size of the available gene pool (Gressey 2013).

In 2017,189.8 million hectares of transgenic crops were planted by up to 17 million farmers in 24 countries. With the advent of 1.7 million hectares under transgenics in 1996 when the first transgenic crop was commercialized, the 189.8 million hectares planted in 2017 indicated marked 112-fold increase showing that transgenic are the fastest crop under adoption. For the past six years, developing countries have planted more transgenic crops than the developed one. In 2017, 19 developing countries planted 53% (100.6 million hectares) of the global transgenic area, while 5 developed countries took the 47% (89.2 million hectares) share. A report of ISAAA (2017) said that this trend is expected to increase in coming future as number of countries for adoption of transgenic are rising in southern hemisphere. The land under cultivation in the year 2017 comprises of soybean standing first followed by maize, cotton, and canola. Although there was only 3% increase in the planting of transgenic soybean but its adoption rate was as high as 50% of the global transgenic crops or 94.1 million hectares. Transgenic maize occupied 59.7 million hectares globally, which was 32% of the global maize production in 2017 followed by cotton (24.1 million hectares) and canola (10.2 million hectares).

It is also need to be emphasized the agronomic and economic benefits of GM crops are significant, as these benefits are dependent on the modified trait and geographical area (Klumper and Qaim 2014). GM potato (Innate™) generation I with multi-trait resistance to black-spot bruising and browning was developed using RNA interference technology (Simplot Company) and successfully commercialized in 160 ha in the USA (James 2015). Later Innate™ II with a disease resistance trait for late blight of potato was subsequently approved. In terms of genetically modified animals, landmark approval of the first GM salmon was granted by FDA in 2012 for commercial food production and human consumption. Labelling and traceability of GM crops are both mandatory and voluntary but this process is dependent from country to country. Recently, a transgenic cotton expressing Cry10Aa toxin conferring resistance to cotton boll weevil has been developed (Ribeiro et al. 2017).

It is true that transgenic crops are grown in

countries which have 60% of total world population to combat food shortage but the complete picture says that most densely populated countries comprising 4 billion people like China, India mainly cultivate GM cotton. On the other hand, transgenic for food and feed are grown mainly in North and South America which occupies only 14 % of world population. Mexico, European countries, and China refuse to grow GMmaize, GMrapeseed (canola), and GMsoybean, respectively particularly because of the risk of genetic contamination of their traditional varieties as well as emergence of herbicide resistant weeds. However scientific community are vigilant about the potential threats that may lead to serious repercussions and that is why experimentation is limited to11 crops: soybean, cotton, maize, canola (rapeseed), sugar beet, alfalfa, papaya, largefruit pumpkin, tomato, sweet pepper, and eggplant.

Strict regulations and legislation existed at present has obstructed the commercialisation of transgenic and GMO derived products. On the other hand, critics continue spreading non-scientific allegations about transgenic crops that affect regulations and approvals. The continuous growth in the adoption of biotech crops is attributed to the technology's positive impact on the environment, human and animal health, as well as on the improvement of socioeconomic conditions of farmers and the general public. Studies have confirmed that delays in transgenic crop approvals lead to immense economic losses and opportunity costs.

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MOLECULAR BIOLOGY

18519

6. CRISPR: A New Gene Editing Technology

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What is CRISPR

CRISPR technology is a simple, powerful and novel tool for genome editing. It can control gene expression in plants, animals, and even in humans by deleting the undesirable traits and, potentially, inserting desirable traits with more precision. The technology is also known as CRISPR/Cas9.

In 1987, A group of scientists studying E. coli bacteria first came across some unknown unusual repeating sequences in the genome of E. coli. Over time, other researchers across the found similar clusters in the DNA of other bacteria (and archaea). They called these sequences as Clustered Regularly Interspaced Short Palindromic Repeats or CRISPR. These are made up of short palindromic DNA sequences, repeated along the molecule and are regularly-spaced, are an integral part of bacterial defense system. The CRISPR molecule also includes CRISPR-associated genes, or Cas genes. These encode proteins that unwind DNA, and cut DNA, called helicases and nucleases, respectively.

How it Works

The bacteria produce enzymes to fight off viral infections as they are constantly under viral assault. Whenever a bacterium's enzymes manage to kill off an invading virus, other little enzymes will come along and scoop up the remains of the virus's genetic code and chop it into tiny bits. The enzymes then store those tiny bits in CRISPR spaces called "spacers" in the bacterium's own genome. The bacteria use the genetic information stored in these spacers in future to fend off viral attacks. When a new viral infection occurs, the bacteria produce special attack enzymes, known as Cas9, that carry around those stored fragments of viral genetic code. When these Cas9 enzymes come across a virus, and if there's a match between the stored bits of viral genetic code and attacking viral genetic code, the Cas9 enzyme starts chopping up the virus's DNA to neutralize the threat (Fig: 1).

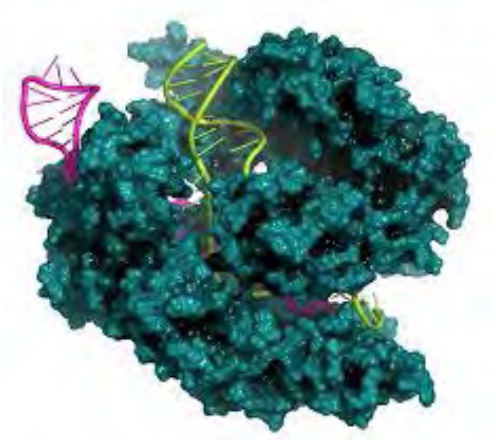

FIG. 1: Bacterial Cas9 enzyme chopping up the virus's DNA. (Image courtesy: ThermoFisher Scientific)

The scientists discovered they could alter the entire process by Cas9 protein by feeding it with an artificial RNA, a single guide RNA (sgRNA) to target genes. They observed that the enzyme would search for anything with that same code, and start chopping by initiating a double stranded break in the genomic region using the Cas9 endonuclease. These breaks are then repaired by an innate DNA repair mechanism, the non-homologous end-joining (NHEJ). As NHEJ is error-prone, and results in genomic deletions or insertions, which then converts into permanent silencing or inactivation of the target gene. Thus, they proved the CRISPR/Cas9 system could use to chop up any genomic region of interest resulting in the gene silencing mechanism or **Gene Knock-Out.**

CRISPR-Cas9 Applications

- Genome editing of agriculturally important crops is more desirable in terms of quality and yield: CRISPR is a versatile novel technology that can help identify genes associated with desired crop traits much more quickly and to insert precisely the desired traits into crops.
- Example: Scientists from Beijing Key Laboratory of Vegetable Germplasm Improvement, led by Shouwei Tian used CRISPR-Cas9 to target ClPDS, the phytoene desaturase in watermelon, to obtain an albino phenotype. All genome-edited watermelons harbored mutations in ClPDS and showed full or mosaic albino phenotype. This study served as a proof of the concept of using CRISPR-Cas9 system in watermelon breeding.
- New tools to stop genetic diseases: CRISPR/Cas9 can edit the human genome and to knock out genetic diseases like hypertrophic cardiomyopathy, Huntington's disease or cystic fibrosis.
- CRISPR-Cas9 can allow the generation of different animals suitable for human disease modeling.

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MICROBIOLOGY

18496

7. Kombucha Tea

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Kombucha tea is a refreshing, slightly sweet and acidic beverage produced by fermentation of tea. It is believed to have originated in North-East China (Manchuria) during Tsin Dynasty around 200 B.C. It was used in East Asia for its detoxifying and healing properties. It has different names like Cainiigrib, Cainiikvass, Japonskigrib, Jsakvasska, Heldenpilz and Kombuchaschwamm. Kombucha is produced by fermentation of sweet tea decoction with tea fungus. Tea fungus is a symbiotic association of yeasts and acetic acid bacteria embedded in a supporting pellicle of cellulose. Yeasts belonging to genera *Saccharomyces, Schizosaccharomyces, Zygosaccharomyces, Brettanomyces etc.* and acetic acid bacteria like *Acetobacter, Gluconobacter etc.* are generally found in the consortium (Roussin, 1996). Acetic acid bacteria produce a cellulosic mat on the surface of the tea broth and maintains anaerobic environment for yeasts to produce alcohol, which is converted to acetic acid by the bacteria. Kombucha tea so produced contains various organic acids, such as acetic acid, citric acid, lactic acid, oxalic acid *etc.* Vitamins like B_1, B_2, B_6, B_{12}, C, amino acids, ethanol and minerals are also found (Blanc, 1996). The cellulosic layer produced due to fermentation has acetic acid bacteria and yeast cells attached to it and thus, the name "tea fungus" has originated. Tea fungus has been found to be rich in crude fiber, crude protein and the amino acid lysine.

Steps of Preparation

- Drinking water (1 L) is boiled with 50 g sucrose.

- Around 10 g tea leaves is added and removed after 5 min by filtration.
- The tea broth is cooled to room temperature and transferred to a sterilized glass beaker
- The tea broth is inoculated with 24 g 'tea fungus' (culture)
- The growth of undesirable microorganisms can be inhibited by adding 50 mL of previously fermented Kombucha, if available, to lower the pH.
- The beaker is tightly covered with a paper towel to keep away from insects.
- The setup is kept at room temperature (20 ºC to 28 ºC) for 5-7 days.
- In the next few days, a newly formed cellulosic layer will float and form a clear thin gel-like membrane across the available surface.
- The tea fungus is then discarded or stored for future use.
- The fermented broth, now called Kombucha tea is filtered and stored in capped bottles at 4 ºC or consumed chilled

Beneficial Effects

- Detoxification of blood
- Reduction of cholesterol level and blood pressure
- Alleviation of arthritis, rheumatism and gout symptoms
- Promotion of liver functioning
- Improvement in intestinal activity and balancing of intestinal flora
- Regulation of appetite
- Have an antibiotic effect against certain pathogens (Shreeramulu et al., 2000)
- Enhancement of immune system and interferon production
- Reduction of stress and headache
- Enhancing general metabolism

Ill Effects

There are no reports on Kombucha toxicity, except that sick and people on medication should avoid consumption because of their immunity being compromised. Also, Kombucha may turn toxic if contaminated in the beginning.

Conclusion: Kombucha tea is a traditional drink, gaining lot of importance. It is also refreshing and tasty. Being a source of a wide range of bioactive components, the consumption of Kombucha will lead to improved metabolism at the cellular level. In the present world, where the unhealthy sugary carbonated drinks rule, Kombucha can become a potent competitor for its high nutritive and medicinal properties. It is simple to prepare and very cheap.

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AGRICULTURAL MICROBIOLOGY

18400

8. Microbial Degradation of Organophosphorus Compounds (OPs)

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INTRODUCTION: Organophosphorus compounds (OPs) are most widely used around the world and have been used as pesticides in agriculture, plasticizers and chemical warfare agent. Although OPs play important roles in protecting agricultural crops from insect pests and weeds and in controlling disease-transmitting vectors. Organophosphate Pesticides are also called "non-persistent pesticides" because they break down fairly rapidly in the environment (within days or weeks), reducing their potential to accumulate in the tissues of plants, animals or humans. Organophosphorus pesticides irreversibly inactivate acetyl-cholinesterase (AChE), which is essential to nerve function in insects, humans and many other animals.

Organophosphorus pesticides such as chlorpyrifos, parathion, methyl parathion is most extensively used in many agricultural practices (Barthidasan *et al*., 2014). Tabun (GA), Sarin(GB), Soman(GD) and VX are used as chemical warfare agents (nerve agent). Continuous and excessive use of OPs has led to the contamination of several ecosystem in different part of the world and cause serious environmental pollution problem (Musa *et al*., 2011). Use of microorganisms in detoxification or decontamination of OPs in considered a viable and environmental friendly approach.

Mode of Action

The mode of action of OP compounds can be attributed to the inhibition of the enzyme acetylcholinesterase (AChE). This enzyme is essential for the central nervous system, and being present in both humans and insects. The normal function of AChE is the hydrolysis of acetylcholine neurotransmitter in the synaptic membrane to prevent its accumulation, and as a result forming acetylated enzyme and releasing choline. The high percentage of released choline is transported back into the nerve ending for reconversion to acetylcholine and storage. This degradation process results in a lowered level of acetylcholine, and ultimately the termination of nerve impulses.

OP compounds covalently block the active site of serine residue of AChE by undergoing nucleophilic attack to produce a serine-phosphoester adduct. This irreversible inactivation leads to an excess accumulation of acetylcholine in the peripheral and central nervous system causing cholinergic manifestations. At high doses, there is depression of the respiratory centre in the brain, followed by peripheral neuromuscular blocked causing respiratory paralysis and death. The pharmacologic effects and toxicity of these OP compounds are dependent on their stability, rate of absorption by various routes, distribution ability to cross the blood-brain barrier, rate of reaction with AChE.

Microbial Metabolism of Ops

Microbial degradation of OP insecticides has been recognized as the most important process controlling their environmental fate. However, the extensive and repeated use of soil-applied OP compounds on certain occasions has led to reduced biological efficacy due to microbial adaptation. This phenomenon was named as enhanced or accelerated biodegradation, and was attributed to the development of a soil microbial population that was able to rapidly mineralize the OP pesticides.

The significance of enhanced biodegradation depends on use of the pesticides, Frequency of use, Interval between successive applications and Stability of the active microflora without the presence of pesticides. There are four major reactions involved in OPs metabolism: hydrolysis, oxidation, alkylation and dealkylation. Hydrolysis of the phosphoesteric P–O–C or phosphothiesteric P–S–C bonds present in the OP molecules is considered the initial step in their metabolism.

Microbial Enzymes

Microbial enzymes that can hydrolyze organophosphorus compounds have been identified and characterized from different microbial species. Several bacterial and fungal isolates with novel enzyme/gene systems are reported (Hsu *et al*., 2008).

1. Organophosphorus Hydrolase (oph)

This enzyme was isolated from bacteria, *P. diminuta*. It has the widest range of substrate specificity. It hydrolyzes P–O, P–F, and P–S bonds to different extents. The lowest specificity is for the P–S bond.

2. Organophosphorus Acid Anhydrolase (OPAA)

It has been isolated from A. radiobacter and was found to have 90% homology to OPH at the amino acid level and a very similar overall secondary structure. Despite these similarities, the two enzymes have different substrate specificities. This enzyme which detoxify the organophosphorus nerve agents. Highly active OPAA from *Alteromonas undina* was isolated and purified and is composed of a single polypeptide with molecular weight 53 kDa. It possesses low catalytic activity against P–O but high activity against P–F bonds.

3. Laccase: Phenol Oxidase

It is a broad-spectrum fungal enzyme which degrade organophosphorus phosphorothiolates. It is isolated from a white-rot fungus *P. ostreatus*. This enzyme attacks P–S bond, which is comparatively resistant to OPH and OPAA cleavage. Several white-rot fungi are capable of organophosphorus degradation and it will be interesting to know if the degradation capability of all white rot fungi towards organophosphorus compounds is mediated by the presence of laccase, or whether different fungi possess different enzyme systems.

Conclusion: Even though OPs degrade rapidly, upon accumulation cause contamination. Physical and chemical methods are in use but they also have adverse effect on environment. As alternative, microorganisms are put to use, since they efficiently degrade OPs without harming the environment. Further research works are needed to improve the microbial strains and enzyme catalytic activity.

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CROP PHYSIOLOGY

18379

9. Plant Responses and Mechanisms to Mitigate Abiotic Stress

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Introduction

Plant stress: It is a stress when plant is exposed to adverse environmental conditions, it affects plant growth and development.

The effects of stress lead to decrease growth, development and crop yield, in severe cases permanent damage or death if the stress exceeds the plant tolerance limits. In nature Plants experience two types of stresses.

1. Biotic stress
2. Abiotic stress

Biotic stress: The stress induced on plants by living organism like fungus, bacteria, virus, insects *etc.*, are called biotic stress.

Abiotic stress: This stress is induced by temperature, cold, light, drought, flooded condition, toxic metallic ions *etc.*, are called abiotic stress.

Heat stress: When plant exposed to high temperature results in heat shock or heat stress.

Low-temperature stress: when plant exposed to above freezing temperature is called Chilling or when plant exposed to below freezing temperature is called freezing, which induce ice formation in plant tissues, leading to cellular dehydration.

Water stressor Drought: absence of sufficient soil moisture for seedling growth is called water stress.

Oxidative stress: when plant exposed to biotic and abiotic stress as a result formation of active oxygen species.

Salinity stress: soil contain excess soluble salts which limit the plant growth and development.

Losses Caused by the Abiotic Stress

- The excess salts lead to salinization of soil, global salt affected area accounts around 20 % of irrigated land in world.
- High temperature coupled with drought during pollination period of maize and rice plants can result in up to 60 - 100 % yield loss.
- The estimated potential yield losses are 40 % due to drought, 20 % due to salinity, 15-20 % due to high temperature, 10 % due to low temperature.

By 2050, the world experiences a rise of temperature by 4°C which leads to heavy yield loss. The expected yield loss of C_3 plants is about 20-30% due this rising temperature in south Asia. The water depletion expected in India by 2025 is more than 40% which leads severe water stress.

How Plants Respond to Environmental Stress?

- Stress resistance mechanisms:

Avoidance Mechanisms

1. Prevents exposure to stress
a) Minimum water loss
b) Closure of stomata
c) Leaf rolling
d) Reduced leaf area

Tolerance Mechanisms

1. Permit the plant to withstand stress.
a) Osmoregulation
b) Synthesis of heat shock proteins
c) ROS scavenging enzyme
d) Synthesis of compatible solutes
e) Synthesis of Saturated fatty acids

Escape Mechanism

1. Alter their physiology in response stress.
a) Early flowering/reduced growth duration.

Plants molecular Mechanisms in Response to Stress involve:

- Activation of signaling pathways: ABA pathway
- Production of ROS Scavenging enzymes: Zn SOD, Fe SOD
- Activation of ABA transcription factors Ex: CBF/DREB1, ABRE transcription factors
- Synthesis of osmolytes: Proline, betaines, mannitol, sorbitol, polyamines.
- ROS detoxification.
- Osmoregulation
- Decrease in protein synthesis
- Stomatal closure under stress

18536

10. Impact of Temperature and Light in Vegetable Crops

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Impact of Temperature

Relationships between the photo-thermal environment and cumulative crop yields are reasonably well understood (Cockshull *et al.*, 1992), the effects on the weekly pattern of crop yield are harder to predict. Consequently, a better understanding is required of the factors that affect the growth and development of tomato fruits. Tomato plants have, within certain limits, the ability to integrate temperature. Plants exposed to fluctuating temperature regime often suffer on overall lose of yield when compared with those grown in a constant regime having the same mean temperature. Furthermore, dry matter partitioning is not greatly affected by temperature. However, fluctuations in temperature may affect the pattern of growth yield. As the rate of developmental events such as fruit maturation is determined largely by temperature (Hurd and Graves,1985). Indeed, commercial crop yields fluctuate greatly from week to week; this probably reflects changes in the time taken for fruits to ripen (Adams *et al.*, 2001). Hurd and Graves (1984, 1985) found that the time taken for fruits to mature decreased throughout the early part of the season, probably in response to higher mean air temperatures.

Temperature and Light Influence in Tomato-Lycopene Development

According to Duggar (1913) in the walls of epidermal cells and unidentified pigment made the fruit yellow or transparent. When it combined with lycopene in the flesh, superimposed with yellow skin colour gave the fruit orange red appearance. He mentioned that high temperature during young fruit developmental stage failed to develop red colour pigment in flesh and appeared light yellow. Smith (1936) light during the ripening period had a considerable effect of carotenoid in the skin and also the colour of the outer epidermis.

Impact of Light

Light is one of the most important environmental factors, acting on plants not only as the sole source of energy, but also as the source of external information, affecting their growth and development. Plants are empowered with an array of photoreceptors controlling diverse responses to light parameters, such as spectrum, intensity, direction, duration etc. These photoreceptors include the red and far-red-absorbing phytochromes, the blue and UV-A light absorbing cryptochromes, phototropins, and other implied photoreceptors, absorbing in UV-A and green regions. Spectral changes of illumination evoke different morphogenetic and photosynthetic responses, which can vary among different plant species.

Effect of short-Wavelength Light on Growth and Development of Lettuce

Light Source

LED- based luminaries consisting of high flux of red light and additional short wavelength light in combination with high pressure sodium lamps were designed and fabricated by Project participants

They performed growth treatments of lettuce, radish and other plants and estimated the effect of such lighting on growth parameters, photosynthetic system, phytohormone contents and sugar, nitrate and vitamin C metabolism. The results are summarized below:

TABLE 1: Effects of different short wavelength light in vegetable crops

Light colour	Effects
Blue light (450 nm)	Affects the chlorophyll formation; photosynthesis processes, stomata opening, promotes dry matter production and inhibits cell elongation in stems and leaves. The optimal flux of blue light for leafy plants is about 10-15% of the total photosynthetically active radiation. The higher flux of blue light is essential for radish (for normal carbohydrate metabolism and photosynthetic assimilate transport from leaves to the storage organs, thus assuring tuber formation). Also, it has a slight effect on primary and secondary metabolite synthesis.
Green	Enhances biomass accumulation in the above-ground part of the plants, and also affects chlorophyll and carotenoid synthesis, thus improving the color of leaves.

Light colour	Effects
Cyan	Supplemental lighting with cyan light emitting diodes (505 nm) significantly affected carbohydrate and nitrate metabolism in lettuce and slightly improved radish growth. Cyan light ranges near to green. So, its biological activity is being close to green light
near-UV light	Though overexposure to UV light is dangerous for the flora, small amounts of near-UV light can have beneficial effects. In many cases, UV-light is a very important contributor for plant colors, tastes and aromas. This is an indication of near-UV light effect on metabolic processes. According to their results, the UV light (385 nm) promotes the accumulation of phenolic compounds, enhances antioxidant activity of plant extracts, but do not have any significant effect on growth processes.

CROP ECOLOGY AND ENVIRONMENT

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11. Effect of Climate Change on Agriculture

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Climate Change and Agriculture

Climate change and agriculture are interrelated processes, both of which take place on a global scale. Climate change affects agriculture in a number of ways, including through changes in average temperatures, rainfall, and climate extremes (*e.g.*, heat waves); changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods and changes in sea level.

Climate change is already affecting agriculture, with effects unevenly distributed across the world. Future climate change will likely negatively affect crop production in low latitude countries, while effects in northern latitudes may be positive or negative Climate change will probably increase the risk of food insecurity for some vulnerable groups, such as the poor. Animal agriculture is also responsible for CO_2 greenhouse gas production and a percentage of the world's methane, and future land infertility, and the displacement of local species.

Agriculture contributes to climate change both by anthropogenic emissions of greenhouse gases and by the conversion of non-agricultural land such as forests into agricultural land. Agriculture, forestry and land-use change contributed around 20 to 25% to global annual emissions in 2010.

Impact of Climate Change on Agriculture

Despite technological advances, such as improved varieties, genetically modified organisms, and irrigation systems, weather is still a key factor in agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variabilities in local climates rather than in global climate patterns. On the other hand, agricultural trade has grown in recent years, and now provides significant amounts of food, on a national level to major importing countries, as well as comfortable income to exporting ones.

In the long run, the climatic change could affect agriculture in several ways:

- productivity, in terms of quantity and quality of crops
- agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers
- environmental effects, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity
- rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities.
- adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice.

Pest Insects and Climate Change

Global warming could lead to an increase in pest insect populations, harming yields of staple crops like wheat, soybeans, and corn. While warmer temperatures create longer growing seasons, and faster growth rates for plants, it also increases the metabolic rate and number of breeding cycles of insect populations. Insects that previously had only two breeding cycles per year could gain an additional cycle if warm growing seasons extend, causing a population boom. Temperate places and higher latitudes are more likely to experience a dramatic

change in insect populations

Plant Diseases and Climate Change

Climate change may alter the developmental stages of pathogens that can affect crops. The biggest consequence of climate change on the dispersal of pathogens is that the geographical distribution of hosts and pathogens could shift, which would result in more crop losses. This could affect competition and recovery from disturbances of plants. It has been predicted that the effect of climate change will add a level of complexity to figuring out how to maintain sustainable agriculture.

Temperature Potential Effect on Growing Period

Duration of crop growth cycles are above all, related to temperature. An increase in temperature will speed up development. In the case of an annual crop, the duration between sowing and harvesting will shorten (for example, the duration in order to harvest corn could shorten between one and four weeks). The shortening of such a cycle could have an adverse effect on productivity because senescence would occur sooner.

Effect of Elevated Carbon Dioxide on Crops

Elevated atmospheric carbon dioxide effects plants in a variety of ways. Elevated CO_2 increases crop yields and growth through an increase in photosynthetic rate, and it also decreases water loss as a result of stomatal closing the growth response is greatest in C_3 plants, C_4 plants, are also enhanced but to a lesser extent, and CAM Plants are the least enhanced species.

Effect of Drought Stress on Crops

Increase in global temperatures will cause an increase in evaporation rates and annual evaporation levels. Increased evaporation will lead to an increase in storms in some areas, while leading to accelerated drying of other areas. These storms impacted areas will likely experience increased levels of precipitation and increased flood risks, while areas outside of the storm track will experience less precipitation and increased risk of droughts. Water stress effects plant development and quality in a variety of ways first off drought can cause poor germination and impaired seedling development in plants. At the same time plant growth relies on cellular division, cell enlargement, and differentiation. Drought stress impairs mitosis and cell elongation via loss of turgor pressure which results in poor growth. Development of leaves is also dependent upon turgor pressure, concentration of nutrients, and carbon assimilates all of which are reduced by drought conditions, thus drought stress lead to a decrease in leaf size and number. Plant height, biomass, leaf size and stem girth has been shown to decrease in Maize under water limiting conditions. Crop yield is also negatively affected by drought stress, the reduction in crop yield results from a decrease in photosynthetic rate, changes in leaf development, and altered allocation of resources all due to drought stress. Crop plants exposed to drought stress suffer from reductions in leaf water potential and transpiration rate, however water-use efficiency has been shown to increase in some crop plants such as wheat while decreasing in others such as potatoes.[87][86] Plants need water for the uptake of nutrients from the soil, and for the transport of nutrients throughout the plant, drought conditions limit these functions leading to stunted growth. Drought stress also causes a decrease in photosynthetic activity in plants due to the reduction of photosynthetic tissues, stomatal closure, and reduced performance of photosynthetic machinery.

Land Use

Agriculture contributes to greenhouse gas increases through land use in four main ways:

- CO2 releases linked to deforestation
- Methane releases from rice cultivation
- Methane releases from enteric fermentation in cattle
- Nitrous oxide releases from fertilizer application

Together, these agricultural processes comprise 54% of methane emissions, roughly 80% of nitrous oxide emissions, and virtually all carbon dioxide emissions tied to land use.

The planet's major changes to land cover since 1750 have resulted from deforestation in temperate regions: when forests and woodlands are cleared to make room for fields and pastures, the albedo of the affected area increases, which can result in either warming or cooling effects, depending on local conditions. Deforestation also affects regional carbon reuptake, which can result in increased concentrations of CO_2, the dominant greenhouse gas. Land-clearing methods such as slash and burn compound these effects by burning biomatter, which directly releases greenhouse gases and particulate matter such as soot into the air.

AGRONOMY

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12. Ideal Conditions for Introduction of Integrated Farming System

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It is a resource management approach to achieve economic and sustained production to meet diverse requirement of farm household while preserving resource base and maintains high level of environmental quality. Farming enterprises like crops, dairying, poultry, fishery, sericulture, apiary, trees etc. a combination of one or more enterprises with cropping when carefully chosen, planned and executed gives greater dividends than a single enterprise, especially for small and marginal farmers. An emphasis in these systems is managing interactions so that waste from one component becomes an input for another component of the system which reducing the need for purchasing and applying expensive and potentially polluting inputs, such as fuel, fertilizers and pesticides, reducing leakages to the environment and improves production and income. Integrated farming system approach is not only a reliable way of obtaining fairly high productivity with considerable scope for resource recycling but also concept of ecological soundness leading to sustainable agriculture.

The key factors in integrated farming systems are the inter-dependence among enterprises within the system, synergetic transfer of resources among enterprises and the flexibility in the system to be sustainable in the long run (Hendrickson *et al.*, 2008). These enterprises not only supplement the income of the farmers but also help in increasing the family labour employment. The emergence of Integrated Farming Systems has enabled us to develop a framework for an alternative development model to improve the feasibility of small sized farming operations in relation to larger ones.

It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock, may sometimes be known as integrated bio systems. Sustainability is the objective of the farming system in which process of production is optimized through efficient utilization of inputs without infringing on the quality of environment with which it interacts on one hand and attempt to meet the national goals on the other.

Benefits of IFS

- It improves space utilization and increase productivity per unit area.
- Less reliance to outside inputs - fertilizers, agrochemicals, feeds, energy, etc.
- It provides diversified products.
- Improves soil fertility and soil physical structure from appropriate crop rotation and using cover crop and organic compost.
- Reduce weeds, insect pests and diseases from appropriate crop rotation.
- Utilization of crop residues and livestock wastes.
- Higher net returns to land and labour resources of the farming family.

Ideal Conditions for Introduction of IFS

- The farmer wishes to improve the soil quality.
- The farm household is struggling to buy food or below the poverty line.
- Water is stored on-farm in ponds or river-charged overflow areas.
- The farmer is looking to reduce chemical control methods.
- The farmer wants to reduce pollution or waste disposal costs.
- Fertilizers are expensive or the recommended blend is unavailable.
- Soil salinity has increased as a result of inorganic fertilizer use.
- The farmer is seeking to maximize profits on existing holding.
- The farm is being eroded by wind or water.

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13. Crop Diversification: Need for Remunerative Agriculture

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Indian agriculture has been undergoing spectacular changes in recent period. These changes are manifestations of large scale commercialisation and diversification taking place in the agricultural sector. They broadly include cultivation of new crops and varieties, increase in the share of area under cash crops, large scale spread of livestock activities and fisheries, pursuance of hi-tech agriculture in the areas of aquaculture, biotechnology, horticulture, processing, etc. The latest changes are basically responses of our agriculture to new economic environment ushered in by the process of liberalisation.

Crop Diversification Programme

Diversification is introduction of alternate crops, may give good scope to break the monotony of the traditional system of cultivation. Crop intensification is the main course of future growth of agriculture. Because of changing rainfall pattern over years, groundwater depletion, hike in labour wages, the existing cropping pattern may be economically not viable. It is the time to critically examine and redesign alternative cropping patterns based on agro climatic zone and this must be demonstrated in the farmer's holdings in order to effectively utilize the natural resources and also to stabilize the production and profitability. Crop diversification is mainly focusing on the following

- From low value to high-value crops
- From water-loving crop to water saving crop
- From single crop to multi / mixed crop
- From crop alone to crop with crop – livestock-fish – apiculture
- From agriculture production to production with processing and value addition

Sensitization and motivation of farmers to shift to alternative crops in water deficient areas is most required. There is urgent need is required to focus on drought resistant and less water consuming crop.

1. Diversification through Effective Irrigation Management Practices

Where water is scarce, high value but low water requiring crops should be promoted. Among several possible approaches, the important approach that could be implemental is adoption of improved water saving technologies including micro-irrigation. A transition to drip irrigation in the water-starved areas could reduce off take of groundwater and bring down the level of overexploitation taking place in some of the areas. With this view farmers are encouraged to adopt micro – irrigation system. Drip fertigation and drip herbigation can also be encouraged.

2. Yield Gap

Yield gap is major issue determining agricultural stagnation. The gap between actual and potential yield is maximum in many of our agricultural crops. An integrated approach is necessary to remove the technological, infrastructure, and social and policy constraints responsible for the prevailing gap between actual and potential yields.

3. Companion Crop

Sugarbeet is an excellent supplementary crop in sugarcane-based industry area. Because it is a short duration crop and requires less water for its growing period. It is also grown under saline soil condition.

4. Increased Cropping Intensity and Employment

Continuous cropping provides increased employment opportunities in agriculture throughout the year. Possibility of increasing the cropping intensity especially in rainfed areas with the suitable introduction of crops is the foremost thing.

5. Grey to Green Agriculture

Vast wasteland areas that include areas suitable for dry land-hardy crops can be made available to local communities. While providing an income-earning opportunity for the poor, these perennial tree and shrub crops also help rehabilitate these lands by building the fertility of their soils.

6. Diversification from Crop to Multi / Intercropping

Multi / intercropping is an effective strategy to efficiently use all growth resources for the benefit and crop diversification should mainly focus on that

7. Crop Diversification and Agroforestry

Agroforestry on farmlands can be used for promoting plantation without affecting crop production.

General Constraints in Crop Diversification in India

- Over 60 per cent of the cropped area in the country is completely dependent on rainfall.
- Sub-optimal and over-use of resources like land and water resources, causing a negative

impact on the environment and sustainability of agriculture.
- Inadequate supply of inputs.
- Fragmentation of landholding less favoring modernization and mechanization of agriculture.
- Very weak in agro-based industry.
- Weak research - extension - farmer linkages.
- Inadequately trained human resources together with persistent and large-scale illiteracy amongst farmers.
- Host of diseases and pests affecting most crop plants.
- Poor database and decreased investments in the agricultural sector over the years.

Future Potential

- There is need to develop and disseminate eco-technologies for rain-fed and semi-arid, hill and island areas, which have so far been bypassed by modern yield enhancement technologies.
- Farming systems intensification, diversification, and value-addition should be promoted.
- Water conservation and sustainable management will need particular attention.
- Develop and popularize crop mixtures based on considerations of ecology and economics, such as high-value fruits, vegetables, and biofuel crops.

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14. Methods of Application of Fertilizers

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Generally, 3 methods of application of fertilizers are in practice.

1. Broadcasting: Uniform distribution over the whole cropped field.
2. Placement: Application in bands or in pockets near the plants or plant rows.
3. Foliar application: Using low or high-volume sprayers, the fertilizers are sprayed covering the plants.

The method of application has to be chosen to suit the particular nutrient, the crop, as well as method of cultivation. Nitrogen is generally applied as broadcast to irrigated crops. Phosphorus needs to be placed near the plant rows. Potassium is also applied as broadcast. As all the 3 nutrients are applied using a complex fertilizer at the time of sowing or planting, it is a good practice to apply the fertilizer as placement. Micronutrients are mostly applied as foliar sprays.

Broadcasting of fertilizers is practiced on all crops with a dense stand and not sown in rows. In the case of plants whose roots spread widely in the soil and on very fertile soils or when high rate of fertilizers are used. When readily soluble nitrogenous fertilizers are applied and when potassic fertilizers are applied in light soils.

Drawbacks with broadcast application-May stimulate weed growth with the result that the crop does not derive full benefit of fertilizers. Fertilizers may come in contact with a large volume of soil and are likely to be fixed and unavailable for that crop. This is particular in the case of super phosphate application.

Different Methods of Placing the Fertilizers includes

- Banding i.e. placing fertilizers in bands to one or both sides of the rows. This is also called as side dressing.
- Drilling in between rows.
- Spot placement i.e. by placing in between the plants. This is mostly practiced for vegetable crops.
- By placing in a circular band away from the base of the plants as in the case of fruit trees.

No single method can be considered best for all the crops. The method of placement varies with the crop, fertilizer, and weather.

Placement of fertilizers is practiced when small quantities of fertilizers are to be distributed or when phosphatic fertilizers are applied in acidic soils where fixation of phosphorus is a problem. In case of crops sown in wider rows and soils with low fertility.

Advantages of Band Placement

- Placing fertilizers below the seeds without touching the seeds stimulates early growth of seedlings.
- For application of phosphatic fertilizers as phosphates are less mobile. Broadcast application will result in unavailability to roots.
- More availability of phosphates to crops grown in acidic soils where fixation of phosphates is a problem.
- Early root development will be rapid and extensive and plant growth will be stimulated.
- Under rainfed conditions, due to extensive and deeper root development, plants will be able to draw moisture from lower depths of soil and better withstand drought.

Foliar application of fertilizers- Fertilizers are dissolved in water and such diluted solutions are sprayed directly on the plant's foliage. Hand operated sprayers are used for smallholdings. On individual farms a tractor drawn low volume sprayers can be used while on large scale aircrafts are used for foliar spraying.

Chemical Fertilizer Sprayed on Crops

- Only those fertilizers that do not scorch (burn) leaves are sprayed.
- Usually micronutrients, which are required in low rates, are foliar sprayed.
- Urea sprays are used for supplying nitrogen.
- Ammonium phosphate fertilizer is also used to spray to improve seed setting in multicut fodder legumes like Berseem.
- For the reason that low concentration of fertilizers needs to be sprayed most of the fertilizers are not used for foliar application.

Precautions to be Observed for Spraying Urea

- Size of sprayer's nozzle is important. The increase in concentration depends on the nozzle type. The sprays should be fine as mist but not as droplets of water.
- Bigger droplets fall off from the leaf surfaces and are wasted. Also, leaves may be scorched if the droplets are retained on the leaves.
- Sprayings are best done after 04:00 PM in the evening.
- While spraying the nozzle should be kept at least 1 to 2 feet away from the vegetative growth.
- The weather should not be cloudy.
- The concentration of urea should not exceed 3% in case of knapsack sprayers and 20% in case of power prayers (low volume high pressure sprayers).
- It is advisable to mix 1% of sugar or jaggery with the urea solution for better absorption.

Optimum Concentration for Spraying Micronutrients

Zinc sulfate	0.2%
Borax	0.1%
Ferrous sulfate	0.2%
Molybdic acid	0.05%
Manganese sulfate	0.2%
Copper sulfate	0.2%

Nutrients Applied through Foliar Sprays to Fruit Trees

- Plant nutrients are generally applied as foliar sprays on fruit trees to prevent nutritional disorders of micronutrients.
- Nutrient deficiencies of nitrogen, phosphorus, potassium, calcium, and magnesium can be corrected through foliar sprays.
- Nutrient sprays can be applied at any time during the growing season to improve the appearance of foliage and color, size and quality of fruits.
- For most fruit crops, plant nutrients are sprayed along with the regular spray program of pesticides.
- The compatibility of nutrients and the pesticide chemicals should be ascertained before such mixtures are sprayed.

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15. Zero Tilled Rapeseed-Mustard: A Boon for Increasing Farmer's Income in Manipur

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In Manipur, due to lack of proper irrigation systems, crops are normally sown under rainfed conditions. During *Rabi* season, as a result, 80% of the field remains fallow due to non-availability of irrigation water. Rapeseed-mustard has huge potential for succeeding the kharif rice crop in the Rabi season with the residual moisture and additional one or two life-saving irrigations. Rapeseed and mustard are among the most important choices for the farmers of Manipur as it can help in increasing their income without much investment. Moreover, the residual moisture and nutrients present in the soil can be utilized by the succeeding rapeseed crop. Minimum tillage with or without a straw or zero tillage enhances the conservation of soil moisture as well as increases the soil properties. With the introduction of zero tillage technology, around 1000 ha areas of Manipur have been transformed to double cropping system of rice-rapeseed/mustard instead of the normally followed rice- fallow mono cropping system.

The following techniques for sowing rapeseed-mustard under zero tillage or minimum tillage are being followed in Manipur after the kharif rice.

Relay Cropping

It is interplanting or inter sowing of the succeeding crop in the proceeding annual crops, where the succeeding crop is sown after the proceeding crop has reached the maturity stage but before the harvest of standing crop. When the soil moisture is optimum as indicated by the change in soil colour or if slight footprint impressions are observed in the soil, then it is considered as an optimum condition for sowing the rapeseed seeds. Usually, the seeds are sown 4-7 days before harvesting the rice crop @ 35-40 kg/ha. Sowing is done at higher seed rate in case of mustard

than rapeseed as they can be heavily thin out to use as a vegetable when the plants are young and tender. After the harvest of rice crop, seeds of rapeseed start germinating, and when they reach 1-2 true leafed stage, urea is top dressed based on the requirement. The crop can be left in the field to mature without much effort or care by the farmers.

Sowing among the Stubbles with Straw Mulching

Right after the harvest of rice, the seeds of rapeseed are sown in between the stubbles left by the previous rice crop. Longer stubbles are left in the field for this purpose so that the soil moisture does not dry up fast. After sowing, planking is done to press the stubbles on the soil which will act as mulch for the rapeseed seeds. Some straws can also be scattered very thinly over the entire field. This method also helps in increasing the soil organic matter by decomposing the stubbles and straw.

Sowing Seeds after Burning Straw

Although burning of rice straw is not recommended due to its impact on the environment, the farmers of Manipur widely follow this practice for sowing rapeseed- mustard. In this method, the farmers harvest rice crop at the height of 15-20 cm from the ground level. The threshed-out rice straws are thinly scattered over the entire rice field and then burnt. Then the seeds are sown. Some farmers carry out the sowing just before burning the straw and stubbles. In this method the ashes serve as soil mulch to conserve soil moisture as well as rooting medium for the germinating seeds. This method is more advantageous in moist field and also helps in controlling weeds and insect pests. It is also believed that the ash left after burning the straw helps in absorbing moisture from the air and thus helps in faster germination of rapeseed.

Benefits of Zero Tillage of Rapeseed-Mustard

Zero tillage has many more advantage over conventional tillage particularly in rapeseed and mustard cultivation for the poor farmers, when grown as rainfed crop in rice fallows.

1. Timely sowing of rabi crops is possible under zero tillage which otherwise is usually delayed under conventional tillage. Delayed sowing leads to uneven germination of seeds and attack of insect pests and diseases.
2. It protects young seedlings from abiotic stress like heat and wind during early growing stage as the standing stubbles reduce wind speed at ground level and reflects heat.
3. Studies show that the growth and yield parameters in all the rapeseed-mustard varieties were better in zero tillage than conventional tillage due to residual soil moisture after rice harvest.
4. Thinning out of young and tender mustard plants is carried out and sold to the market for extra income.
5. In Manipur, adoption of bee rearing is carried out by some of the farmers during flowering stage of rapeseed- mustard for enhancing pollination and in turn gets extra income from the sale of honey by the end of the cropping system.
6. Adoption of zero tillage technology has a positive impact on the overall economics of rapeseed and mustard cultivation due to lower cost of cultivation and higher gross and net income due to increased productivity under zero tillage cultivation of rapeseed and mustard.
7. It improves soil condition over time by addition of organic matters and improving the soil physico-chemical as well as biological properties.
8. It helps in maintaining clean environment by increasing carbon pool of soil and reducing carbon dioxide release to the atmosphere.

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16. Rice Bean: An Underutilized Potential Leguminous Crop

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Vigna umbellata (Thunb.) Ohwi and Ohashi, earlier known as *Phaseolus calcaratus* is a warm season perennial legume which can be grown annually. It is believed to be originated in Indo China border. Rice bean bears yellow colour flowers and small edible beans, colour range from greenish yellow to black through yellow and red. It can grow up to a height of 30 cm to 100 cm and has a deep root system of 100-150 cm. It has trifoliate leaf and fruits are cylindrical with 6-9 cm long and 7.5-12.5 cm long respectively. Seeds are oblong with a concave hilum, 6-10mm long and 6-8mm thick. Rice bean can be sown in February-March or July-August. It matures in 120-150 days and protein content ranges from 20% to 25 %. Climatic requirements are similar with cowpea and can tolerate harsh conditions of drought, water logging and acid soils but can't withstand frost. Rice bean prefers full light and its growth can be hampered if it is intercropped with tall companion crops. The twinning habit of rice bean makes them suitable to intercrop with maize, sorghum and millet although harvest becomes a problem.

Despite of its high nutritional value and excellent seed productivity, it has failed to emerge as a major leguminous crop. Also, because of its high fodder production, it is now attracting attention as a leguminous fodder crop. The consumption of rice bean has been decreasing due to the increase availability of more preferred pulses in the local market. The rice bean seeds are less preferred for making dal due to their fibrous mucilage that prevents hulling and separation of the cotyledons. Indigenous landraces and current varieties are susceptible to shattering and show high levels of hard seededness. No modern plant breeding methods has been applied to improve the crop and only landraces having low yield are cultivated by the farmer. A major initiative has been taken up under INCO programme of the European Commission's Sixth Framework Programme (FP6) and FOSRIN (Food Security through Rice bean Research in India and Nepal), which targets to promote rice bean on a wider scale, assess production chain and nutritional aspects of the crop, and also to evaluate the range of germplasm and indigenous information available.

The nutritional Potential of Rice Bean (*Vigna Umbellata*) has been reported by many scientists and researchers. The protein content can reach a maximum of 25.57% with in vitro digestibility of 54.23%. Crude fat content ranges from 1.2 to 2.2%. Some authors have reported that albumins (6.13% to 7.47%) and globulins (13.11% to 15.56%) are the major constituent of proteins (Sadana *et al*., 2006). Cysteine and methionine contents of rice bean ranged from 30.1 to 63.8 and 64.6 to 130.1 mg/g N, respectively. High content of minerals and vitamins viz. niacin, thiamine, riboflavin and ascorbic acid were also reported. The fatty acid profile of rice bean signifies a higher percentage of unsaturated fatty viz., linoleic and linolenic acid, which are nutritionally desired in our diet. (Rajan, K. 2013)

Farmer descriptors of some major rice bean types:

Local name	Farmers' distinguishing traits
Red rice bean	Red, small to medium sized grain, medium in maturity, drought tolerant, low yield.
Brown and bold grain	Brown with stripes and bold grains, late in maturity, high yielding.
White bold grain/ Yellow bold grain	Bold white to yellowish grains, late in maturity, high yields, intermediate, larger one can be intercropped with maize
Early small seeded	Greenish to yellowish, small grains, early maturity, low yield.
Large rice bean	Climbs strongly and can reach 5-6 meters if grown on poles or in trees, seeds are yellowish in colour with some variegation.

Some common uses of Rice Beans

- Grain- Dal, Curry, Biraula, Batuk roti, Masaura, Khichadi, green pods can be used as vegetables.
- Green foliage- Livestock fodder (Late maturing and indeterminate landraces)
- Green foliage- Green manure (Late maturing and indeterminate landraces)
- Dry straw- Animal feeds.

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17. Internet of things and Artificial Intelligence: A Step for Advanced Farming

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By 2050, **the** world population is expected to reach nine billion, in order to feed this huge population, there is a need to increase agricultural production by 70%. Of this only about 10% increased production may come from the availability of unused lands and the rest of 90% should be fulfilled by intensifying the current production. Moreover, climate change, labour scarcity, fluctuating market prices, and depletion of valuable resources like water, fossil fuels, etc., are making a significant negative impact on the farming sector. In this context, there is a need of latest technological solutions and automation to make farming more efficient. While Artificial Intelligence (AI) and the Internet of Things (IoT) are already revolutionising various sectors, they can also bring a revolution in present-day farming conditions we are seeing.

Internet of things is the network of interconnected devices which transfer data without human intervention. Artificial intelligence, act as an engine or the brain that will enable analytics and decision making from the data collected by IOT. In IOT and AI we use various technologies like wireless sensor networks, drones, robotics, satellites, remote sensing

etc., that can perform various farm operations and gather large amount of data from the field that can be analysed with more accuracy to enable the farmers for addressing all the uncertain issues faced by them in the agriculture sector. IoT and AI have its applications in Precision farming, climate monitoring, crop health monitoring, crop readiness monitoring, automated greenhouse, livestock monitoring, field management, food processing, agricultural marketing etc. IOT and AI will enable the farmers to do more with less, apart from they also help the farmers in intelligent decision making, to have complete control over his farm, improve the quantity and quality of production and also ensure quick go to market strategy.

Though IOT and AI offer opportunities in various applications, there still exists a lack of familiarity among farmers with high technology machine learning solutions. Exposure of farming to external factors like weather conditions, soil conditions, High cost of the hardware involved, farmers may feel fearful in adopting new technologies, small fragmented land holdings, difficulty in building robust architecture etc. These challenges can be met by developing low cost hardware with low maintenance, robust architecture and ease of operation. By taking up new projects by the government sector collaborating with the state universities and corporate companies also help in making this smart technology to reach farmers and to achieve the goal of automation in Indian farming.

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18. Aerobic Rice Cultivation: A Strategy to Enhance Crop Performance and Yield

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Food production has to increase to meet the demand of a growing population and therefore, future agricultural production systems must be productive and efficient in terms of inputs such as fertilizer and water. Rice (*Oryza sativa* L.) is an important food crop worldwide and requires a higher amount of water and nutrients. To achieve potential rice yields, modern cultivars of rice require a large number of fertilizers. Among all fertilizers, nitrogen (N) is one of the most important nutrients for plant development, growth and grain quality, and rice production.

Rice is conventionally grown by transplanting in the puddled field in flooded soil condition. To grow rice sustainably, farmers must adopt the emerging alternative non-flooded systems like aerobic rice cultivation where rice is grown continuously in non-submerged conditions. In order to reduce the overall N losses in aerobic soils, N is applied in split doses, and the application of organic amendments is adopted. Changes in field hydrology from flooded to non-flooded systems may affect crop performance by changes in canopy structure, root growth, hormonal levels, remobilization of carbon from stems to grains, grain filling, harvest index, and use-efficiencies of nitrogen or water, so proper management strategy crucial for aerobic rice cultivation. Aerobic rice cultivation is a production system in which especially developed "aerobic rice" varieties are grown in well-drained, non-puddled, and non-saturated soils. The characteristic features of aerobic rice are; 1. upland hydrology, 2. intensive crop management, 3. input-responsive, 4. upland-adapted varieties. Using the right source of nitrogenous fertilizer and understanding the water and nitrogen interaction, nitrogen losses under aerobic soil conditions can be avoided. Irrigation regimes and sources of fertilizers have a significant effect on crop performance related to grain yield and water productivity. With good management, the aerobic rice cultivation aims for yields of at least 4-6 tons per hectare which is double than that of the conventional method. Studies have shown that application of nitrogen fertilizer at the young panicle differentiation stage results in a higher number of spikelets significantly. There is a close relationship between the spikelet number and the amount of nitrogen accumulated by the late spikelet differentiation stage. There is also evidence that application of the ammonical form of nitrogenous fertilizer in aerobic rice cultivation can develop drought tolerance mechanisms and result in higher water use efficiency. In conclusion, it is clear that aerobic method of rice cultivation is more advantageous in terms of resource use efficiency and is also important for better sustainability of modern agriculture.

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19. Cloud Seeding an Approach to Enhance Downpour

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Cloud seeding is a method of weather alteration that aims to change the amount or type of precipitation that falls from clouds by dispersing substances into the air that materials then modify microphysical processes within the cloud, for example by providing additional condensation / ice nuclei or altering relative humidity by introducing hygroscopic particles. It depends on differences in vapour pressure over ice and supercooled water at the same temperature.

The usual intent is to increase precipitation (rain or snow), but hail and fog suppression are also widely practised.

Vincent Schaefer discovered the principle of cloud seeding in July 1946 through a series of serendipitous events.

Materials used for Cloud Seeding

Chemicals: silver iodide (nucleation temperature -6 to -9°C), potassium iodide and dry ice (solid carbon dioxide at nucleation temperature < -80°C), Liquid propane (which expands into a gas), table salt (Hygroscopic)

Others: talcum powder, soils, dust

Types

For cold cloud: If cloud top temperature is negative then it is cold cloud. Two methods employed for seeding cold cloud:

1. **Static cloud seeding:** Reason for non-precipitation is deficiency of ice crystals.
2. Based on the principle that chemical used provides a crystal around which moisture can condense. Basically, the fact that the equilibrium vapor pressure is lower over ice than over water. The formation of ice particles in supercooled clouds allows those particles to grow at the cost of liquid droplets. When sufficient growth takes place, the particles become heavy and fall as precipitation from clouds. This is known as "static" seeding.

a) Example: AgI essentially makes rain clouds more effective at distributing their water.

3. **Dynamic cloud seeding**: It aims to boost vertical air currents, which encourages more water to pass through the clouds, translating into more rain. Seeding of warm-season or tropical cumulonimbus (convective) clouds quest to exploit the latent heat released by freezing. This strategy of "dynamic" seeding assumes that the additional latent heat annex buoyancy, strengthens updrafts, assures more low-level convergence, and eventually bring on rapid growth of properly selected clouds.

a) Massive amount up to 100 times more ice crystals are used in dynamic cloud seeding than in the static method.

b) **For warm cloud:** If cloud top temperature is positive then it is warm cloud method employed for seeding warm cloud is:-

4. **Hygroscopic cloud seeding:** principle involves that it disperses salts through flares or explosives in the lower portions of clouds. The salts grow in size as water joins with them and finally rain occur. It is hypothesize that hygroscopic seeding causes the droplet size spectrum in clouds to become more maritime (bigger drops) and less continental, vitalizing rainfall through coalescence.

Mechanism

Precipitation occur when supercooled droplets of water that are still liquid even if at a temperature below the usual freezing point of 0°C which form ice crystals generally. Rainstorm happens after moisture collects around naturally occurring particles in the air, causing the air to reach a level of saturation at which point it can no longer hold in that moisture then numerous collisions are needed to make a rain drop. Now as they are too heavy to remain suspended in air, fall and melting in their way down reach the ground as rain.

Cloud seeding essentially helps that process along, providing additional "core" around which water condenses. Silver iodide is efficacious because its form is similar to ice crystals. Calcium chloride is often used in warm or tropical areas.

In case of snow fall their goal is the same: to "seed" clouds with particles of silver iodide, a compound that freezing water vapor easily attaches to. That combination makes ice crystals form, which eventually become snowflakes.

Technology used: An electronic mechanism was tested in 2010, when infrared laser pulses were directed to the air above -Berlin by researchers from the University of Geneva. The experimenters posited that the pulses would encourage atmospheric sulfur dioxide and nitrogen dioxide to form particles that would then act as seeds.

A 20th-century technology: Cloud seeding

machines generate smoke that floats into the air like incense.

Top Seeding by Aircraft: Seeding agent is deployed above or inside cloud. Adequate products are both burn-in-place or ejectable flares.

Eg. Aircraft-mounted generators or – when seeding warm clouds – hygroscopic systems

Below-cloud Seeding by Aircraft: Seeding agent is deployed below the cloud and then naturally compartmentalized by updrafts or thermals. Burn-in-place flares, aircraft-mounted generators or hygroscopic systems may be employed to achieve this.

Ground-based Seeding by Generators: Especially for seeding low-hanging, cold clouds (*e.g.* in mountainous terrain) ground based generators may be applied to economically deploy the seeding agent. When released by devices on the ground, the fine particles are carried downwind and upward by air currents after release.

Application of this technique

Hail Suppression: Reducing large hail stone formation in storms.

Rain Enhancement / Rain Reduction: Alter the amount of precipitation to supply fresh water, support plant growth or for recreational purposes.

Snow Augmentation / Snow Reduction: Snowfall takes place when temperatures within the clouds are between −4 and 19 °F (−20 and −7 °C). Introduction of silver iodide, which has a crystalline structure similar to that of ice, will effectuate freezing nucleation. Significantly accelerate the amount of natural snowfall to enhance fresh water reserves or improve conditions for winter sports. Also reduce snow pack to prevent damage to buildings or mitigate avalanche risks. Cloud seeding could increase snowfall by 5 to 15 percent — but only when the right conditions for seeding were met, or during 30 percent of snow events.

Fog Dispersal: Improve visibility and ensure safe operation of airports, roads, tunnels and industrial facilities by clearing fog and low-hanging clouds.

Harmful Sway

- Silver iodide can cause temporary incapacitation or possible residual injury to humans and other mammals with intense or chronic exposure.
- Environmentalists are concerned about the uptake of elemental silver in a highly sensitive environment affecting the pygmy possum among other species as well as recent high-level algal blooms in once pristine glacial lakes.

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20. Nutrient Use Efficiency in Maize through Drip Fertigation and Biofertilizers

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INTRODUCTION: In India, maize is cultivated throughout the year in all the states for various purposes including grain, fodder, cobs, sweet corn, popcorn in many areas. It is essentially a crop of warm countries with adequate moisture, performs well under well drained deep loams and silt loams containing adequate organic matter and available nutrients. USA is largest producer, contributing 35% of total production in the world and it's the driver of US economy. It also got the highest productivity (>9.6 t ha^{-1}) double than global average (4.92 t ha^{-1}). In India, maize is the third most important cereal crop after rice and wheat. Predominant maize growing areas in India include Rajasthan, Maharashtra, Bihar, U.P., M.P., Telangana, A.P. Maize is a cross pollinated crop, and the cultivars grown in India comprise of varieties, hybrids, composites and synthetics.

Nutrient Use Efficiency (NUE (%))

Nutrient use efficiency may be defined as yield per unit fertilizer input or in terms of recovery of fertilizer applied.

NUE = (Crop nutrient removal / Nutrient input) * 100

Factors

- Selection of improved genotypes
- Improved tillage practices
- Temperature, solar radiation, and precipitation during crop growth influences nutrient availability in soil and the plants ability to take up
- Enhanced beneficial microbes in the rhizosphere
- Mobilization and solubilization of unavailable organic/inorganic nutrients.
- Best fertilizers management practices such as source, rate, method of application and split application of nutrients based on soil, plant and climatic factors.
- Crop factors usually include yield potential and crop value and in some cases tissue nutrient concentrations or leaf color as several crop cultural practices can influence nutrient management;
- Soil factors often involve soil nutrient supplying

indices or other physical, chemical or biological properties that influence nutrient cycling and crop growth.

Effect of Drip Fertigation on Yield (kg ha^{-1}) of Maize

Ramah (2008) conducted field experiments during *Kharif* 2006-07 under sandy clay loam, at Coimbatore, India to study the effect of drip fertigation on yield (kg ha^{-1}) of maize. Drip irrigation at 75 per cent WRc resulted in similar growth and yield of crops with 100 per cent WRc, indicating a saving of 25 per cent irrigation water. The higher irrigation level of 125 per cent WRc has not increased the growth and yield of the crops when compared to lower level of irrigation, instead it lowered the yield and was comparable to 75 per cent WRc, indicating the wastage of irrigation water. While comparing drip fertigation at 75 per cent RDF and soil application of 100 per cent RDF with drip, 75 per cent RDF through fertigation is sufficient to produce comparable yield with that of later indicating a saving of 25 per cent fertilizers besides increasing the fertilizer use efficiency.

Effect of Drip Fertigation on Nutrient Use Efficiency (kg kg NPK^{-1}) of Maize

The nutrient use efficiency was higher under fertigation level of 75 per cent RDF in crops. Drip irrigation at 100 per cent WRc resulted in higher nutrient use efficiency. Similar to nutrient uptake, the available nutrients in the soil were observed to be higher under irrigation regime of 100 per cent WRc and fertigation level of 125 per cent RDF. The nutrient use efficiency was higher under fertigation level of 75 per cent RDF. Drip irrigation at 1.0 E pan resulted in higher nutrient use efficiency. Similar to nutrient uptake, the available nutrients in the soil were observed to be higher under irrigation level at 1.0 E pan and fertigation level of 125 per cent RDF. For achieving maximum yield and net profits, the maize crop can be safely irrigated at 1.0 E pan under drip irrigation resulting in saving of irrigation water. A fertigation level of 100-125% percent recommended dose of nitrogen and 100-125% percent recommended dose of potassium along with recommended dose Phosphorus can be adopted to achieve higher yields.

Increasing Nutrient use Efficiency in Maize through Drip Fertigation and Biofertilizers

Farmers use chemical fertilizers to increase the production, but the excessive use of fertilizers leads to contamination of soil and groundwater and reduce soil fertility. On the other hand, for marginal farmers in India, the purchase of chemical fertilizers is difficult and expensive. Nutrients and water are supplied near the active root zone through fertigation which results in greater absorption by the crops. So, Bio-fertilizers can replace partially chemical fertilizers. Bio-fertilizers are eco-friendly, non-hazardous, improves soil health without causing damage to environment.

Application of Biofertilizers in Combination with other Sources of Nutrients to Improve Nutrient use Efficiency in Maize

The combined application of *Azospirillum* and *Rhodotorula* in presence of half the recommended doses of NPK and either the full or half the recommended dose of sulfur produced comparable results to that obtained due to the application of the recommended doses of NPK regarding grain yield. The combined application of efficient biofertilizers, reduced doses of NPK and half the recommended dose of sulfur could be an integrated treatment to be applied in maize production to get a yield of good quantity (3.76 ton fed^{-1}.) and quality in addition to keep the environment clean.

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21. Direct Seeded Rice: A Sustainable Rice Production System

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INTRODUCTION: Rice (*Oryza sativa* L.) second most important cereal crops of the world after wheat. It is the staple food crop for people of south, south-east and East Asia where about 90% of the world's rice is produced and consumed. Among the cereals, rice is the leading crop worldwide and more than half of the human race depends on rice for their daily sustenance. World's rice demand is projected to increase by 25% from 2001 to 2025, to keep pace with population growth and therefore, meeting ever increasing rice demand in a sustainable way with shrinking natural resources is a great challenge. In Asia commonly rice is grown by transplanting seedlings into puddled soil. Conventional rice production system is water, labor and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce. It also degrades the physical properties of soil, adversely affects the performance of succeeding upland crops. To address this issue, it required a major shift from puddle transplanted to direct seeded rice cultivation. The direct seeded rice cultivation is

a very old traditional practice of sowing of rice and most commonly followed in Asian countries in low land rice cultivation ecosystem. The direct seeded rice combining with conservation agriculture gaining importance to address the rising water and labour scarcity. The conventional puddled transplanted rice is a major source of greenhouse gas emission, especially methane responsible for global warming and climate change. The Inter-Governmental Panel on Climate Change (2007) estimated a temperature increase between 1.1 and 6.4°C by the end of the 21st Century. Efforts therefore, have to be made to mitigate toxic gas emission from rice and develop strategies to grow rice with less water. Conventional transplanted rice cultivation requires 3000 to 5000 litres of water to produce 1-kilogram rice. At worldwide about 70-80 per cent of fresh water is used in agriculture and rice accounts for 85 per cent of this water. Rice requires about two times as much water as compared to wheat or maize and in some regions, such as northwest India, water requirement of rice is about 5–6 times than that of wheat. This may lead to scarcity in the supply of available water near future. The decreasing availability, decline in quality of water and increasing costs are already affecting the sustainability of conventional irrigated rice production systems in many parts of South Asia. Ground water table is declining at an alarming rate in Northern part of India like, Punjab, Haryana and western part of Uttar Pradesh due to excessive withdrawal of groundwater through bore wells for paddy cultivation. Water requirement in rice production, therefore, needs to be decreased by increasing water-use efficiency through reduced losses caused by evaporation, percolation and seepage. The direct seeded rice (DSR) has got potential to improve the efficiency of water use.

Despite having potential to address major sustainability problems, the yields have been variable in some regions, especially with dry seeding due to uneven and poor crop stand, higher spikelet sterility, poor weed control, crop lodging, and poor knowledge of water and nutrient management. Thus, getting more benefit from direct seeding it is important to careful management of weeds, nutrient especially nitrogen and water.

Direct Seeding can be done by three ways

1. **Dry- DSR**- in which dry paddy seeds are drilled or broadcast on unpuddled soil either after dry tillage or zero tillage or on a raised bed.
2. **Wet-DSR**- in which pre-germinated paddy seeds with a radical in varying size from 1 to 3 mm are broadcast or sown in lines on wet/ puddled soil, and
3. **Water seeding**- in which pre-germinated paddy seeds are broadcasted in standing water on puddled or unpuddled soil.

TABLE 1: Amount of water evapotranspired (liters) to produce one kilogram of major cereals

Crop type	Minimum	Maximum
Rice	625	1667
Wheat	588	1667
Maize	370	909

Major Drivers for Adoption of Direct Seeded Rice

- Current rice culture is a major freshwater user and is highly inefficient in its use.
- Water scarcity is increasing and availability of water for agriculture is decreasing.
- The labor shortage and increasing labor wages.
- Crop intensification and recent developments in DSR production techniques.
- Adverse effects of puddling on soil physical properties and the succeeding non-rice crop.
- Declining/stagnating crop and factor productivity and a deteriorating resource base in cereal systems such as rice–wheat have led to the promotion of conservation tillage-based agriculture

Advantages of Direct Seeded Rice

- The savings of labor ranged from 0% to 46%, with an average of 25% in wet direct seeding and in dry direct seeding 4% to 60%, with an average of 29%.
- Reduces drudgery by skipping transplanting operation.
- In DSR water savings ranged from 12% to 35%. Water savings in different types of DSR ranked in the following order: CT wet- seeding < CT-dry seeding < ZT-dry-DSR < Bed-dry-DSR.

- It reduces percolation loss of irrigation water due to fewer soil cracks.
- It reduces methane emissions (6–92% depending on types of DSR and water management).
- Increases the total income of farmers depending on type of DSR.
- It helps in timely planting of subsequent crop due to early harvest of direct seeded rice crop by 7–14 days.

Risk in Adoption of Direct Seeded Rice

- Sudden heavy rainfall immediate after sowing can adversely affect seed germination and crop establishment.
- Reduces availability of soil nutrients such as N, Zn, and Fe especially in Dry-DSR.
- Perpetuation of new weeds such as weedy or red rice.
- It promotes over reliance on herbicides.
- Increases incidence of new soil-borne pests and diseases such as nematodes.
- Enhances nitrous oxide emissions from soil.
- Relatively more soil C loss due to frequent wetting and drying.

ORGANIC FARMING

18568

22. Role of Crop Rotation in Organic Farming

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INTRODUCTION: This is a system of cultivation which denoted moving from simple monoculture to a higher level of diversity begins with viable crop rotations, which break weed and pest life cycles and provide complementary fertilization to crops in sequence with each other. This process helps maintain nutrients in the soil and reduce soil erosion. According to US National Organic Program definition, Crop rotation is "The practice of alternating the annual crops grown in a specific field in a planned pattern or sequence so that the crops of a same species or family are not grown repeatedly without interruption on the same field".

Organic farming is a farming system of crop production totally based on organic farm resources for all practices like weed management, nutrient management and pest management. This farming is an environmentally safe with sustainability of soil productivity. At present time, availability of plant nutrients are decreasing through cultivation of crops without added organic manure and crop rotating. Therefore, organic farming practices with crop rotation are necessary for higher crop production and soil fertility.

In 2017, 69.8 million hectares of organic agricultural land, including in conversion areas, were recorded. The regions with the largest areas of organic agricultural land are Oceania (35.9 million hectares, which is half the world's organic agricultural land) and Europe (14.6 million hectares, 21 per cent). Latin America has 8 million hectares (11 per cent) followed by Asia (6.1 million hectares, 9 per cent), North America (3.2 million hectares, 5 percent), and Africa (2.1 million hectares, 3 per cent). The countries with the most organic agricultural land are Australia (35.6 million hectares), Argentina (3.4 million hectares), and China (3 million hectares). Almost a quarter of the world's organic agricultural land (16.8 million hectares) and more than 87 per cent (2.4 million) of the producers were in developing countries and emerging markets [Anonymous, 2019].

The total area dedicated to organic agriculture in Asia was almost 6.1 million hectares in 2017. There were 1.1 million produces, most of which were in India. The leading countries by area were China (3 million hectares) and India (almost 1.8 million hectares); Timor- Leste had the highest proportion of organic agricultural land (8.7 per cent).

Globally, 1.4 percent of the farmland is organic – Liechtenstein has the highest organic share with 37.9 per cent. Currently, 1.4 per cent of the world's agricultural land is organic. The highest organic shares of the total agricultural land, by region, are in Oceania (8.5 per cent) and Europe (2.9 per cent; European Union 7.2 per cent). However, some countries reach far higher share: Liechtenstein (37.9 per cent) and Samoa (37.6 per cent) have the highest organic shares. In fourteen countries, 10 per cent or more of the agricultural land is organic. Forty per cent of the world's organic producers are in Asia, followed by Africa (28 per cent) and Latin America (16 per cent). The countries with the most producers are in India (835,000), Uganda (210,352), and Mexico (210,000) [Anonymous, 2019].

FAO analysis shows that intensification of organic farming in most subsistence systems yields 40% more; while there will be transition losses with organic farming adopted in intensive agriculture situations, this can be overcome in 4-7 years' time – it is a matter of planning incremental shifts; Indian NARS data shows nothing to fear on yield losses, except in wheat crop (Table 1); Sikkim is an example

to draw courage from.

TABLE 1: Expected changes in in production due to organic farming of major food crops (based on the area, production and productivity of 2010-11)

Crop	Area ('000 ha)	Production ('000 t)	Productivity kg ha^{-1}	8 Year* Mean Yield with 100 % Organic**	Expected production under organic system ('000 t)	Change
Rice	42008	89084	2121	3719	156227	+
Wheat	28457	80802	2839	2536	72166	_
Maize	8255	16710	2024	3688	30444	+

* Including conversion period, ** On-station yield
ICAR-Indian Institute of Farming Systems Research, Modipuram (UP)
Note: This table has been copied from an ICAR-IFSR presentation on July 30th 2015.

Advantages of Crop Rotation in Organic Farming

Crop rotation is fundamental to organic agriculture but, with the low and falling cotton price in recent years, more and more farmers are moving away from cotton to grow other crops, such as marigold in India, which can fetch a higher price on the market. This means that reported land area figures do not necessarily reflected the land area used to grow only organic cotton, and may therefore seem disproportionately high compared to the organic cotton volumes harvested. Some advantages of crop rotation in organic farming given below:

Quality Production

Improve and stabilize production quantity and quality, minimize losses between harvest and trade, Improve control of pest and diseases and optimize tuning of N supply to N demand.

Sustainable Management of Resources

Maintain and/or improve biological, physical and chemical soil fertility by a wider and more diversified crop rotation, well-focused use of organic manure and (leguminous) green manure. Improve organic matter management and control soil health.

Clean Environment

Limit nitrogen leaching, prevent accumulation of phosphate and heavy metals, and abandon use of ecosystem endangering so called "biological pesticides".

Attractive Landscape and Diversified Nature

Strengthen and protect the current ecological values on the farm, integrate it in an ecological infrastructure, enhance a liveable landscape for man, flora and fauna.

Farm Continuity

Safeguard income and farm continuity by strengthening the quality production. Develop strategic farm management that includes a careful planning of farm activities based on a coherent vision on the desired farm development. Important points are planning of crop rotation and fertilization, labour organization and integral quality chain care (Anonymous, 1999).

Agriculture can be productive and profitable without the damaging effects on the nation's soil, water, and air caused by today's widespread use of two-crop systems (like Rice- Wheat). Farmers can maintain high yields and sustained profits through an updated approach, one involving a more diverse set of crops and a modified strategy for protecting the soil productivity. Supported by a set of policy changes that increase technical assistance and assist with up-front costs, some country's farmers can make the transition to a farming system that supports their livelihood, protects the natural resources on which it depends, and reduces the cleanup burden on taxpayers—all at once. So, crop rotation with organic farming is a key of turning the profits.

Conclusion: Crop rotation is one of the very basic building blocks of organic farming systems. The crop rotation in organic farming must provide the soil fertility required for maintaining productivity and it must prevent problems with weeds, pests and diseases. This is obtained through a proper sequence of crops in time and space and through the use of N2 fixing crops and cover crops (Lampkin, 1990). This is contrary to conventional farming systems, where lack of soil fertility can be ameliorated by use of artificial fertilizers and weeds, pests and diseases can be controlled through use of agro-chemicals. Much of the research on crop rotations must therefore be designed specifically for use in organic farming systems.

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23. Remote Sensing, GIS and GPS in Precision Farming

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Remote Sensing

Remote sensing is a potential tool in providing spatial and temporal information on soil and crop variables which could be related with crop growth and yield models. The kind of information on soil and crop variables largely depends on the remote sensing platforms (ground based, aircraft and satellite) and the remote sensors (camera radiometers and scanners with different resolutions).

GIS

GIS is a computer – based technology capable of gathering, storing, analyzing and retrieving geographically referenced data. GIS combines different kinds of data (map, tables, digital data and point data). It integrates layers of information about to give better understanding of that place. For example, it can combine soil maps, rainfall maps, topographic maps and land use maps to show areas where there is high danger of soil erosion. GIS requires suitable software for the data analysis and integration.

GIS is an invaluable tool in planning and monitoring of natural resources like soils, lad use etc., at a regional or national level. It can be used as decision making tool in agriculture. It can take in to account of soil fertility, gradient of lands, annual rainfall, availability of rural labour and access to markets.

GPS

Without having a reliable method of locating equipment and items in a field, it is difficult to manage in-field variability. A crude method might be to stake out the field to show areas that require different treatment, but this is not practical on large fields. A reliable positioning method is needed to accurately locate field features to make precision agriculture work. Some local positioning systems were developed but not successfully commercialized. The advent of GPS allowed for low-cost, reliable positioning of equipment in the field. Data from other sensors could be tied to a specific point in the field with precision.

Role of GPS in precision agriculture: a) Yield mapping b) Variable rate control c) Field mapping d) Asset tracking e) Irrigation f) Tracking livestock g) Aerial spraying h) Auto steering i) Drainage j) Guidance

Steps in Precision Farming

The basic steps in precision farming are, (i). Assessing variability (ii). Managing variability and (iii). Evaluation

i) Assessing Variability

Assessing variability is the critical first step in precision farming. It is clear that one cannot manage what one does not know. Factors and the processes that regulate or control the crop performance in terms of yield vary in space and time. Quantifying the variability of these factors and processes and determining when and where different combinations are responsible for the spatial and temporal variation in crop yield is the challenge for precision agriculture.

ii) Managing Variability

Once variation is adequately assessed, farmers must match agronomic inputs to known conditions employing management recommendations. Those are site specific and use accurate applications control equipment. For successful implementation, the concept of precision soil fertility management requires that within-field variability exists and is accurately identified and reliably interpreted, that variability influences crop yield, crop quality and for the environment. Therefore, inputs can be applied accurately.

The higher the spatial dependence of a manageable soil property, the higher the potential for precision management and the greater its potential value. The degree of difficulty, however, increases as the temporal component of spatial variability increases. Applying this hypothesis to soil fertility would support that Phosphorus and Potassium fertility are very conducive to precision management because temporal variability is low. For N, the temporal component of variability can be larger than its spatial component, making precision N management much more difficult in some cases.

iii) Evaluation

There are three important issues regarding precision agriculture evaluation. 1. Economics 2. Environment and 3. Technology transfer the most important fact

regarding the analysis of profitability of precision agriculture is that the value comes from the application of the data and not from the use of the technology. Potential improvements in environmental quality are often cited as a reason for using precision agriculture. Reduced agrochemical use, higher nutrient use efficiencies, increased efficiency of managed inputs and increased production of soils from degradation are frequently cited as potential benefits to the environment. Enabling technologies can make precision agriculture feasible, agronomic principles and decision rules can make it applicable and enhanced production efficiency or other forms of value can make it profitable.

WEED SCIENCE

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24. Integrate Management of Parasitic Weeds

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There are around 3,000 species of parasitic angiosperm, Distributed amongst 17 families. Parasities belonging to Orobanchaceae (*Aeginetia*, *Orobanche*, broomrape) and Scrophulariaceae (*Alectra*, *Striga*, witchweed) families are most serious weeds and causes economic loss to the farming community. Parasitic weeds cause heavy damage to numerous crops by reducing both crop yield and quality. Yield losses could be estimated up to 30–80 % in staple food and industrial crops in every continent. Details of predominate parasitic weeds appear in India and their control measures are discussed below.

Cuscuta

In India, *Cuscuta* spp. pose a serious problem in Oilseeds (Niger, linseed) and pulses (blackgram, greengram, lentil, chickpea, especially in rice fallow) and fodder crops (lucerne and berseem) under rainfed as well as irrigated conditions. Cuscuta infestations can weaken the host plant, making it susceptible to pest and diseases, and many eventually kill its host. The yield reductions due to *Cuscuta* are reported to the tune of 30% in Greengram and blackgram and 85% in lentil, checkpea, and alfalfa depending on the severity of the infestation.

Control Measures: Non chemical methods such as use of *Cuscuta* free crop seed, use of resistant crops / varieties, deep ploughing, burning, crop rotation and inter-cropping, stale seed technique, mechanical weeding, etc. may be useful in preventing/reducing *Cuscuta* infestation. Shade of dense foliage crops suppresses *Cuscuta* sufficiently.

Non selective herbicides like paraquat (1%) and glyphosate (1%) and others like 2,4-D kill *Cuscuta* effectively where it occurs in patches. Use of pre-emergence herbicides viz., Trifluralin or pendimethalin at 0.75 to 1.0 kg ai/ha (relevant to crops) will lower the menace of *Cuscuta* in addition to other weeds in niger, linseed, chickpea and lentil. In lucerne, early post-emergence (10 days after sowing) of pendimethalin at 0.5 kg/ha was also effective in killing the emerging *Cuscuta*.

Orobanche

Broomrape (*Orobanche* spp.) is complete root parasite with about 130 species worlds over parasitizes wide range of hosts comprising food leguminous crops, oilseed crops, solanaceous crops and medicinal plants belonging to families- Solanaceae, Chenopodiaceae and asteraceae. In India, *Orobanche cernua* and *O. Aegyptiaca* are occurring on crops- tobacco, cumin, mustard, plantago, lentil, potato, brinjal and tomato, and cause losses upto 30-35% in tobacco and more than 80% in solanaceous vegetables.

Control Measures: Broomrage control include hand weeding of shoots before seed set, soil solarization, trap crops such as maize, sorghum, linseed, shifting of planting time of the crop, flooding, fertilizer management, use of tolerant cultivars and spraying of herbicides. Application of neem cake/vermicompost/castor cake and higher dose of nitrogen (N) was found effective in reducing parasitism of *Orobanche* and enhancing growth of crop.

Seed treatment with imidazolinones and sulfonylureas proved to be effective for controlling *Orobanche*. In mustard crop spraying of glyphosate twice @ 25 g/ha at 30 days after sowing followed by 50g/ha at 55 days after sowing controlled broomrage by 65 to 85 %.

Striga

Striga or witch weed is an obligate parasitic plant infects major cereal crops such as sorghum, maize, upland rice, millets and sugarcane. *Striga* causes yield losses of 15 to 75 % in sorghum, pearlmillet, maize and sugarcane.

Control measures: Hand weeding of *Striga* in early stages will be helpful for the long run control but most of the damage occurred while the *Striga* is still in the soil. Cultural practices such as stubble cleaning

after harvest, crop rotation with non-hosts and with catch crops, mixed cropping without host crops, fertilizer management with high dose of nitrogen as top dressing, and use of resistant or tolerant varieties help in reducing *Striga* infestation. Post-emergence application of 2,4-D is effective when sprayed on the *Striga* leaves. In Sugarcane, pre-emergence application of atrazine 1.0 kg/ha + hand weeding at 45 days after planting (DAP) with the earthing up at 60 DAP combined with post-emergence spraying of 2,4-D Na salt 5 g/l (0.5%) + urea 20 g/l (2%) at 90 DAP. Deep placement of oxyfluorfen 250 g/ha into furrow at 90 DAP is very effective in controlling *Striga* seed bank.

Loranthus

Loranthus longiflorus is a common parasite on subtropical trees. *Viscum* is another genera of the sub-family Viscoidae (family Loranthaceae). *V. articulatum* and *V. album* are most common species found in Himalayas. They depend on their hosts for water, and under wet conditions may do little harm. Under drought stress they often cause death of infected branches. In India a wide range of species occur, of which *Dendrophthoe falcate* is perhaps the more common, damaging many fruit, ornamental and forest tree species. In many parts of India, it occurs on almost all forest trees, high value timbers fruits/commercial trees.

Control measures: On *loranthus*, scrape the bark of the parasite at the point of the attachment of the haustoria on the tree and pad with cotton containing 1 g 2,4- D Na salt 80 WP in 20 ml. Directed spraying of ethrel (Ethephon 39 SL) 25 ml/lt on the parasite causes complete defoliation without harming the host plants and regrowth do not occur for at least 6 months. Other method is to top off the branches infested with *Dendrophthoe* to prevent further growth and spread in the initial stage itself.

WATER MANAGEMENT

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25. Drip Irrigation: A Tool to Overcome the Challenges of Indian Agriculture

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Challenges for Farmers in Indian Agriculture

International Water Management Institute (IWMI) has estimated that by the year 2025, one-third of the world population will face strongest water scarcity and amongst semi-arid regions of Asia, the Middle East, and Sub-Saharan Africa will hit the most. Agriculture is the largest consumer of water in India. It accounts for approximately 90 percent of 7,61,000 bn litres of annual freshwater withdrawals in the country. India's population is standing at1.27 billion and is estimated to rise to 1.6 billion by the year 2050. According to the World Bank, about 54% of India faces high to extremely high-water stress. Today, India's ground system is the biggest system which covers 160 million ha of cultivated land in India with 39 million ha irrigated by ground water, 22 million ha by irrigated canals and about two third of cultivation still depends on monsoon. India is not a water rich country and is further deprived due to climate change, improper use and the different water pricing policies. The Northern Ganga sground and surface water. India receives an average of 4,000 billion cubic meters of precipitation every year. However, only 48% of it is used in India's surface and groundwater bodies. Per capita consumption of water in agriculture sector ranges from 4,913 kl to 5,800 kl per capita per year. Nearly 40% of water demand in urban India is met by ground water. To fulfill the demand, ground water tables in most cities are declining at a threatening rate of 2-3 meters per year. If the population continues to grow, it will evolve into a major threat in distribution of resources.

Solution to this Key Challenge: Drip Irrigation

Drip system is an advanced method of irrigation, which can be used to save sufficient irrigation water. It can be defined as a method of crop irrigation that involves a controlled delivery of water to plants through system of pipes, valves, tubing and emitters. The water is delivered from a source directly to the root zone of individual plants or to the surface of the soil. It is also called trickle irrigation and release water at a very low rates (2-20 litres/hour) from outlets called as emitters or drippers to only the roots of the plant unlike traditional method of irrigation. In this system, water drips constantly over plants to keep them well watered. This method can be adopted for most crops, depending on the type of soil, the size of the farm and the efficiency of the sources and water. The irrigation efficiency of the drip method is approximately 80-90 percent. With the increase in the yield of crops, this method can be used to ensure high quality of yield, efficient utilization of chemicals

and fertilizers, reduction in water irrigation and reduction of weeds with saving of water.
efficient utilization of chemicals and fertilizers, reduction in water irrigation and reduction of weeds with saving of water.

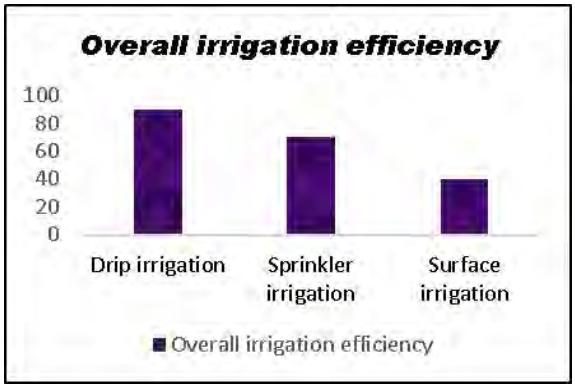

FIGURE 1: Overall irrigation efficiency of different methods

The use of this method is increasing rapidly in the whole world as it has proved very effective in reducing the amount of water resources and also has deducted the environmental problems. Drip irrigation techniques are most suitable for successfully cultivating commercial crops in those areas where it is expensive to make land and difficult or impossible. The drip system is a more frequent irrigation system in which the water is given around the root of the plant. Through drip irrigation, the plant can be irrigated as per the requirement. By this method, a saving of 30-40 percent of the fertilizer, and upto 70 percent of water can be made which has the potential to increase the yield by 100 percent. Apart from this, there are savings in energy and reduction in risk. Also, evaporation, runoff and deep percolation too gets reduced in drip irrigation. According to Government of India, the overall irrigation efficiency of drip irrigation is about 80-90 %, sprinkler with 60-70% and surface irrigation being the least efficient with 30-35 % as depicted in **figure 1**.

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26. Surge Irrigation: An Improved Technology Over Traditional Method

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Over exploitation of surface water resources and unscrupulous pumping of groundwater have led the farming community to a precarious situation of counting every drop of water towards sustaining maximum possible crop production. Even as micro irrigation systems embedded with fertigation components are gaining popularity and momentum, surface irrigation systems such as border strips or furrows or check basins are still in vogue and are quite inevitable from the point of view of farm management. The premise that 'more crops per drop of water' warrants effective land utilization and efficient water and nutrient application by a carefully chosen irrigation mode that should result in minimum deep percolation and runoff losses. Since 'water saved is water earned' the performance of irrigation system is evaluated in terms of percentage saving in water and the relative irrigation usage efficiencies.

Advance Technology

Modern concept of irrigation such as drip, sprinkler or surge aim at minimizing the application and the storage losses of water by way of runoff and deep percolation so that water storage and distribution efficiency can be achieved in the range of 85-97 percentage with barest minimum losses of 15-8 percentage. However, surface irrigation, our oldest method of applying water on to the cropped land, has withstood the test of time because of its many advantages. Over the years, minor changes have been made to improve the efficiency of surface irrigation system. Cut back technology and run-off recovery are resorted to minimize irrigation losses thereby improving the operational efficiency of irrigation system.

Current Scenario

Water scarcity in Tamil Nadu had resulted in the

lessening of the irrigated area by about ten percent every year. The water table in several parts of the state had receded appallingly and the irrigated area had shrunk during the last six years from 56 lakh hectares to 30 lakh hectares. Tamil Nadu stands the third most intensively irrigated state after Punjab and Haryana. Despite this, about one-fifth of the total water requirement is not being met. The total water supply is about 4.72 MHM (Million Hectare Meters) with comprises 2.41 MHM of surface water, 2.31 MHM of ground water and an equal quantum of inter-basin transfer. On the other hand, the total demand is 6.8 MHM which includes 5 MHM for agricultural use. It has been observed that the present trend of over exploiting the ground water would lend the wells become undependable source of irrigation in future. Although there are 40319 tanks of various sizes in Tamil Nadu, the area irrigated by tanks had fallen from 9 lakh hectares1960 to 6.5 lakh hectares in 1999 -2000. Despite the rotational system of water allocation, the canal commands are also subject to heavy seepage and percolation losses, resulting in reduced irrigation potential. Such circumstances now force us to devise viable means for a judicial usage of the water available for surface irrigation.

Traditional Method

In Tamil Nadu, the surface irrigation is accomplished with furrows and basins. The conventional furrow layout comprising short strip furrows (4m to 6m long) carved on level basins are predominantly used for raising row crops such as maize, sorghum, cotton, sugarcane, vegetables etc., while rice is cultivated in basins. The short strips furrow layout leads to more than 20 per cent of the area lost for cultivation. Too many field inlets and manual cutting and plugging of cross ridges and feeder channels to divert water into furrows require high time and labor to complete irrigation. Besides, on account of extensive channel conveyance losses through seepage and deep percolation, the irrigation efficiency in short strip furrow layout get reduced and the area lost results in reduced plant population. A long furrow layout though limited by the availability of sufficient field length seems to be a feasible solution in order to minimize the land loss and to minimize irrigation efficiencies particularly when coupled with surge irrigation.

Improvisation over the Traditional Check Furrow

Surge irrigation is a relatively new technique over the traditional check furrow irrigation layouts that are replaced by a series of long furrows originating from a single feeder channel. In case of the continuous flow mode, water front advance and infiltration take place simultaneously thereby making the advancing water front to take a relatively longer time to reach the furrow tail end. The surge mode of water application involves alternate ON-OFF cycling of intermittent flows into the furrows in such a way that during the ON time water front advances and influences the soil intake during the OFF period when water soaks into the soil and saturating the subsoil. The partial or complete saturation of subsoil creates an apparent reduction in the instantaneous infiltration rates of the soil so that the water front advance gets accelerated. The net result is a reduction in soil infiltration rates during subsequent surge ON periods and an increase in the rate of water front advance. Thus, the difference in intake opportunity time between the upper and lower ends of the furrow becomes less and results in a more uniform soil moisture storage and distribution along the furrow after irrigation. However, the surge effect depends upon a number of factors such as soil texture and consolidation, antecedent moisture content and number and duration of the ON- OFF cycles. Invariably in all the continuous flow long furrows the water front advance could not reach the furrow tail end within the design duration of irrigation and nearly 25% to 40% additional times were required to make the water front reach the furrow tail end. The continuous flow long furrow layout could have high water distribution uniformity around 55% only but the surge irrigation will have 80 % to 85%. Therefore, surge irrigation shows it relative **s**upremacy over the continuous furrow long furrow layout in reducing the deep percolation losses in order to achieve high order of water distribution and irrigation usage efficiency.

SOIL SCIENCE

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27. Soil Fertility Management in Dry Lands

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Dryland soils are not only thirsty, but also hungry". Moisture stress and nutrient stress are the major causes for low yields of crops in dry farming regions. Poor fertility status in drylands is due to many factors such as slow weathering of minerals, low organic matter content, reduced microbial activity, erosion, very low addition of manures and fertilizers, soil salinity and alkalinity, reduced mobility of nutrients

and nutrient fixation. Improving and maintaining soil fertility are essential for sustaining and enhancing the productivity in drylands. Farmers in drylands however do not apply sufficient quantity of nutrients since nutrient sources like organic manures and fertilizers are costly with no assurance on higher crop yields and increased monetary returns.

Factors Influencing Nutrient use Efficiency in Drylands

a) Rainfall and Soil Moisture Availability

Information about the quantity, distribution and probability of rainfall are very useful to make decisions on soil fertility management. If the onset of monsoon in a particular region is dependable, it will have adequate soil moisture for crop establishment for which basal dressing of fertilizer would be safe. If there is continuous and assured rainfall in early growth stages of the crop, then top dressing would be beneficial.

b) Crop and Variety

Cereals and millets respond more to nitrogen, legumes to phosphorus and oilseeds to N, P and K.

c) Soil Properties

Soil physical properties influence crop response mainly by affecting the availability of soil moisture. The available nutrient status of soil also has a significant effect on crop response. Drylands are generally deficient in organic matter and Nitrogen and so there is universal response to N. Response to P application depends on fixation in soil and depending on the leaching loss and soil texture, the response of crops to K application varies.

d) Management Practices

The quantity, time, source and method of application of fertilisers, incorporation of organic manures, inclusion of legumes in cropping system, soil moisture conservation practices, etc influences the nutrient use efficiency in drylands.

Integrated Nutrient Management for Drylands

Organic Manures

Organic matter content in drylands soils is low and its improvement is essential to promote aggregation, soil moisture storage and nutrient supply. This can be accomplished through addition of FYM/compost, green manure/green leaf manures and crop residues. Inclusion of legumes in crop rotation, and cultivating the legume crops during fallow periods in dryland regions may enhance the soil nutrient supply to upcoming crops

Fertilisers

Fertiliser use in dryland soils is less than the irrigated lands. The quantity, time and method of fertilizer application influences the yield and income. Great care is required in deciding on the quantity because of high cost of fertilizers. It depends on soil nutrient content, type of crop and availability of soil moisture.

Legumes in Cropping System

Legume intercropping is very common in drylands. When a short duration legume is intercropped with a long duration non-legume the legume haulms after picking pods can be incorporated to benefit the non-legume by transfer of legume fixed Nitrogen.

Biofertilisers

Seed inoculation for legumes with Rhizobium and seed inoculation and soil application with Azospirillum for cereals, millets, cotton, sunflower and sesamum is recommended. Besides N fixation, Azospirillum reportedly improves root growth through the exudation of growth promoting substances. Use of phosphobacteria as seed inoculation and soil application for solubilising native P is also recommended. VAM is found to play a crucial role in P nutrition of dryland crops especially soybean, sorghum and pearl millet.

Low-Cost Technology and Nonmonetary Inputs in Soil Fertility Management

Nutrient supply is a costly input, compared with other components of dryland technology package. Hence low-cost technologies and nonmonetary inputs relevant to soil fertility management must be given due importance. The strategy of conservation agriculture which involves reduced tillage, planned crop rotation and use of crop residue mulch also help enhance the nutrient deposition, cycling and retention within the dryland soils with substantial improvement in soil moisture.

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28. Hydrogel: A Superabsorbent Polymer

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Polymer, are material which engross and retain huge quantity of fluid depends on its reasonable mass or weight. There are 3 diverse classes of hydrogels are generally under use *viz*. natural, semi-synthetic and synthetic polymers. They are available in numerous trade names like root watering, drought crystals and superabsorbent polymers, jointly known as "hydrogels". They are highly cross-linked, can engross

and retain moisture about 300 to 400 times than its original mass and made readily accessible to the crop within the 15-bar tension.

Moisture Absorption Mechanism of Hydrogel

Water absorption of hydrogels is mainly due to the hydrophilic clusters of the polymer chain. When such polymers are placed in moist medium, the water move into the polymer cluster due to the process of osmosis. Which leads to the leaving of positive hydrogen ions. This process creates several negative charges along the length of the polymer. Due to repelling of these negative charges causes the polymer chain to unwind and open up. When water available in soil it enters into these polymers and bind to the negative charges of polymer with the help of hydrogen bonding. As the soil become dry, polymer release the water into the soil. It regains water when irrigation applied or rainfall occurs. This mechanism can continue up to 2–5 years based on the superiority of hydrogel after that period, hydrogel will decompose.

Benefits of Hydrogel in Agriculture

- Increase the capability of soil to engross the water.
- Augment soil permeability and infiltration.
- Decrease irrigation rate and frequency.
- Lessen nutrients to leach.
- Diminish compaction of soil.
- Decreases the soil loss due to erosion.

Important Features of Hydrogel

- Give better results under extreme temperatures (40°–50°C) also.
- Ready to retain more amount of water
- Enhances the soil pore spaces.
- Proliferate the microbial actions in the soil.
- Postponing the inception of PWP.

Amount of Application

Based on the texture of soil, the amount of application is varying from soil to soil. In clay soil it is 2.5 kg ha^{-1} and for sandy soil it is up to 5.0 kg ha^{-1}.

Methods of Application

1) For Field Crops

Before the application of hydrogel in the field, make the furrows with desirable depth according to crop. Mix the hydrogel and sand in the proportion of 1:10. Apply the hydrogel before or at the time of sowing.

2) For Nursery Bed

For bed system, application of 2 g of hydrogel m^{-2} of nursery bed in surface 5 cm depth will give the better results.

3) For Transplanting

Mix 2 g hydrogel in a litre of water and let the hydrogel to absorb water for about 30 minutes. Just before transplanting in the field, dip the plant roots in the solution.

Hydrogels are eco-friendly in nature

Hydrogel having altered bonds, those can break easily by biological processes after a period of time. Degradation of hydrogel leads to the formation of carbon dioxide, water and ammonia. In making of hydrogel a monomer used is polyacrylamide. It is not a toxic compound but acrylamide is toxic one. The polyacrylamide never converts to its monomer. Even in crop and soil also the acrylamide residues are not detected when hydrogel was used.

18443

29. Composting of Crop Residues for Improving Soil Fertility

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INTRODUCTION: Composting is a fascinating segment for converting generated on-farm waste materials into a productive resource. However, many of the farmers in the world and developing countries are unable to use the best composting technology due to lack of awareness. In India, over 700 million tons of biodegradable organic waste is generated annually. More waste is generated in rural areas as crop residues (over 300 m. tons = 6.2 m tons NPK) and as cattle dung (over 320 m. tons = 11.2 m. tons NPK). The rest in urban areas as municipal waste (40 m. tons in 5161 cities/towns = 0.6 m tons NPK) and as crop-processing factory wastes and others including human excretions in general (about 40 m. tons = 0.6 m. tons NPK). Around 25% of the nutrients taken up by plants are generally retained in the stalks and other plant residues which by all means are the important sources of carbon. So is the case with animal wastes. Burning or just dumping these wastes without proper use is really a sin. We need to decompose these wastes properly to produce quality manures and composts in farms and villages to meet much of the nutritional requirements of our crops. This is the best way of recycling nutrients and working in harmony with nature.

More biomass producing plants can also be

grown in fields as a green manure crop (Subabul and Gliricidia spp.). They can be crushed directly into the soil at flowering to add more organic matter into the soil as was the common practice in olden days. These plants can be grown at some intervals in a field, and their green biomass can be harvested at some interval to cover open spaces between the crop rows to help retain more water and reduce evaporation of moisture from the soil. This practice, commonly called mulching, is also helpful in building the fertility of the soil.

Composting crop wastes and generated biomass at one place is often ideal as it helps to clear the field immediately and getting the biomass nutrients quickly into the compost without loss. Plants species ideal for green manuring of fields is also good for high biomass production. Here, the waste is dumped every day into a pit to decompose slowly with the action of microbes contained in the wastes. This process takes 6-12 months, and there are often nutrient losses to leaching from wastes, particularly during rains. Here the material remains in and out of water due to rain and the decomposition is partly by aerobic and partly by anaerobic microbes. The compost obtained is not of a uniform quality product. Some material often remains undecomposed even after a long time.

Method of Aerobic Microbial Composting

Key Requirements

1. Any organic waste of plant or animal origin (Crop waste, cattle and domestic animal wastes, poultry waste, vegetable waste, kitchen waste, food and fruit processing plants' waste, sugar factory waste including press-mud, municipal organic waste and all sorts of wastes that are of organic nature).
2. Composting microbial culture (Madhyam®, Bioculum®, etc.). 1.0-1.5 kg is required for a ton of material and sufficient water

Other Requirements

1. A shredder cum chipper machine when waste is dry plant waste. A tractor operated and power operated shredder/chippers are available in the market.
2. Material mixing machine when the operation is to be done on a larger scale. A tractor with a rotator or cultivator attachment is ideal.
3. Urea, nitrogen source when dry plant material is the major waste.
4. Compost nutrient enrichers (Rock phosphate, Phosphate solubilizers, Nitrogen fixers etc.), if required

General Methodology for Aerobic Composting

- If animal waste is cow dung, poultry waste, etc., mix microbial culture directly and heap it.
- Mix green plant waste if available with animal waste and apply the culture.
- Dry plant waste needs to be shredded into small pieces and mixed with some animal waste (minimum 20%, more use will hasten up the process, best up to 50%).
- The idea is to mix green and dry plant wastes with animal waste. Kitchen and other organic wastes can also be added.
- Add Urea @ 1.0-1.5 kg/ton to balance Carbon and Nitrogen in the total waste mix, if there is more of dry plant waste. The C: N ratio of 25-30:1 is ideal for proper decomposition. The C/N ratio should not exceed 40:1 else the composting process does not start.
- Mix culture @1.0-1.5 kg/ton of the total waste depending upon the type of waste material.
- Mix all ingredients thoroughly either manually or by machine (a Tractor Rotovator is ideal for mixing) and heap the material to a height of around 5 ft. Long windrows of conical the shape could be formed when large quantities are to be composted.
- After heaping sprinkle or pour water on the heap uniformly to have 50% moisture during the whole process.
- Leave the heap in the open until 10 days while sprinkling or pouring some water on the heap every 1-2 days to maintain 50% moisture in a heap.
- In a day or two, one sees smoke come out slowly from the heap indictable that microbes are active working. The temperature inside the heap rises to 70° C and cool after 8-10 days.
- After 10 days, break the heap to turn it upside down and re-heap it. Apply and continue to apply water on the heap to maintain 50%.
- Turn heap again after 10 days following the same process of turning and applying water.
- After 2-3 turning the material will be seen fully composted. Turning at a lesser interval of a week hastens the process
- 30-60 days are normally required for complete composting depending on the materials used. The more the animal waste, the lesser the period. Animal waste alone requires 25-30 days.

FIG 1: Mixing of Madhyam culture for fast decomposition

FIG 2: Mixing of madhyam culture in the compost pit

You can now move this material in bulk or filled in bags to a shed and use it on the farm when required. You can enrich this compost, if required, by adding products like Phosnitroculum® (Nitrogen fixing and Phosphate solubilizing and other beneficial microbes 1-2 weeks before using the material in the field). Add these products to compost @ 1 kg/ton. Compost can also be mixed with powdered rock phosphate to have a higher content of phosphorous.

18474

30. An Essential Aspect of Soil Health: Green Manuring

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Soil health is an important factor for higher and quality crop production. Soil health is the resultant interaction of many things like soil physical properties, chemical properties and biological properties. At present time the government, farmers and many other institutions are giving much attention towards the soil health because they all know that after green revolution, the injudicious way of application of chemical formulation like fertilizers, pesticides etc makes our soil sick. There are many ways to improve the soil health in which the green manuring may be an important aspect.

Green Manuring

Any green plant or plant parts like green leaf along with twigs when applied in soil for improving the soil physical, chemical and biological properties is known as green manuring and the crop used for this purpose are green manure crops. Green manuring is not new in our agriculture but during past few years we are not giving attention on this that's why our soil becomes sick. Green manuring can be obtained by two way: by growing green manure crops in the field where it is going to be used as green manuring or collecting the green parts of plants from one place and application of this in any other fields. *Sunnhemp, dhaincha,* pillipesara, *cluster beans and* Sesbania rostrata are commonly used green manure crops.

FIGURE: Green manure after decomposition incorporation

Type of Green Manure Crops

Green manure crops are mainly of two types: i) leguminous crops- there are many leguminous crops which are used as green manures. The important feature of these crops is their fast decomposition. These crops further divided in two parts i.e. Green manure (*e.g.* Daincha, Sunhemp, Kolinji) and Green leaf manure (*e.g.* Gliricidia, Cassia, *Pongamia glabra).* ii) Non-legumes- these crops further divided in two parts *i.e.* Green manure (*e.g.* Sunflower, Buck wheat) and Green leaf manure (*e.g.* Calotropis, Adathoda, *Thespesia*).

Characteristics desirable in Legume Green Manure Crops

1. The crops should be multipurpose use.
2. The growth period must be short duration and fast growing.
3. Wide ecological adaptability
4. Efficiency in use of water
5. Early onset of biological nitrogen fixation
6. High N accumulation rates
7. Timely release of nutrients
8. Ease in incorporation
9. The crop should be pest and disease resistant.
10. High N sink in underground plant parts.

Benefits of Green Manure

The green manure crops have a number of benefits some are enlisted below:

- After decomposition of green manure crops the organic matter and humus materials increase in soil.
- Leguminous green crops have ability to fix atmospheric nitrogen so it also increases the soil nitrogen.
- Green manure crops provide protection to the soil surface and prevent soil erosion
- Humus act like a binding agent between soil particles so improve soil structure
- Reduced susceptibility to leaching.
- Access to unavailable nutrients from lower soil profile.
- Provide readily available nutrients to the next crop.

How to Uses

1. For increasing the soil fertility level, the green manure crop should be fast growing and for this purpose we should apply 25 to 30 kg/ha of nitrogen (urea) for leguminous crops and 45to 50 kg nitrogen for non-leguminous crops. The seed of green manure crops should be broadcasted in field at optimum moisture level for their better germination.
2. Basically, the green manure crops should be cut down in field at flowering stage of crop.
3. The green manure crops should be plough with the mould board plough before 35 to 50 days of sowing of next crops. If more time given to the green manure crops so it become hard and problems will create for its decomposition.

Disadvantages of Green Manuring

There are some disadvantages with green manuring mentioned as below-

- The moisture of soil plays an important role in both the germination of seed of green manure crops and decomposition of plant materials. So, under rainfed conditions these both processes may not take place properly.
- •A satisfactory stand and growth of the green manure crops cannot be produced, if sufficient rainfall is not available.
- •Establishment costs - a marketable crop is not achieved with green manure crops. Cost of producing a green manure crop should not exceed potential soil and N benefits.
- Sometimes green manure crops may also be a source of the insects, pests and nematodes which could harm the succeeding crop.

Conclusion: At present time soil health, minimize environmental pollution and minimum use of chemical in agriculture is giving more importance and it is also a demand of time. So, the green manuring technology can be a solution for these above things. Application of green manure crops supplements many macro and micro nutrients to plants and restores soil fertility. So, green manuring is an eco-friendly and low-cost technology to conserve our soil health besides maintaining environmental quality in a sustainable manner.

18502

31. Soils of India

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INTRODUCTION: There is so much diversity in our country. In plants, animals' environment and also in soil. Different type of soil found in different region. Because of that we can cultivate different types of crops. For particular crop there is different type of soil. Variation in soil due to some biotic, abiotic and many other factors.

What is Soil?

Soil is a dynamic natural body on the surface of the earth in which plants grow, composed of mineral, organic materials and living forms.

Classification of Soil

According to ICAR soils are divided into 8 categories:

1. Red soil
2. Laterite and lateritic soil
3. Alluvial soil
4. Black soil
5. Desert soil
6. Forest and hill soil
7. Peaty and marshy soil

8. Terai soil

Soils of India

Red Soil

- Red soils occur mainly in the peninsular portion of India and along the east coast, North-east and some are found in east central India.
- In this soil mainly gneisses and schist are main constitute.
- Red colour due to Ferric oxide. The lower layer is reddish yellow or yellow.
- Red soil is rich in Iron as they are slight acidic in nature and ideal for cultivation of fingermillet, groundnut, millets, potato and tobacco.
- They are poor in nitrogen, phosphorous and humus there by soil depth varies from shallow to very deep in nature.
- Red soils have low base saturation, poor in nutrient status, low cation exchange capacity and low organic matter content having acidic in reaction.
- Red soils order is Alfisols and ultisols.

Laterite and Lateritic Soil

- The laterites are found in tropical and sub-tropical climates having an alternate wet and dry season.
- The heavy rainfall conditions and high temperature triggers the laterization process which removes silica, instead of sesquioxides from the upper layers and
- thereby leaving sesquioxides to concentrate in the solum.
- The heavy rainfall conditions and high temperature makes the soil rich in oxides of Iron and Aluminum depleting in completely from Silica.
- They are acidic in elevated areas and poor in retaining moisture but essentially heavy loam to clayey on the plains.
- The soils are rich in sesquioxides, devoid of bases and primary silicate minerals.
- In this soil Kaolinite is the dominant clay mineral.
- Red colour due to iron oxide. Rich in Iron and Aluminum and poor in Calcium and Magnesium and ill drained soil as they are favourable for rice cultivation and plantation crops like cashew, rubber, tea and coffee.
- These soils have in the order of Oxisols.
- They are mainly found in the Western Ghats and Eastern Ghats along with Vindhyas and Satpura's found in States of Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Assam and Tamil Nadu.

Alluvial Soil

- Alluvium are fine particles of rock materials carried in suspension and later deposited by the river in its bed and bank. The soil which is composed of alluvium is called alluvial soil.
- Mostly available soil in India (about 43%) which covers an area of 143 sq. km. They are depositional soil transported and deposited by rivers, streams etc.
- These soils cover the largest area in the country.
- Soils are present in Indo-Gangetic Plain, Brahmaputra valley and high rainfall area.
- The most recent and sub-recent soils are locally classified as "Khadar" (newer alluvium) and "Bhangar" (older alluvium) respectively.
- It is one of the most important and fertile soils of India as they support growth of wide variety of crops such as rice, wheat, sugarcane, cotton, jute, potato and vegetables, but they are deficient in nitrogen, phosphorous and humus.
- Alluvial soil may fit in the order Entisols and inceptisols.

Black Soil

- Black soil also called Black cotton soil or Regur.
- These soils are found in central, western and southern state of India. Most of Deccan is occupied by black soil.
- Black cotton soil is developed on basaltic rocks under semi-arid condition.
- Black soil is rich in iron, lime, calcium, potassium, aluminum and magnesium but poor in phosphorous, nitrogen and organic content.
- High water retaining capacity.
- Swells and will become sticky when wet and shrink when dried.
- Self-ploughing is a characteristic of the black soil as it develops wide cracks when dried.
- Black soils come under order Vertisol.

Desert Soil

- Desert soils are found in arid and semi-arid condition. Mainly found in western Rajsthan.
- Deposited mainly by wind activities.
- Structure less to sub-angular blocky in structure, poor in nutrient and water holding capacity there by moisture is deficient making the pH of the soil, vary from 7.2-9.2 under generally high in salt content.
- Infiltration is restricted due to calcium carbonate content is high. Organic matter is low.
- Desert soil is containing illitic clay predominantly with small amount of kaolinite, chlorite and vermiculite.
- Desert soils may fit in the order Aridisols and Enisols.

Forest and Hill Soils

- The total forest area in India is estimated more than 75 m ha.
- Forest soil are found in region of high rainfall.
- Humus content is low; soil is acidic in nature and having low base saturation.
- Forest soil is formed from igneous and metamorphic rocks.
- Brown forest soils have moderate CEC and high biological activity.

Peaty and Marshy Soil

- Peaty soils occur in heavy rainfall and high

humid regions.
- Peat soil is black in colour. Peaty soils fine texture and an accumulation of ferrous and aluminium sulphates, iron pyrite in tidal swamp areas.
- These soils are strong acidic in reaction (pH <4.0). Those soils are also called cat clays or acid sulphates soils as decomposition of organic matter under anaerobic conditions.
- Marshy soils occur in coastal areas of Odisha and Sundarban area of West Bengal and south-east coast of Tamil nadu.
- The soils are very problematic because of the presence of pyrite.

Terai Soil

- These types of soils are found in foot hills of Himalayas, Jammu & Kashmir, Bihar and West Bengal.
- Terai soils have high water table and high moisture regime.
- These soils are acidic in reaction and, low available nutrient contents and very poor base saturation.
- Drainage facilities are very poor.
- Terai soils comes under order Mollisols.

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32. Heavy Metal: Sources and their Remediation

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INTRODUCTION: Heavy metals are naturally occurring substances (*e.g.* metal and metalloid) on crust of the earth having density >4000 g/cm^3 and atomic weight > Iron. Number of the heavy metals are required to plants but in low concentration as parts per million (ppm) or parts per billion (ppb). When they exceed certain threshold concentration, become toxic to plants and animals. Once they enter inside plant or animal body, at higher concentration react with biomolecules and form stable compounds which are extremely persistent in nature. There are few heavy elements such as As, Cd, Cr, Pb and Hg are systemic toxicants to animal body and are known to induce multiple organ damage, even at lower level of exposure. Their bioavailability is influenced by physical factors such as temperature, phase association, adsorption and sequestration; Chemical factors such as valence state, particle size, solubility, biotransformation, and chemistry of thermodynamic equilibrium, lipid solubility and water partition coefficients; Biological factors as species characteristics, tropic interactions, and physiological adaptation.

Sources of Heavy Metal Contamination

Industrial sources include metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations and high-tension lines, plastics, textiles, microelectronics, wood preservation and paper processing plants. Although heavy metals are naturally occurring but most environmental contamination and human exposure are result of anthropogenic activities such as mining and smelting operations, industrial production, use of metals and metal-containing compounds in agricultural other sectors. Under agriculture sector large quantity of fertilizers are regularly added to soils in intensive farming systems to provide adequate N, P and K for crop growth, these fertilizers contain traces of heavy metals (*e.g.* Cd and Pb) as impurities. Natural phenomenon such as weathering and volcanic eruptions has also been reported to contribute heavy metal contamination significantly. Heavy metals in the soil from anthropogenic sources tend to be more mobile than pedogenic or lithogenic sources hence their bioavailability is more.

Heavy Metals as Contaminants

Globally there is more than 20 Mha of land contaminated with the heavy metal (loid)s As, Cd, Cr, Hg, Pb, Co, Cu, Ni, Zn, and Se. Heavy metals become contaminant in the soil environment because of the following reasons: (i) generation of heavy metal through anthropogenic cycles are much more rapid than natural cycles, (ii) they are easily transferred from mines (sources) to ambient environmental where higher potentials of direct exposure occur, (iii) metals concentration in by-products are relatively higher compared to those received from environmental. A simple mass balance equation of the heavy metals in the soil is expressed as:

$$M\text{total} = (Mp + Ma + Mf + Mag + Mow + Mip) - (Mcr + Ml)$$

where "***M***" represents to heavy metal, "***p***" to parent material, "***a***" to atmospheric deposition, "***f***" fertilizer sources, "***ag***" indicates agrochemical sources, "***ow***" to organic waste sources, "***ip***" other inorganic pollutants, "***cr***" crop removal, while "*l*" represents to losses due to leaching,

volatilization etc.

Remediation of Heavy Metal Contaminated Soil

To rehabilitate heavy metal degraded land over last few years some efficient and low cost in-situ and ex-situ remediation techniques has been promoted widely, to get rid of heavy metals on heavy metal-contaminated sites which includes surface capping, encapsulation, landfilling, soil flushing, soil washing, electro-kinetic extraction, stabilization, solidification, vitrification, phytoremediation, bioremediation etc. These remediation techniques are based on extraction, removal or immobilization of heavy metals. Overall objective of any soil remediation approach is to create a solution that is protective of human health and the environment.

1. **Immobilization technology**: Immobilization technique is based on decreasing the concentration of dissolved contaminants at contaminated site by sorption, which decreases metal availability to plants. In immobilization process organic and inorganic amendment are used to accelerate the attenuation of metal mobility and toxicity from soils. Immobilizing amendments alter to the original soil metals to more geochemically stable phases via sorption, precipitation, and complexation processes. Amendments applied mostly are clay, cement, zeolites, minerals, phosphates, organic composts, and microbes.
2. **Phytoremediation** (Botanical bioremediation): It involves the use of green plants to decontaminate soils. It can be applied to both organic and inorganic pollutants present in the soil environment. However, the ability to accumulate heavy metals varies significantly between species based on their genetic, morphological, physiological and anatomical characteristics. The various categories of phytoremediation are phytoextraction, phytofiltration, phytostabilization, phytovolatization and phytodegradation, depending on the mechanisms of remediation. In Phytoextraction metal ions are extracted from soil and accumulated in the aerial parts can be removed or burnt to recover those metals. There is another technique of heavy metal remediation called "induced phytoextraction" in which plants are converted into water-soluble compounds so that plants can effectively take up contaminants. Here chelating agents are added in soil to desorb toxic metals and allow easy uptake by roots. Phytofiltration involves removal of metals from aqueous wastes by means of the plant roots or seedling. In phytostabilization, plant roots absorb the pollutants from the soil and keep them in the rhizosphere, rendering them harmless by preventing them from leaching. Phytovolatilization involves use of plants to volatilize pollutants from their foliage such as Se and Hg. Phytodegradation includes use of plants and associated microorganisms to degrade organic pollutants.
3. **Soil Washing:** Soil washing is essentially a volume reduction or waste minimization treatment process**.** Ex situ soil washing ensures the rapid clean-up of a contaminated site as it has potential to completely remove contaminants from soil. But its disadvantage is that the contaminants are moved to different places, where they are associated with the risk of spreading off. There are two popular method of removing heavy metals from soil: Acid soil washing and Chelator soil washing. Washing the soils with water alone would be expected to remove low amount of cations in the leachates, hence to add efficiency chemical agents are added to the washing water.
4. **Electro-remediation**: This method is receiving an increasing attention at present. In this technology, a low-level direct current (DC) is passed through the contaminated soil and due to different transport; the contaminants are transferred to the electrodes and removed from the soil.

Conclusion: Nowadays, heavy metals pollution in soil, ground water and river/lake has gradually become a major concern worldwide. Remediation of soil contaminated by heavy metals is necessary in order to reduce the threat to human health and environment. Among all the listed technologies for cleaning up heavy metal contaminated soils immobilization, soil washing, and phytoremediation are frequently used.

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33. Study of Potassium Dynamics Under Different Soils and Cropping Systems

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Potassium (K) was first isolated in 1807 by Sir Humphrey Davy. The word "potash" is often used

to refer to potassium chloride (KCl), a common K fertilizer and derivative from "pot ashes" which refers to the earliest practice of applying the leachate of wood ashes as a source of K. Although K constitutes ~2.5 % of the lithosphere, in the soil the K concentration varies widely between 0.04 and 3.0 % (Sparks and Huang, 1985). Igneous rocks such as granites and syenites (46–54 g K kg^{-1}), basalts (7 g K kg^{-1}) and peridotites (2 g K kg^{-1}) have higher K content than sedimentary rocks like clayey shales (30 g K kg^{-1}), whereas limestone has an average of only 6 g K kg^{-1} on the Earth's crust (Malavolta, 1985). In general, a mineral soil ranges between 0.04 and 3 % K. The upper and subsurface layers of the soil profile contain between 3- and 100-ton ha^{-1} of total K. Of this total K, about 98 % is bound in the mineral form, whereas only 2 % is in soil solution and exchangeable phases.

K in soil exists in four different forms namely, water soluble, exchangeable, non-exchangeable and fixed K. The dynamics of these four forms are affected by various cropping systems and soils. In the last fifty years, consumption of potassium (K) fertilizer in India constituted not more than 10% of total fertilizer-NPK consumption. Though local fertilizer recommendations advocate balanced use of N, P and K, most of the farmers apply only N or N and P with very little amount of K fertilizer (Sanyal *et al.*, 2014). It is reported that the concentration of total K increased from 2008 to 2016, while the concentrations of soil organic matter, and available K declined over the same period. Variation in nutrient levels appeared to be driven by different soils and cropping systems. Thus, it is challenging to predict the dynamics of soil nutrients throughout the period (Ye *et al.*, 2019). Exchangeable K was the most important K fraction contributing to K nutrition of rice and wheat grown in sequence (Sharma *et al.*, 2013). An increase in K uptake was observed with increasing initial exchangeable K. As the solution K is removed in plant uptake, more K is released from the non-exchangeable to exchangeable and solution pools (Sharma *et al.*, 2010). In an experiment, it was observed that incorporation of lantana over the last 12 years had resulted in significant build-up of all the fractions of K (Sharma *et al.*, 2013). The potential buffering capacity (PBC^K) of rice followed by pulse cropping system suggested less frequent application of K-fertilizer compared to rice-rice cropping system which has low PBC^K and require frequent application of K-fertilizer (Lalitha and Dhakshinamoorthy, 2015).

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34. Customized Fertilizer: Manufacturing Methodologies

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Customized fertilizer supplies the plant available nutrients in adequate amount and in proper proportion, leads to the balanced application as it supplies not only primary nutrients but also secondary and micro nutrients and the particular texture ensures uniform distribution of nutrients. It is a very unique method developed in agriculture industry with tremendous scope for future. The manufacturing process of customized fertilizers requires outmost care as it is programmed to improve soil fertility hence is environmental friendly and improve soil health.

Different methods are there to manufacture customized fertilizers. The following methods can be adopted for the manufacturing of customized fertilizers based on the suitability.

Bulk Blending

Simplest and cheapest option available for the production of customized fertilizers, which involves pure mixing of solid fertilizers in a ratio required to get the desired nutrient ratio. It only requires warehouse, weighing balance and mixing equipment. It has the advantage of smaller capacities of decentralized production uniquely suited to give the customer exactly the NPK ratio he requires. The physical standard should be such that the shape and size of all fertilizers, raw materials, which are to be used in bulk blends, are similar and also high-quality granular fertilizer material is needed. In Indian context importing of the raw materials is needed because of these stringent specifications of raw materials, and for large scale production it is not suitable. But for the experimental purposes this is the most suitable method.

Compound Granulation or Steam Granulation

Raw materials are in solid form and uniform size reduction of this fertilizer material is the key to granulation. Agglomeration of granules can be attained by use of hot water or low-pressure steam. Then the granulated materials should be dried and cooled by dehumidified air. Hygroscopic products like urea containing grades need dehumidified bagging plant also otherwise caking of the products will occur. This is the most suitable method for the large-scale production of customized fertilizers in India.

Chemical Granulation

Chemical granulation is also called 'slurry granulation' or 'complex granulation' Here fertilizer production start with the basic raw materials like rock phosphate, acids and ammonia rather than their salts like diammonium phosphate and urea. So, the large capacity plants are needed to carry out chemical reactions. Infrastructure cost of handling and storage of acids and ammonia are huge here. Because of the difficulty in undertaking chemical reactions it is less flexible to produce variety of grades.

Compaction

Compaction is also called as 'dry granulation' process as not using any liquid binders for making it as granule. Fertilizer material should be powdered and apply high pressure on these powdered materials to squeeze them together which results in large dust generation and the final products in the form of briquettes or flakes.

Customized Fertilizer Formulations Available in India

There are about 36 formulations approved by fertilizer control order of India. The important companies in the market producing customized fertilizers are Tata Chemicals Ltd., Deepak Fertilizers, Nagarjuna Fertilizers, Coromandel Industries Ltd. Etc. Some of the formulations released by them for particular crops for particular area are shown in the table below.

TABLE 1: Different customized fertilizer formulations available in India

Company	Crop	Formulations (N:P:K:S:Zn:B)	Location
Tata chemicals Ltd.	Potato	8:16:24: 6:0.5:0.15	Agra, Aligarh, Budaun, Baghpath
	Wheat	10:18:25: 3:0.5:0	Muzaffarnagar, Mathura, Meerut, Etah
	Rice	8:15:15:0.5:0.15:0	Rampur, Ghaziabad, Shahjahanpur
	Rice	15: 32: 8:0.5 (N, P, K, Zn)	Andrapradesh
Deepak Fertilizers	Grape, Paddy, Gourds, Sugarcane, Tomato, Leafy vegetables	20:10:10: 5:2:0.5:0.3:0.2 (N:P:K:S:Mg:Zn:B:Fe)	Nasik, Dhule, Jalgaon, Pune, Ahemednagar, Aurangabad
	Maize	20:0:15: 0:0:0.2	Andhra Pradesh
	Groundnut	17: 17: 17: 4: 0.5: 0.2 (N, P, K, S, Zn, B)	Kadappa, Chittor
Coromandel Industries Ltd.	Groundnut	15:15:15: 9:0.5:0.2	Anantapur
	Maize	20:0:15: 0:0:0.2	Warangal

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35. Soil Test Crop Response (STCR) Approach for Profitable Agriculture

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INTRODUCTION: India's enormous success from its past green revolution has been followed by doldrums or declining agricultural productivity, even with increased total fertilizer use in the country over the years. This declining factor productivity is largely due to imbalanced usage of chemical fertilizers (Kumar et. al. 2007). Fertilizer is one of the most costliest input in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection. Soil testing thus enables to fit out the fertilizer recommendation for different crops, based on initial fertility status of the soil and as such it is considered to be one of the simplest means of evaluate soil fertility for giving fertilizer recommendations to cultivars before the actual sowing of the crops.

The concept of fertilizer recommendation for desired crop yields was first introduced by Troug (1960). The most comprehensive approach of fertilizer application by incorporating components like soil test values, crop nutrient requirement, nutrients contribution from soil, manures, fertilizers and fixing targeted yields is possible only through Soil Test Crop Response (STCR) approach. Soil test crop response (STCR) approach estimates the amount of the nutrient removed by the crop, initial level of soil fertility, nutrient efficiency and nutrient uptake from the soil and fertilizers. The fertilizer dose based on this method is designed to maintain soil fertility and reduce fluctuations in yields. For obtaining maximum yields and sustaining the soil fertility, application of required nutrients as per soil test value (STCR technology) is essential. Soil test crop response (STCR) studies facilitate to come up with fertilizer adjustment equations and calibration charts for recommending fertilizers on the basis of soil test values and achieving targeted yield of crops (Singh and Biswas, 2000).

Fertilizer (organic or inorganic) is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for profitable framing and environmental safety. To enhance farm profitability under different soil and climatic conditions, it is necessary to have data on optimum fertilizer doses required for crops. In this, soil testing plays an important role as its use and interpretation based on local soil test crop response relationship data provide fertilizer recommendations at farmer's level for obtaining maximum returns from inputs on fertilizers. Soil testing, thus enables to adjust fertilizer recommendations to different crops, based on initial fertility status of the soil and as such is considered to be one of the simplest means of assessing soil fertility for giving fertilizer recommendations to farmers before the actual crop sowing.

Concept

- In the era of precision agriculture, the concept of "Soil test-based fertilizer recommendation" correlate the much-debated approaches like, "Fertilizing the soil" versus "Fertilizing the crop" ensuring for actual balance (not apparent balance) between the applied fertilizer nutrients among themselves and with the available soil nutrients.
- In the "Inductive Approach" of STCR field experimentation, all the needed variation in soil fertility level is obtained not only by selecting soils at different locations, but by intentionally bring it in one and the same field experiment in order to reduce heterogeneity in the soil population studies, management practices adopted and climatic conditions.
- Field specific balanced nutrient amount i.e. N, P and K were advise based on crop-based estimates of the initial supply of N, P and K and by modelling the expected yield response as with nutrient interaction.
- The specific yield equation based on soil health and ensuring sustainable crop production also guides the farmers towards economic use of costly fertilizer inputs.
- Indian Council of Agricultural Research initiates a Coordinated Soil Test Crop Response Correlation Project to provide a scientific base for fertilizer use in 1967 at 8 centres which were increased to 13 during 1970-1971.

This approach established the basis for selection of soil test methods and divided the soil test values into three categories as low, medium and high. With the introduction of high yielding varieties and hybrids of crops which are responsive for fertilizers and crop intensification under expanded irrigation facilities during 1960's and the general fertilizer recommendations themselves being on the higher order, the interpretation of soil test classification and fertilizer recommendation by soil test laboratories needed to be reoriented to suit the modern agricultural technology by generating soil test calibration research work.

Soil test crop response approach is based on the three basic requirements *i.e.*, the quantity of nutrients

required in kg per quintal of economic yield, the percentage contribution of nutrients by the soil and the contribution of nutrients through the fertilizers to optimize the yield. Another added advantage is the estimation of fertilizers required to be added for different soil test values and targeted yields. This approach is based on the principle of Leibig's law of minimum.

Liebig's law of minimum states that the growth of plant is limited by the presence of smaller amounts of plant nutrients, all others being in adequate quantities. From this it follows that a given amount of a soil nutrient is sufficient for any one yield of given percentage nutrient composition. Ramamoorthy *et al.*, (1967) established the theoretical basis and experimental proof for the fact that Leibig's law of minimum operates equally well for N, P and K. This forms the basis for fertilizer recommendation for targeted yields as advocated by Troug (1960). The targeted yield method is unique in the sense that this method not only indicates soil test-based fertilizer dose but also the amount of yield that the farmer can hope to achieve if good agronomical practices are followed in raising the crop. The essential basic data required for formulating fertilizer recommendation for targeted yield are

- Nutrient requirement in kg/q of produce, grain or other economic produce.
- The percent contribution from the soil available nutrient (CS (%)).
- The percent contribution from the applied fertilizer nutrient (CF (%)). (Ramamoorthy et al.,1967).

These three parameters are calculated as given below:

Nutrient Requirement = total uptake of nutrient (kg)/grain yield (q)

CS (%) = Uptake in control plots (kg ha^{-1}) X 100/soil test value in control plots

CF (%) = Total uptake of nutrients in fertilizer plots – (STV in fertilizer plots) X CS X 100/ Nutrient applied through fertilizer (kg ha^{-1})

Advantages of Soil Test Crop Response Approach

- Efficient and profitable site-specific fertilizer recommendation for increased crop production and for maintenance of soil fertility.
- Aims to provide balanced, efficient and profitable nutrient application rates for targeted yield giving consideration to basic fertility status of soil.

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36. Soil Testing: Mechanical Analysis of Soil by Bouyoucos Hydrometer Method

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The process of determining the amount of individual soil separates below 2 mm in diameter i.e. sand, silt and clay is called particles size analysis. It consists of determination of the percentage of various sized particles (sand, fine sand, silt and clay) as they exist in the soil. An essential first step is to separate the particles so that they function as individuals. This is called dispersion. The completely dispersed individual primary particles are usually referred to as textural separates. There are several methods of mechanical analysis, of which the hydrometer method and pipette method are important. Both methods are based upon the differential rate of sedimentation of soil particles in water and the accuracy of the methods depends upon various conditions and assumptions. During mechanical analysis of soil, all larger rocks, pebbles, roots and other rubble are removed and measured by screening the finer soil parts through a 2mm sieve before analysis.

i) **Principle**: The hydrometer method is based on the principle that the density of the suspension at a given depth decreases as an initially homogeneous dispersed suspension settles. The rate of decreases in density at any given depth is related to the setting velocities of the particles, of a given size to settle can be calculated by using Stokes's Law.

ii) **Stokes's Law**: Stokes (1851) stated that the velocity of a falling particle is proportional to the radius square and not to its surface.

Equation

$$V=\frac{2gr^2(dp-d)}{9n}$$

Where,

V = velocity of setting particle
dp = density of particle
d = density of liquid
g = acceleration due to gravity
r = radius of particle
n = viscosity of liquid

iii) **Equipment and Glassware**: Bouyoucos soil hydrometer, Fahrenheit scale thermometer. Electric stirrer or homogenizer, Glass cylinder with marks at 1000 mL.

iv) **Reagents**: 30% hydrogen peroxide (H_2O_2), 5% sodium hexametaphosphate (dissolve 50 g sodium hexametaphosphate in 1000 mL distilled water).

Procedure

1. Weight 40 g air dried (2mm sieve passed) soil into a 1000 mL beaker in duplicate and moist it with distilled water.
2. Then add 5 mL of 30% H_2O_2, continue to add another 5 mL of 30% H_2O_2 until subsequent additions. Usually 15 mL of 30% H_2O_2 is sufficient for oxidizing organic carbon in normal soils containing less than 0.5% organic carbon.
3. Remove excess H_2O_2 by placing the beakers on a water bath or on a hot plate at low heat for 3 to 4 hours. Heat the contents to boil gently for 10 minutes to expel any remaining H_2O_2. Do not allow the contents to become dry.
4. Cool the sample and transfer the beaker to an oven at 105°C, until the soil dries to a constant weight. Determine the oven dry mass of organic carbon free soil.
5. Add 100 mL of 5% sodium hexametaphosphate solution in beaker containing organic carbon free soil sample, cover the beaker with a watch glass and leave for overnight.
6. Next day, add water and made volume of suspension to 500 mL, homogenize the soil water suspension at moderate speed with electric stirrer or homogenizer for 5 to 30 minutes depending upon the soil texture (5 minutes for sandy, 10 minutes for loamy and 30 minutes for clay soils)
7. Transfer suspension quantitatively into a 1000 mL cylinder and make up the volume to 1000 mL with water.
8. Simultaneously in another cylinder of the same size, add 100 mL of 5% sodium hexametaphosphate solution and dilute it to 1000 mL with water.
9. Mix well, insert hydrometer, and take hydrometer blank reading (Rb).
10. The blank reading must be re-determined for temperature changes of more than 2°C from 20°C.
11. Mix soil water suspension in cylinder and immediately insert the hydrometer and take hydrometer reading after 40 second. This gives silt + clay (Rsc) soil. Leave the suspension undisturbed and after 4 hours, again insert the hydrometer and take the hydrometer reading. This gives clay (Rc) in soil.

Calculations

% Silt + Clay = (Rsc-Rb/dry weight of O.C. free soil) x 100
% Clay = (Rc –Rb)/dry weight of O.C. free soil) x100
% Silt = % Silt + Clay - % Clay
% Sand = 100 - % silt + clay

Using soils size fraction data determine the soil textural class from the fig. 1

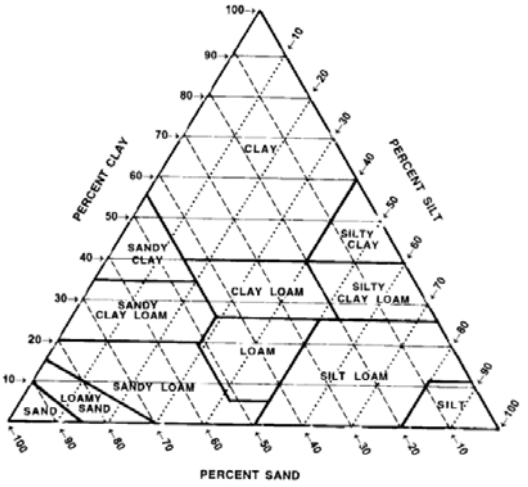

FIG.1: soil textural classification triangle by U.S.D.A.

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37. Do's and Don'ts of Handling and Applying Pesticides

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Ultra-care and vigilance are required for handling and application of pesticides. Though you are a farmer or grower, precaution and care need to be front and centre since we all believe in a notion **"prevention is better than cure"**. Pesticides can be defined as those materials *viz.*, natural, organic and synthetics that have benn used to control, suppress, or repel pests.

Certainly, we use pesticide as a last alternative as far as pest management practices are concerned and that is totally based on economic threshold level. There are abundant chances of exposure to people, pets, wildlife and the environment to substances that can cause health and environmental effects while handling pesticides. Keeping these facts in mind certain do's and don'ts have been formulated for handling and application of the pesticides as given below:

Do's

- Standing crops should be monitored at regular intervals and categorize the pest status based on that pesticide application can be done.
- Always registered pesticides or the one recommended by the State Universities/ICAR Institutes should be used.
- Instructions written on pesticides should be strictly followed
- Only recommended dose should be sprayed.
- Always use perfectly calibrated sprayers and nozzles.
- Insecticides should be used immediately after mixing.
- Records of pesticide spraying activity should be maintained.
- Always keep the pesticides away from the reach of children and animals.
- Containers should be stored in a safe and cool place.
- Empty containers should be disposed properly (if possible, bury it in a pit).
- Entry of livestock and pet animals should be prohibited from the sprayed area for a legitimate period.
- Approach the nearest physician immediately for any type of emergency or accidental poisoning.
- Choose particular form of pesticide best suited to your target site and the pest you want to control
- Use safety equipment properly and protective clothing listed on the label.
- Sanitation of all tools and equipment should be ensured and apply rinse water
- Stay safe, responsible and prepared!

Do Not

- Use of non-registered or non-recommended/ banned pesticides should always be avoided.
- Higher doses of pesticides should be avoided.
- Always avoid frequent and repeated application of pesticides.
- Avoid mixing incompatible pesticides or pesticides with fertilizers or micronutrients.
- Never transfer pesticides from the original containers.
- Do not dispose pesticide containers in the field or waterbodies.
- Never reuse pesticide containers.
- Never have food while spraying.
- Expired pesticides should never be used.
- Do not mix pesticides bare handedly.
- Do not spray pesticides against wind.
- Inhale of pesticide dusts, sprays or vapours should be avoided.
- Dispose of unused product down the drain, sink or toilet should be avoided.
- Reuse empty pesticide containers as they can be as hazardous as a full one
- Pesticides should be transferred to other containers like plastic bottles
- Storage of pesticides should be avoided in vicinity of food and animal feed.

HORTICULTURE

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38. Specifications of Mulberry Plant for Silkworm Rearing

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Mulberry foliage is the only food for the silkworm (*Bombyx mori*) and is grown under varied climatic conditions ranging from temperate to tropical. Mulberry leaf is a major economic element in sericulture since the quantity and quality of leaf produced have a direct effect on cocoon harvest. In India, most states have adopted sericulture as an important agro-industry with excellent results. The total area of mulberry plantation in the country is about 2, 82, 244 hectares. Out of which approx. 8237-hectare mulberry plantation belongs to Jammu and Kashmir. There are four indigenous species of mulberry viz *Morus indica, Morus alba, Morus laevigata* and *Morus serrata*. Jammu and Kashmir State has the privilege of possessing all the four indigenous species of mulberry. Mulberry thrives under various climatic conditions ranging from temperate to tropical located north of the equator between 28° N and 55°N latitude. The ideal range of temperature is from 24 to 28°C. Mulberry grows well in places with an annual rainfall ranging from 600 to 2500 mm. In areas with less rainfall, growth is restricted through moisture stress, resulting in low yields. On average, mulberry takes 340m3/ha of water every ten days in case of loamy soils and 15 days in case of clayey soils. Atmospheric humidity in the range of 65-80 per cent is perfect for mulberry growth. Sunshine is one of the main factors for controlling growth and leaf quality of the mulberry tree. In the tropics, mulberry grows with a range of nine to 13 hours of sunshine a day. Mulberry can be cultivated from sea level up to an elevation of 1000 m. Mulberry grows well in soils that are deep, fertile, flat, loamy to clayey, well drained and porous with good moisture holding capacity. The ideal range of soil pH is 6.2 to 6.8, and the optimum may be 6.5 to 6.8.

Mulberry plant should grow in either paired row plantation or 3M Plantation. In Paired Row Plantation, the mulberry plants are placed in rows which are distance of 90cm (3') from each other. A pair of rows is distanced by 150cm (5'). The plants are placed in each row at a spacing of 60cm (2'). Here, each plant occupies 0.8 m' (8ft') and there are12,500 plants/ha. The paired row gardens can be cultivated with tractor and power tilled operated machines. The 3M plantation modification of 90x90 cm (3'x3') plantation where the movement of tractor-operated machinery is not feasible. In 3M Plantation, the mulberry plants are placed in blocks where each block contains 9plants. In each block, the plants are spaced at 90cm from each other. The blocks are separated from each other by 120 cm. In 3M plantation, each plant occupies an area of 1m^2 (10ft^2) and there will be10,000 plants/ha. There are three types of mulberry plants based on the cutting of the main stems follows.

1) Bush Type

For the preparation of bush type mulberry plant, after plantation cut a sapling at 1 to 1.5 feet from the base. After 10 to 15 days, leaving 3 to 4 buds from the top and remaining all buds will remove for effective bush formation. This type of plantation is very useful for chawki rearing because leaves are very soft and small in size, which is very useful for feeding of small size worms. Such type of plantation is also having many other benefits such as harvesting and preparing of mulberry cutting is easy and the stumps are maintained straight, Sprouting occur early, thereby harvesting rate increases and occurrence of damage due to pests and diseases is very less. In case any infection is noticed it is easy to adopt control measure. The growth rate of shoots is early which enables the early harvesting, and it has high utility value for rearing during summer and autumn silk worm, because hardening of leaves is delayed as the growth is rich even during late autumn. Demerits of such type of plantation are the leaves get soiled easily during heavy rains and plants are susceptible to damage by frost and snow.

2) Dwarf Type

For the preparation of bush type mulberry plant, after plantation cut a sapling at 3 to 3.5 feet from the base. After 10 to 15 days, leaving 3 to 4 buds from top and remaining all buds will remove. This type of plantation is having medium characteristics of leaf size and plant size. Such type of leaves can be used in both for chawki rearing and late age rearing. Management of such type of plantation is easy because plants having a medium in size and also plucking of a large number of leaves in less time are possible.

3) Tree Type

For the preparation of tree type mulberry plant, after plantation cut a sapling at 4 to 4.5 feet from the base. After 10 to 15 days, leaving 3 to 4 buds from top and remaining all buds will remove. This type of

plantation is very useful for late age rearing because leaves are very large in size and thickness of leaf is more. Such type of plantation is very useful in shoot rearing because plants are having a large shoot, which can be directly applied for feeding to silkworms. The other benefits of such type of plantation are a better quality of leaves; plant age is more, less damage due to frost and snow, Leaves mature rapidly, the Water content in leaves is relatively low, Damage due to floods is less. Demerits of such type of plantation is difficult to manage adjustment of stump, difficult in harvesting leaves, rate of harvesting leaves is less, takes too long time for the plants to get ready for harvest, The plants get easily damaged by wind, and it is difficult to supplement for the dry stumps, Plants get easily damaged by pests and diseases.

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39. Traditional Storage Methods Boost the Storage Life of Onion and Garlic

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Onion and garlic is an important vegetable as well as spice crop which cultivated throughout the world for its culinary dietary, therapeutic and medicinal value. Being a seasonal crop, bulbs of onion and garlic are usually stored in ambient storage condition until the harvest of next season crop or for longer period to avoid the glut in market as well as year-round availability. Both these crops being semi-perishable gets deteriorate during storage. Despite of the ample production of both these commodities, generally 40-50 % of the produce failed to reach the market due to the huge post-harvest losses in storage. These losses comprise of physiological weight loss (PLW), *i.e.* moisture loss and shrinkage (30-40%), rotting (10-12%) and sprouting (8-10%). In garlic, major losses recorded are physiological weight loss (10-15%) and further due to storage pest and diseases (15-20%). The PLW occurs mainly in the months of May-July when atmospheric temperature is high, whereas, rotting losses are more pronounced during rainy season when atmospheric humidity is predominant and sprouting occurs in month of September-October when temperatures starts declining. The traditional storage methods of onion and garlic are very important for regular supply to consumers, value addition and exercising control over price fluctuations.

Factor Affecting Storage Life of Onion and Garlic

The storability of both crops is influenced by several factors such as varieties, pre and post-harvest management practices and storage environment.

Selection of Varieties: The storage capacity of onion and garlic varieties varies with its genetic background and season of cultivation. The genetically controlled factors influencing storage may be dry matter content, pungency, skin colour, number of adhering scales and period of natural dormancy in the variety. Onion varieties having bulbs with dry skin, thin neck with tendency of neck-fall, 50-60 mm diameter and light red colour have better storage life. Well cured (dried neck and outer skins), clean bulbs firm to the touch could be selected for storage.

Pre-Harvest Management Practices: Integrated use of mineral fertilization, organic manures and biofertilizers produces higher onion and garlic yield. Zinc @ 10 Kg/ha as basal is recommended in areas having zinc deficiency for onion and garlic for better bulb formation. Irrigation at 8-15 days interval depending upon soil type, climatic condition and stage of crop is generally recommended for better storage. Irrigation should be stopped 2-3 weeks before harvest. Bulbs are harvested when 50-60% plants show neck fall is the most important factor for getting good quality bulbs. Any delay in harvest may result in bulbs with thick neck, bolters, splits, poor skin quality and firmness which affect its storage quality.

Post-Harvest Management Practices: Pre-cooling is an effective process for maintaining the quality of onion and garlic produce before storage. Curing is the most important practices, which allows formation of strong intact outer protective skin and closure of onion neck. Curing significantly decrease the surface area, volume and, increase the bulk density and hardiness of the freshly harvested bulbs. Curing under field conditions for 3-4 days with windrow method and at 30°C in controlled chamber found effective for storage of bulbs. Exogenous application of ethylene and ethylene binding inhibitor, 1- Methylcyclopropene (1-MCP) suppress sprouts during storage in onion. Gamma irradiation (0.15 kGy) also inhibit the sprouting, but its effect depends upon pre-harvest growing conditions, seasonal variation, curing period, bulb dormancy as well as storage environment/structures. Proper grading of onion and garlic bulbs should be done for getting good market price and reducing storage losses. The onion bulbs are graded in three different

grades *i.e.* A (>55 mm), B (35-55 mm) and C (>35 mm) grades according to their size. However, Indian garlic's have different sizes ranging from 15 mm–30 mm, 30 mm–40 mm, 40 mm and above.

Atmosphere of Storage Room: Temperature and relative humidity are important factors for the storage of onions and garlic it increases the wrath of the fungus and the onion starts rotting. And when the humidity is low (more than 65%), the transpiration of onion is high and the weight decreases more. For good storage, the storage houses are 25-30 °C and humidity should be between 65-70 per cent. In the months of May-June, due to high temperature and reduced humidity of the warehouses, weight loss of bulb is high. The onion and garlic storage structure should be planned and designed in such manner that it can achieve and maintain the desired storage condition in lowest possible cost within the available resources.

Cold Storage: Storage of onion and garlic under cold storage has become beneficial for farmers. Onion and garlic store best at 0-2°C temperature with 65-70 % relative humidity. Sprouting is the main problems when the bulbs are immediately exposed outside from cold store to room temperature. To address this issue, the temperature should be raised gradually by 2-5°C of stored bulbs before removing to avoid condensation of moisture on bulbs. Thus, cold storage along with the use of gamma irradiation treatment may be helpful in minimizing post-harvest storage losses in onion and garlic.

Traditional Storage Methods are:

- **Onion on a String:** With help of rope onion bulbs are tied on their neck arranged in spirally manner around the rope and hanged in well-ventilated shed.
- **Spread Onion on Floor:** the onion bulbs are spread on floor in the shed- making layer of 10 to 15 cm thick.
- **Onion Bulbs in Trays:** Onion bulbs are kept in tray or tiers containing 2 to 3 layers of bulbs. These trays are arranged in well-ventilated room or shed.
- **Bottom and Side Ventilated Single Row Structure:** This structure is constructed with bamboo or wooden framework provided with bottom ventilation. This design is profitable for small and marginal farmers. The roof is made up of thatch from dried sugarcane leaves or grasses. The length can be kept as per requirement and bulbs can be stored in a compartment of about 15 feet.
- **Bottom and Side Ventilated Double Row Structure:** These structures are of permanent/ semi-permanent type and usually constructed with capacity of 25-50 tonnes. They have length of 30-50 feet and width of 12 feet with two rows. The width of each row is 4 feet and free space of 4 feet in between the two rows is kept for walking. The length should not be more than 50 feet as increase in length may increase rotting losses. These structures are constructed at 2 feet above ground level to provide bottom ventilations supported over RCC pillars. The bottom and sidewalls can be made of bamboo or wooden bantams. Door side and opposite to door sidewalls are covered with green shade net to protect from rain. The roof is made with asbestos sheets.
- **Top and Bottom Ventilated Structure with Mud Plaster on Side Walls:** This structure is best for humid and high-temperature areas and constructed with G.I. framework. The floor is ventilated and constructed with wooden bantams. The sidewalls are made of bamboo and plastered with clay and cow dung paste. The ventilation provides a lower portion of western sidewall and upper portion of the eastern sidewall. The lower portion ventilator of western sidewall has control flaps to regulate the entry of hot winds in summer and high humid wind in rainy season. Plastered sidewalls controls humidity in rainy day, whereas maintain inside temperature during summer. The structure can be constructed with 25-50 tonnes capacity.

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40. Post-Harvest Technology, Processing and Value Addition of Makhana

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Makhana is scientifically known as *Euryale ferox* and it belong to the family of Euryalaceae. Makhana is very popular in Northern part of Bihar, North Bengal, Assam and other northeastern states of India. Makhana is profitably cultivated in water a body which does not have huge current or water velocities. It is cultivated in ponds, lakes, tanks and other aquatic bodies. Makhana have potential to be a very profitable crop for farmers and increase the income of the people where it is grown. This article would highlight the important post-harvest operations, processing aspect and value addition of makhana.

Maturity Indice: Makhana is matured when the colour of the seed is dark black. Generally, this stage is achieved in the month of September – November. The seeds are matured after 30-42 days of

flowering. Upon maturity the fruits get ruptured and the floppy seeds usually float in the surface water. After floating for 2-3 days, the floppy nature of the seeds is not there and hence the seeds settle down at the bottom of the pond and the field. A yield of 1.4-3.5 tonnes/ha is obtained.

Method of harvesting: Harvesting of makhana seeds can be done exactly when the fruit of makhana attains physiological maturity or the fruit start rupturing. If the fruit already gets ruptured, the seeds can be collected from floating pond water. In case the seeds have already settled down, they are to be collected from below the pond/field. The harvesting time is usually the morning hours, morning 6:00 am to 12:00 pm.

Handling: The seeds are being collected in a bamboo basket or in a trey. The seeds are black in colour and are covered with mud and mucilage. The seeds are washed thoroughly until all the mud gets cleaned up. The seeds are then again poured in a separate container where it is rolled over ground so as to rub the seed coat. After proper cleaning the seeds are placed in gunny bag and are regularly moistened so as to maintain the moisture.

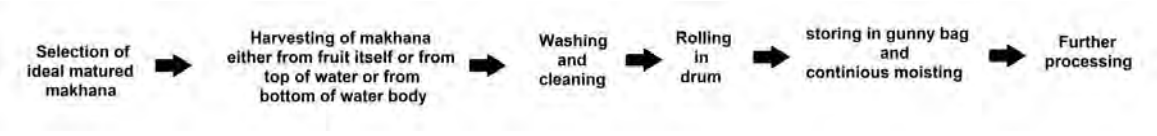

FIG 1: Postharvest operations of makhana

Other post-harvest operations: After harvesting, washing and cleaning operations like drying, size grading, tempering, roasting, popping, polishing, grading and packaging are also important operations. In drying process makhana seeds are dried in sun. In this process the fruits become devoid of total moisture. The water activity (A_w) is also reduced. The moisture is reduced to minimum 25%. After optimum drying, the makhana seeds are graded n sieves according to their size. 7 types of sieves are used in which sieve 1 is having smallest holes. This separates the dust and dirt from the makhana seeds. The sieve 2 separates the smallest makhana seeds from the remaining ones. While the makhana which are still left are the biggest and best graded.

After grading, the makhana's are pre-heated in earthen pitcher or iron *karhai*. A heat of 200-300°C is used in the treatment for 5-7 minutes. The water activity is reduced below 20%. Due to heating the seed coat and the surface expands which on further cooling gets compressed. In the next stage the pre-heated seeds are subject to temperature above 290°C. Due to this, the popping of the seeds takes place. After 1-2 minutes of stirring in hot sand, the seeds make a popped sound and the product is believed to be ready. Then the hard seeds are beaten with a wooden hammer so as to get rid of the seed coat. After this the makhana re-rubbed against each other so as the remove the reddish inner coating. This improves the glossy look of the makhana seeds. After this makhana is either packed in gunny bags or in polythene bags.

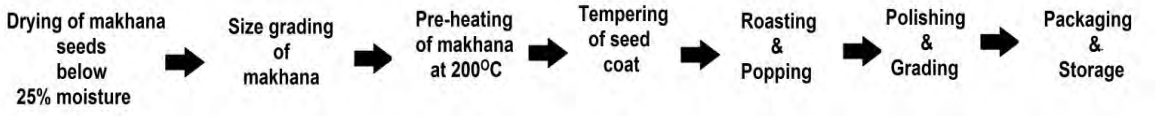

FIG 2: Processing of makhana after harvesting

Value Addition: Value-added products such as popped makhana, salted makhana, makhana roasted, makhana vermicelli, makhana kheer, makhana halva, makhana pickle, etc.

Conclusion: Post Harvest management, processing and value addition of makhana is a newer concept and hence the article could give a brief idea about these above topics.

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41. Physiological Disorders in Under Exploited Vegetable Crops

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Physiological disorders	Symptoms	Causes	Control
SPROUTING BROCCOLI			
HOLLOW STEM	It is characterized by presence of hollow cavity inside the curd	Deficiency of boron. Excess of nitrogen	Spray borax @0.3-0.4%. Reduce the dose of nitrogenous fertilizers. Transplant the crop at closer spacing.
BROWNING	Initially curd shows water-soaked spots and later it they become brown	Deficiency of boron.	Apply borax @ 10- 15 kg/ha at field preparation or spray 0.1% boric acid. Harvest the crop at proper maturity stage
BRUSSELS SPROUT			
LOOSE SPROUTS	The sprouts become loose and loss the market value. Loose sprouts are called blowns.	Presence of warm weather conditions. Application of high doses of fertilizers.	Grow the crop in cooler parts of the season. Do not apply high amount of fertilizers.
CHINESE CABBAGE			
TIP BURN	The tissue near the centre of head is affected. The affected tissue breaks down, losses moisture, becomes dry, papery, and eventually turn black or brown	Deficiency of calcium. High levels of nitrogen. High temperature. Exposure to long hours of daylight. High relative humidity. Fast maturing and high yielding cultivars are most susceptible.	Foliar spraying with calcium. Maintaining the adequate and uniform moisture supply. Apply only required amount of nitrogen
BLACK SPECK	It is characterized by dark spots that occur on outer leaves or sometimes throughout the head. Its symptoms may not appear at harvest but the initial damage occurs in the field with the typical symptoms developing during storage at low temperature	Application of high rates of fertilizers. Fluctuations in temperatures	High rates of potassium in soil have been shown to reduce the severity of disease. Application of required amounts of fertilizers only.
BOLTING Premature formation of seed stock without forming the head is known as bolting	Development of seed stock in the earlier stages. The heads may be partially formed or not formed completely.	Early sowing of seeds in the hot weather. Presence of warm winter. Sudden and extreme changes in temperature during crop growth. Poor growth of seedlings due to inadequate moisture supply, poor viability of seeds, and attack of insect pests and diseases	Avoid sowing in warm climate. Supply adequate amount of nutrients. Transplant healthy seedlings
LETTUCE			
TIP BURN	It is characterized by browning of portions of margins of internal leaves of head, causing severe losses	Prevalence of high temperature, high light intensity and long duration of light. Deficiency of boron and calcium. Excess of nitrogen. High endogenous levels of IAA.	Grow lettuce in cooler parts of the season. Spray the crop with $CaCl_2$ @ 0.5%. Avoid the application of excess nitrogen. Grow resistant varieties like Great Lakes, Imperial 456, Progress

Physiological disorders	Symptoms	Causes	Control
BOLTING	Plant shows premature flowering and seed stock formation. Sometimes the head may appear normal, but it may have the elongated core and stem inside	Exposure to hot and dry weather usually above 29.4°c cause bolting.	Raise the crop during cool periods of the season. Grow resistant varieties like Empire, Ithaca and Great Lakes.
RUSSET SPOTTING Primarily, it is a post-harvest disorder but may occasionally appear in the field also	Small, sunken, rust-brown spots appear on outer head leaves and may progress to inner leaves. In severe cases, spots become large, coalesce and extend to the leaf blades also.	Production of ethylene, either by lettuce itself or by other ripening produce or from outside sources. Storage of lettuce at temperature of 3 and 10°c. Heads of lettuce which are damaged physically are most susceptible to this disorder because they produce ethylene at high rate	Keep the lettuce away from ethylene. Store the lettuce at temperature of 0-2.5°c. Avoid damage to the heads during transport
PINK RIB	It is characterized by discolouration of large midribs to a light or dark pink. In mild cases, ribs of the outer leaves near the base show pink discolouration.	Exact reason is not known but it may be accelerated by higher than the normal storage and transit temperatures	Avoid exposure of lettuce heads to larger temperatures
BROWN STAIN	Small sunken lesions with dark edges occur on the leaf surface. Usually these lesions appear near the leaf base or near the midrib. These lesions are water-soaked when young, but become darker and may coalesce when the injury is severe.	It is caused by excess of CO_2 during storage. This disorder is also increased at a lowered O_2 level and by decreased CO_2 level.	It can be controlled by maintaining the low CO_2 level and an adequate O_2, CO_2 level during storage
RED HEART	It is characterized by brown discolouration and breakdown of small, inner head leaves. The outer leaves may appear normal or may develop numerous brown pits on the midribs and veins.	Lack of sufficient oxygen which results from poor aeration. Prolonged exposure to low temperatures during storage and shipment	Provide adequate aeration and continuous cooling of lettuce to 3.8°c to 4.9°c during storage and transport
CELERY			
CRACKED STEM (brown checking	There is brownish mottling along the leaf margins, followed by the brittleness of the petiole. The affected tissue collapse, become corky and petiole shows cracks	Deficiency of boron. This disorder is accentuated by high rates of nitrogen and potash.	Soil application of 1.25-2.5kg of Boron per hectare before planting. Spraying of 625g of Boron per 1136.5 lit of water per hectare
BLACK HEART	Initially the young leaves show tip burn symptoms. This is followed by drying, blackening and in severe cases the killing of the entire heart.	Deficiency of calcium. Application of more nitrogenous fertilizers. High temperatures and water stress during growing period.	Spray 6.5-12.5 kg of $CaCl_2$ in 1135.5 lit of water per hectare. Regular irrigation should be given
CHLOROSIS	Loss of chlorophyll pigments in the leaf and leads to yellowing of the older leaves.	Due to magnesium deficiency	Spraying Mgso4 @25 kg per hectare on the foliage every two weeks, while soil application is not effective. Cultivars like summer pascal are fairly resistant to this disorder.
BOLTING	Plant shows premature flowering and seed stock formation.	Exposure of young plants to less than 10°c temperatures for more than two weeks.	Sow the seed at right time
PITHINESS	Breakdown of thin-walled parenchyma cells that form the major part of the leaf stalk, resulting in softening of tissues and hollow cavity	It may be due to hereditary factors. It may be due to adverse environmental conditions.	If it is due to hereditary factors, it can be eliminated by careful breeding. If it is due to environmental factors, grow resistant varieties

Physiological disorders	Symptoms	Causes	Control
PENCIL STRIP	Narrow brown lines are formed on petioles	It is associated with high soil phosphorus.	It can be minimized by judicious application of phosphorus fertilizers.
SPINACH			
BOLTING	Premature flower stalk (bolting) formation ensuing seed production can render the plant unmarketable	Deficit in soil moisture can intensify the effect of heat	Grown under long days and warm conditions

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42. Importance of Underutilized Tree Vegetable: Drumstick

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INTRODUCTION: Drumstick (*Moringa olifera*) is one of the most popular tree vegetables and highly valued in the ancient world. It has originated in India and Arabia. It's belongs to family moringaceae. In India, drumstick pod is known as munga, saragwe and generic name is often referred to as moringa. In South Indian peoples are generally used to the process of making sambar and also used as fried (Immature pod and leaves). All parts of the drumstick tree are edible. In other parts of India, especially West Bengal, some parts of Jharkhand, Orissa it is enjoyed very much.

The name drumstick is derived from the pod shape resembling slender and curved stick used for beating the drum. Fruits also resemble the siliqua of radish and hence the name "radish tree".

Nutritional Importance

Drumstick leaves contain more vitamin-A than carrots, more calcium than milk, more iron than spinach, more vitamin-c than oranges and more potassium than bananas and it is one of the most nutritious foods to be found in the world.

Nutritional Value of Leaves and Pods of Drumstick

The nutritive value present of leaf, flowers, pods per 100 gm are given in table below:

Components	Pods	Raw leaves	Leaf powder
Moisture (%)	86.9	75.0	7.5
Calories	26	92	205
Vitamin-C (mg)	120	-	-
Protein (gm)	2.5	6.7	27.1
Fat (gm)	0.1	1.7	2.3
Carbohydrate (gm)	3.7	13.4	38.2
Fibre (gm)	4.8	0.9	19.2
Minerals (gm)	2.0	2.3	-

Components	Pods	Raw leaves	Leaf powder
Ca (mg)	30	440	2003
Mg (mg)	24	24	368
P (mg)	110	70	204

Medicinal use of Drumstick

- The fresh root of drumstick the plant is fulfilling in cases of in intermittent fever.
- An infusion of the roots, recommended for asthma and it is very useful for liver and spleen diseases.
- Root and root bark and stem bark are used as an abortifacient.
- The stem bark and leaf persuade sweating used in anorexia and external ulcers.
- Extracted fresh juice from root bark is used to relive otalgia by pouring it into ears and also used hollow of the tooth in case of dental problems.
- The gum is useful for anti-septic.
- Tender leaves reduce phlegm and fulfill internally for scurvy and catarrhal conditions.
- Leaves juice are reduced to high- blood pressure.
- Its flowers are used as stimulant, tonic, diuretic and cholagogue. They are useful in increasing the flow of bile and used to cure combustibility of tendons and abscesses.
- The immature pods act as a preventive against in testinal worm and also use of an appetizer and preventing eye disorders.
- If, pods made into a soup preparation are prescribed as a diet in sub- acute cases of enlarged liver and spleen, articular pains, tetanus, debility of nerves, paralysis, pustules, patches and leprosy.

Other uses

- Drumstick green leaves used as animals fodder purpose. Because it helps 30% increase in

milk and meat production when their diet was supplemented with 45% drumstick forage.
- The perennial tree vegetable is good in agro forestry system and mixed cropping system and its intercropping with vegetables has been found economical.
- The tree can be planted in ornamental gardens and as we can grow road side avenues for aesthetic beauty.

Pharmacological Activates of Drumstick

Drumstick is rich source of several phyto- chemicals present-

- **Leaves:** Radio- protective, Anti- diabetic, Anti- anemic, Anti- hypertensive, Diuretic, Anti- oxidant, Lactation enhancer, Anti- septic, Hepatoprotective, Anti- athero sclerotic.
- **Flowers:** Anti- arthritic, Diuretic, Tonic, Improving reproductive health.
- **Pods:** Tonic, Anti- rheumatism, Anti- oxidant, Diuretic, Anti- diabetic.
- **Seeds:** Immature- stimulant, Anti- spasmodic, Anti- anemic, Anti- tumor, Anti- arthritis.
- **Seed oil:** Purgative, Anti- oxidant, Tonic, Reproductive, Health promoter.
- **Gum:** Diuretic, Anti- rheumatism, Rubefacient.
- **Bark:** Anti- urolithiatic.
- **Roots:** Cardio tonic, Diuretic, Aphrodisiac, Anti-inflammatory, Anti- urolithiatic, Abortifacient.
- **Seed kernels:** Anti-asthmatics, Anti-inflammatory.

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43. Bagging of Litchi

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Litchi (Litchi chinensis) is most important fruit crop in India. It is a delicious juicy fruit of excellent quality. Botanically it belongs to Sapindaceae family. India is the second largest producer of litchi in the World after China. The production of litchi is highest in Bihar state of India. The national average productivity of litchi is 6.1 t/ha. The average productivity of litchi in Bihar is 8.0 tonnes/ha. and in West Bengal it is 10.5 tonnes/ha. In other states the productivity is much lower, the lowest of 1.0 t / ha in Uttaranchal. Litchi fruit is famous for its attractive red colour, excellent quality characteristics and pleasant flavor. The food value of litchi mainly lies in its sugar content which varies from variety to variety. The fruit is also rich in Vitamin B_1, Riboflavin & Vitamin C apart from proteins (0.7%), fats (0.3%), carbohydrates (9.4%), minerals (0.7%), fibrous matter (2.25%), calcium (0.21%), phosphorus (0.31%), iron (0.03%) and carotene. Litchi makes an excellent canned fruit. A highly flavoured squash is also prepared from the litchi fruits, which is used during summers. Various other products such as pickles, preserves and wine are also made from litchi in India.

An extended harvesting period, superior fruit quality and free from fruit-borer infestation are the three major characteristics for marketing demands of litchi industry in India. But litchi fruit is more prone to sun burn, fruit cracking and attacks of insect pests and diseases in all stages of development that reduce the qualitative and quantitative traits of litchi. The affected litchi fruits gain poor price in the market and such fruits are also rejected for processing. It causes serious economic loss to litchi growers. Recently, the pre harvest bagging technique of fruits has shown promise in the fruits like banana, mango and apple (Sharma, Reddy, & Jhalegar, 2014). Origin of this practice in Japan and Korea Some easy and effective practices is adopted to overcome these problems such as bagging. Among several good orchard practices fruit bagging is becoming very popular in several countries of the world. It is a physical protection technique, which improves fruit appearance by promoting fruit coloration and reducing blemishes. It brings multiple effects to internal fruit quality. Fruit bagging also, mechanical damage, sunburn, fruit cracking, agrochemical residues, and damage by birds etc. Development of fruits inside bags on the tree avoided the infestation of fruit borer because the bags served as a successful physical barrier against the borer insects reduces disease and insect-pest incidence. It reduced the cost of production compared with the cost of control by using pesticides

Bagging of Litchi Fruit

Fruit bagging is the modern and convenient practice of putting bags over fruit to protect them from attack of pests, disease, sunburn of fruit and cracking of fruit etc. Among several good agricultural practices fruit bagging is becoming very popular in several countries of the world. It is a physical protection technique, which improves fruit appearance by promoting fruit coloration and reducing blemishes. Fruit bagging also reduces the incidence of disease and insect-pest, mechanical damage, sunburn, fruit cracking, agrochemical residues, and damage by birds etc. The irregular bearing nature of the litchi is a major obstacle to litchi production, as one year of heavy production can be followed by a year of low or no production (Yokoyama et al. 1991). When there is low- production years, pest damage can reduce production tremendously. Litchi fruit are affected by several major pests such as erinose mites (Eriophyes

litchii) including moths (Cryptophlebia spp.), fruit flies, and birds. Litchi mite affects flowering and fruit development. Common diseases of litchi fruit are Colletotrichum, Phomopsis, Lasiodiplodia, and Pestalotiopsis. Many of the symptoms show up as dark brown lesions on the skin of the fruit or as brown spotting on leaves. These diseases and pest are adversely affected fruit appearance, quality and ultimate total yield.

Types of Bagging

The bags act as a barrier to protect the fruit against attack by summer insect pests and diseases such as litchi mite, fruit borer, bark eating caterpillars etc. Individual litchi fruits are bagged with different types of bags in pea stage (March- April) when remain bagged until two weeks before harvest (May to June). No additional pesticide or fungicides sprays are needed once the bags are placed on the fruit. There are different types of bag available such as;

- Newspaper bag
- Brown paper bag/pink paper bag
- Scurting bag
- Polythene bag
- Butter paper bag
- Muslin cloth bag
- Brown paper with polythene coating etc.

In litchi maximum retention of fruits found by pre-harvest bagging with different types of bags, newspaper bag, brown paper bag and scurting bag the fruit retention found with polythene coating is higher than newspaper bag and brown paper bag. The harvesting time is significantly shortened when bagging with polythene bag, scurting bag, butter paper bag, muslin cloth bag while using newspaper bag, it was significantly delayed. Bagging on fruits also alters the microenvironment around fruits. Bagging of litchi fruits before harvesting with newspaper bag, brown paper bag and brown paper bag with polythene coating improved yield attributes traits viz: weight of fruit, length of fruit, diameter of fruit and pulp weight of litchi fruit. Thus, investigation proved that litchi fruit bagging at 30 days after fruit set with various types of bag modified fruit retention, period required for harvesting, physio-chemical composition, shelf life, occurrence of sunburn and fruit cracking and pest incidence in litchi. Bagging with newspaper bag and brown paper bag improved fruit retention, weight of fruit, diameter of fruit, pulp weight, total soluble solids and reducing sugars at ripe stage. The brown paper bag with polythene coating improved fruit retention, weight of fruit, pulp weight and decreased occurrence of spongy tissue and incidence of mealy bag.

Benefits of Bagging of Litchi Fruits

There are several beneficial and positive effects of bagging of litchi fruits before harvesting such as,

- Increases in fruit growth, size, and weight and total solid.
- Bagging of litchi fruit reduced the incidence or attack of birds, cryptophlebia moths, and fruit flies. Fruit bagging is a good technique to maintain a physical separation between the environment and the produce. One of the most significant effects of fruit bagging has been protection from the damage caused by insect pests in litchi fruits.
- Bagging reduced the direct penetration of light and also prevent sun burn of fruit cover or surface and improve the fruit colour. Fruit colour is the fundamental feature that attracts consumers. An attractive colour improves the physical appearance of the fruit, which helps to get better prices in domestic and export markets. Several studies have indicated that pre-harvest fruit bagging can promote or inhibit fruit colour development.
- It also reduced the incidence of fruit cracking. Reduced amount of damaged fruits. Fruit bagging also prevents pathogens from reaching the developing fruit, which protects them from several diseases that can cause major losses.
- Bagging is a technique used to prevent the fertilization of stigma from undesired pollen by covering the emasculated flower with butter-paper. It is useful in a plant breeding programme because only desired pollen grains for pollination and protection of the stigma from contamination of undesired pollen. Bagging maintain the purity of cultivars of litchi.
- Increased yield (fruit retention and pack-out)
- No need to individually harvest ripe fruit
- Consumers prefer appearance of bagged over un-bagged fruit
- Potential for higher net return

FIGURE 1: Bagging of litchi fruit

FIGURE 2: White and Pink paper bagging

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44. Makhana Production Technology: To Improving Economy of Farmers

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INTRODUCTION: *Euryale ferox* (Salisb) is an important crop, belonging to family Nympheaceae. It is mostly known as Makhana, Gorgon nut or Foxnut. Makhana is mostly grown in perennial not flowing water bodies like ponds and lakes. Makhana is native to South-East Asia and China, but distributed to throughout the world. In India, it is found in West Bengal, Bihar, Manipur, Tripura, Assam, Jammu & Kashmir, Odisha, Madhya Pradesh, Rajasthan and Uttar Pradesh, but mostly grown in Bihar, Manipur, some parts of West Bengal and Madhya Pradesh. In Bihar, Darbhanga, Araria, Sitamarhi, Madhubani, Saharsa, Supaul, Kishanganj, Purnia and Katihar are major Makhana growing districts. Darbangha, Madhubani, Purnia, and Katihar alone produce about 80% total processed Makhana production. In India, Makhana is cultivated about 13,000 ha. The yield of raw Makhana seed is about 1.8-2.0 t/ha of pond area.

Nutritive Value

Edible part of Makhana contains 12.8% moisture, 9.7% protein, 0.1% fat, 0.5% minerals, 76.9% carbohydrates, and 1.4 mg/100 g of carotene. Calorific value is 362 kcal/100 gm for raw Makhana and 328 kcal/100 gm for popped Makhana. Makhana is considered superior to dry fruits such as almonds, walnut, coconut and cashew nut in terms of sugar, protein, and ascorbic acid and phenol content.

Cultivation

Makhana is cultivated traditionally in perennial water bodies having water depth of 4-6 ft or in the field system.

Pond System is the traditional method of Makhana cultivation. Seed sowing is not required in old Makhana growing ponds since left over seeds of the previous crop serves as a planting material of upcoming crop. In pond system, apart from Makhana, fishes get enter into the ponds as wild fishes along with flood water and harvested by the farmers as an additional crop.

Field system: This is a new system of Makhana cultivation. In this system, Makhana cultivation is carried out in agriculture fields at a water depth of 1 ft. Makhana seedlings are first raised in nursery and then transplanting can be done in between first week of February to the third week of April. Through this system, the duration of Makhana crop is reduced up to the four months.

Harvesting

Collection of scattered seeds, from bottom of the pond or shallow water filed. Harvesting of Makhana is done in the month of August-October by divers of "Mallah" community in the morning around 6.00-11.00 am and it involves drudgery. A diver goes deep into the bottom surface of pond, lies down, hold his breath and drag the mud towards the bamboo pole locally known as "Kaara" with both palms. A heap of mud is formed near the base of bamboo pole which is later sieved with locally made bamboo screen called "Ganjaa". The time required for collection depends upon the amount of seeds lying in the bottom of the pond or the fields. Harvesting of Makhana seeds using the improved system involve less drudgery in comparison to traditional system with significantly higher work output.

Processes During Post Harvesting

Sun drying and Storage of seeds: The cleaned seeds of Makhana are sun dried by spread on a mat or cemented floor for 2-3 hrs under bright sun light to lose moisture to near about 31%, for easy of transportation and temporary storage. Makhana storage causes problems to growers; it cannot be stored for longer period in ambient conditions. Generally, the seeds are stored for 20-25 days before processing. It is necessary to sprinkle water at regular intervals during storage of nuts to keep them fresh and maintain the quality of seed.

Grading: According to their sizes sun-dried seeds are categorized into 5 to 7 grades by the set of sieves. Grading of Makhana seed by subjecting to uniform heating of nut during roasting to increases the efficacy of processing.

Pre-heating: Sun-dried nuts are generally heated in earthen pitcher or cast-iron pan by placing them over fire and stirring them continuously. Temperature of the pan surface about 250°C-300°C for 5 to 6 minutes at full capacity of the pan. After pre heating, moisture content of nuts reduces to nearly 20 percent.

Tempering: Storage of pre-heated seeds for 48-72 hrs at ambient condition is known as the tempering of the seeds. Tempering of seeds is done to loosen the kernels within hard seed coat.

Roasting and popping: It is the most important but laborious and painful operation of

Makhana processing. About 300 gm of pre-heated and tempered nuts are taken and roasted in a cast iron pan in single layer over the fire at 2900°C to 3400°C surface temperatures with continuous stirring. After about 1.5-2.2 min, a cracking sound is heard from the seed being roasted. The roasted seeds 5-7 are scooped quickly by hand and kept on hard surface and sudden impact force are applied on them by means of a wooden hammer. As the hard-shell breaks, the kernel pops out in expanded form, which is called Makhana pop or lawa. Depending upon the quality of raw material, the yield of Makhana varies from 35-40% on raw seed weight basis.

Polishing: It is done by rubbing action of Makhana pops among themselves in bamboo baskets. Polishing is provided more whiteness and luster to the Makhana.

Grading: Popped Makhana is generally graded in two grades-Lawa and Thurri. Lawa is swollen and white with reddish spots while, Thurri is semi-popped, hard and reddish in colour.

Packaging: Generally, ordinary gunny bags for local markets and gunny bags with polythene lining are used for distant markets to pack popped Makhana.

Constraints in Makhana Production: Major constraints for Makhana cultivation are identified as fallow:

- Lack of ownership of the pond/land
- Highly skilled nature of operations
- Lack of credit facility
- Lack of scientific knowledge of cultivation
- Lack of improved variety and planting materials
- Short lease period and labor-intensive cultivation

Most of Makhana growers cultivate Makhana in leased on government or private ponds/land and hence the Makhana growers realized it is a main constraint which hinders them to make Makhana a profitable venture.

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45. Tree Transplanting (Burlapping)

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INTRODUCTION: In the cultivation of ornamental and fruit trees, the transplantation of grown trees from one place to another for the purpose of creating orchards, parks, and squares within a short period of time. Trees may be transplanted in early spring or late fall at temperatures no lower than 5°C. The root ball should be 1.25 m in diameter for trees seven to ten years old and 1.5 m in diameter for trees ten to 15 years old. It is not advisable to transplant trees older than 15 years. The root ball should be no less than 60–80 cm high, so that the main part of the horizontal roots is preserved. For trees being moved long distances and for trees being moved from light soils, the root ball is encased in planks. (The minimum root ball radius should also follow international practice of 6 inches (15 cm) from the base of the trunk at ground level for palms)

Steps In Transplanting

Site Assessment	Pre-Transplantation Process
Planting & Supporting	Uprooting and Shifting
Maintenance	

Site Assessment

A methodical inspection of a site in order to learn more about the site's ability to support healthy plant growth. Considers the species transplant tolerance. Reviews the condition of the trees/ plants. Fixes the transplant season, new planting site conditions, equipments needed and maintenance after transplantation. The sites shall be inspected for possible hazards prior to beginning any transplanting procedure. The location of utilities and other obstructions both below and above ground shall be taken into consideration prior to transplanting any tree.

Pre-Transplantation Process

Selection of the right time for transplantation. Cutting of branches to reduce extra weight and canopy. Cut tips are treated with appropriate solutions to avoid attack of pests, etc. Appropriate steps are devised to avoid shock and stress to the tree/ plant.

Root pruning is sometimes required before transplanting a tree. Sufficient time should be allowed between preparation and final lifting for development

of new roots capable of sustaining and continuing the growth of the transplanted tree.

Uprooting and Shifting

Few days before uprooting, the soil is watered, to loosen the hard soil. The area around the tree/ plant is dug. Special care is taken to save the root ball from any damage. On uprooting, the root ball is covered with canvas or plastic to hold back the soil to the roots. The starting level of the trunk above the soil is marked so that the same position is maintained at the new site.

Trees in containers are more resistant to root damage during transportation. This is a recommendable method of transplanting as the root ball is well protected and lifting of the boxed root ball during transplanting will give better protection during the transplanting operation and enhance better establishment of the tree afterwards.

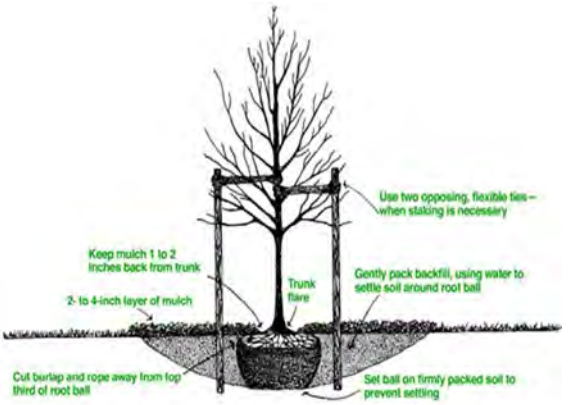
Planting and Supporting

Proper pits are dug, two to three times wider than the root ball. Dry soil is irrigated to avoid post plant water from migrating from the root ball. The stress of a tree can be observed immediately after transplanting or gradually after a period of time. Proper care after transplanting will help to assure survival and minimize stress and ensure a higher successful rate. Maintenance is a continuation of the transplanting process. Efforts and expenses can be wasted if trees are not given proper care after transplanting.

Maintenance

After the transplantation, the soil at the new site is regularly monitored to check for chances of drying out. Mulching, fertilizer treatment, pruning, mechanical support and other protection measures are adopted post transplantation.

Mulch can be used to conserve soil moisture, to buffer soil temperature extremes, to control weeds and other competing vegetation, and to replenish organic matters and nutrients in the soil. Mulch should not be placed too close to the tree trunk or root collar. The size of the mulched area depends on the size of the tree. Mulch layer around 5cm thick usually covers the area where roots will grow during the first two years after planting.



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46. Cultivation and Health Management of Citrus Saplings

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The area under citrus in Madhya Pradesh is estimated to be 74,815 ha of which 55,640 ha is under oranges (*Citrus reticulata* Blanco), 11,116 ha under acid lime (*Citrus aurantifolia* Swingle) and 8,698 ha under sweet oranges (*Citrus sinensis* Osbeck) as per official record of Directorate of Horticulture and Farm Forestry of the state. The area under citrus cultivation is increasing gradually. In Madhya Pradesh orange cultivation was restricted to Chhindwara district which has now extended in Betul, Hoshangabad, Mandsaur, Neemach, Ujjain, Bhopal, Vidisha, Harda Shajapur, Agar Malwa, Khandwa, Khargone, Dhar and Ratlam districts. Out of 55,640 ha under orange cultivation Chhindwara commands approximately 25,000 ha only indicating a good potential for orange cultivation in other districts of the state. Pandhurna and Sausar block of Chhindwara district adjoining to Vidarbha region of Maharashtra are famous for quality Nagpur mandarin. Orange cultivation is also becoming popular in two more blocks viz., Mohkhed and Bichhua of the district commanding approx. 1,000 ha each. The main citrus fruits in Madhya Pradesh are orange, acid lime and sweet orange. As per official record of State Dept. of Horticulture and Farm Forestry for 2012-13, citrus fruits are grown in 49 out of 51 districts of Madhya Pradesh. As per Indian Horticulture data base 2014, the area under oranges in Madhya Pradesh is 52490 ha with

the production of 894430 MT. The productivity is estimated to be 17.04 MT/ha. This is much higher than that of adjoining state Maharashtra.

Planting of Pathogen-Free Seedlings in an Orchard

PF citrus seedlings are best planted in a new area free of diseased citrus trees. However, they can also be planted in the existing citrus-cultivating areas after the diseased trees and alternative host plants are completely removed. The planting layout of PF seedlings comprises a quincunx system *i.e.* four seedlings at each corner of a square with the fifth one in the center. Plant spacing should be adjusted in relation to the species and cultivars of citrus, rootstock, and environmental factors. In general, the recommended plant spacing for sweet orange and mandarin (500 plants/ hectare) is 5 meters between rows and 4 meters between plants; and 6 m × 6 m for pummelo and grapefruit. A planting hole of about 100 cm diameter and 60 cm depth is dug on the planting bed (ridge). The topsoil and subsoil are hollowed out from the planting hole and placed separately to avoid mixing them with each other. An adequate amount of organic manure (10~20 kg) and dolomite or lime stone powder (1~2 kg), or super-phosphate lime (0.5~1 kg) are mixed with the dug soils. The topsoil is returned to the bottom of the planting hole, and the subsoil is placed on the topsoil in the hole. The PF seedling is planted in the center of the planting hole on elevated ridge (15 cm). Some growers cover the planting rows with rice straw after watering.

Health Management of Pathogen-Free Trees in the Orchard

The PF citrus trees can grow luxuriantly and begin fruiting as early as two years after transplanting by following appropriate health management and cultural practices such as watering, fertilization, and pruning. Further information on the recommended horticultural practices

Health management of pathogen-free citrus seedlings in orchards needs to be properly performed using following strategies:

1. Prompt elimination of HLB-diseased citrus trees and alternative host plants to prevent reinfestation of healthy trees.
2. Protection of pathogen-free trees from vector transmission by effectively spraying insecticides such as Dimethod and Lannate at critical sprouting time, and biological control of the vector using natural enemies including Tamarixia radiata.
3. Guarding the orchards by physical barriers such as wind breaker or distance barrier;
4. Pre-immunization of healthy foundation stock by protective mild strains of CTV against severer strains;
5. Chemotherapy of HLB-infected citrus trees: Tetracycline (Achromycin) infusion has been tested by some citrus growers using the antibiotic transfusion method. Recently, the efficacy of the antibiotic therapy has been greatly improved by use of an air-pressured injector. Three applications (2 autumn, 1 spring) of 1,000 ppm Achromycin (2~4 L/tree) by air-pressured injector of 80 lbs have provided the best curing efficacy to diseased trees. No HLB symptoms have reappeared in the injected trees, which are producing normal fruits. Pruning upper die-back branches improves the therapeutic efficacy. The antibiotic transfusion is frequently associated with temporary phytotoxicity such as mild vein necrosis, slender leaves and defoliation, but the trees quickly recover to normal growth. The tree injection method works best for the HLB-affected large trees in which the diseased branches constitute not over half of the canopy and these are in the early stage of disease development.

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47. Cucumber Cultivation

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MPKV, Rahuri

- **Botanical name:** Cucumis sativus (2n=14) L. Family: Cucurbitaceae
- **Origin:** The cucumber native in India.
- **Botany and Floral Biology:** The cucumber, *C. sativus* L. is a diploid (2n=14) with a basic chromosome number, x=7 and monoecious in nature. Flowers are slotory and yellow in colour. Anthesis takes place at 5.30-7.00 a.m. Dehiscence occurs prior to flower opening and is at 4.30-5.00 a.m. Rise in temperature is harmful for pollination.
- **Varieties:** Improved cultivars of cucumber in India

Cultivar	Parentage	Source
Himangi	Poinsett x Kalyanpur Ageti	MPKV, Rahuri
Sel-75-1-10 Phule shubhangi	Selection	MPKV, Rahuri
Co-1	Selection from alocal type of Kanyakumari district	TNAU, Coimbatore
Punjab-1	Selection	PAU, Ludhiana
Balam khira	Selection	PAU, Ludhiana
Pusa Sanyog	Japanese gynoecious line x Green long Naples, F1 hybrid	IARI (Katrain)

Cultivar	Parentage	Source
Pusa Uday	Selection from local cultivar	IARI New Delhi
Swarna Ageti	Hybridization, slicing type	IIHR, Bagalore
Swarna Sheetal	Hybridization, slicing type	IIHR, Bagalore
Pant Khira 1	Selection	GBPUAT, Pantnagar

Soil: Cucumber prefers a well-drained Sandy loam for early crop with rich in organic matter and pH range from 5.5-6.8 are ideal.

Climate: Cucumber is short duration warm season crop optimum temperature requirement ranges between 18-23°C. It prefers dry climate with bright sunshine. Above 30°c, female flower production is reduced considerably. Under high humid conditions, incidence of diseases like powdery mildew, downy mildew, anthracnose and pest like fruit fly, serpentine leaf miner will be severe.

Season: The crop is sown during November – January. In Hills cucumber is sown during April-May. (Vegetable crops- K.V. Peter)

Seed rate: About 2.5 kg of seeds are required for a hectare.

Preparation of field: Land is Ploughed 4-6 times to a fine tilth and well rotten farmyard manure @20-25t/ha is incorporated in the soil at the time of final ploughing.

Sowing: Under large scale cultivation in levelled land, long furrows of 60 cm width are taken at 2.0-2.5m apart. Sow the seeds at an interval of 60 cm distance at the centre of the bed along the laterals. Sow the seeds in polybags @ one per bag for gap filling. Spray pre emergence weedicide like fluchloralin 1 kg *a.i.* or metalachlor 0.75 kg *a.i.*/ha on third day of sowing

Irrigation: Crop is irrigated at 4-6 days interval in summer and less irrigation required in rainy season. The crop should receive regular irrigation at fruiting stage.

Manuares and Fertilizer: Apply FYM 20-25 t/ha as applied at the time of land preparation and 100:50:50 NPK dose apply, half dose of nitrogen and full dose of P and K apply before sowing and remaining half dose of N apply from 30 to 45 days after sowing in equal two proportion.

Fertigation: Apply a dose of 150:75:75 kg NPK/ha throughout the cropping period through split application for F1 hybrid. In respect of phosphorous, 75% has to be applied as a basal dose.

Inter culture operation: Frequent weeding is required for a good crop growth, particularly during rainy season. Light hoeing or intercultivation is useful in initial stages of plant growth

Plant protection: Pest: Control of Thrips and aphids spray emmidachloroprid 70%wg 0.7 gm per 10 liters of water

Disease: Downy mildew and Powdery mildew can be controlled by spraying or Azocetrobin 1 ml/lit or Cymozonil + Mancozeb 2.5 g/lit twice at 10 days interval.

Harvest

The fruits are Harvest at immature stage, about 60-70 days after sowing. On an average 8 – 10 harvests can be done.

Yield

Average yield is 8 - 10 t/ha.

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48. High Density Planting in Fruit Crops

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High density planting is defined as planting at density in excess of that which offers to give maximum crop yield at the maturity if individual tree grows to its full natural size. In other words, it is the planting of more number of plants than optimum through manipulation of tree size.

HDP aims to achieve the twin requisites of productivity by maintaining a balance between vegetative and reproductive load without imparing the plant health. High density orchards were first planted in Europe at the end of 1960.

Principle of HDP

The underlying principle of HDP is to make the best use of vertical and horizontal space per unit time and to harness maximum possible return per unit of input and national resources.

Methods of HDP

By controlling the size of the tree

Use of genetically dwarf cultivars- The genetically dwarf cultivars offer a great scope for close planting.

Some examples of dwarf cultivars

- Mango-Amrapali
- Papaya-Pusa nanha
- Banana- Dwarf Cavendish
- Sapota-PKM-1 & PKM-8

Use of dwarfing rootstocks

- Apple-M-9, M-26, M27
- Guava-Chinese guava
- Kinnow mandrian – Karnakhatta
- Mango – Olour and Vellaicolumban

Pruning and Training

Pruning- It refers to the removal of any vegetative plant part to regulate the production and maintain the balance between vegetative and reproductive growth.

Training- It refers to the judicious removal of plant part to give the plant a particular shape to develop a strong frame work of scaffold branches.

Mango, guava and litchi, ber, fig is generally pruned. The removal of apical portion result in a compact and bushy tree through stimulation of lateral bud growth and suppression of apical dominance.

Use of Growth Retardants

These are synthetic compounds which reduce the growth of stem. The plants appear normal through their stems are normal.

Example

i) AMO-1618
ii) Cycocel
iii) Paclobutrazol (PBZ)
iv) Phospon –D
v) Ancymidal

Induction of Viral Infection

This method of HDP is not commercially adopted. In the method tree size can be reduced by inducing viral infection. Viral infection causes the stunted growth, but it affect the vigour and quality of crop.

Eg: Citrus, Apple.

Use of Incompatible Rootstock

Self-incompatibility: Failure of fertilization even though male and female parts of the bisexual flowers are fully functional.

The use of graft incompatible scion and stock also induces the dwarfness in the composite plant.

Eg – Ber- Zizyphus rotundifolia

By the use of Improved Planting System

Planting systems and optimum of plant density is aimed to achieve high assimilated production for its conversion into economic yield.

Various planting systems adopted for fruit crops:

1. Square
2. Rectangular
3. Hexagonal
4. Quincunx
5. Hedgerow
6. Paired planting
7. Cluster planting

Out of these square and rectangular systems are followed for HDP in mango, kinnow, Banana, papaya and hedgerow system in apple and pineapple in India.

Advantages of HDP

1. It induces precocity, increases yield and improve fruit quality.
2. It reduces labour cost resulting in low cost of production.
3. It also enables the mechanization of fruit crop production.
4. It also facilitates more efficient use of fertilization, water, solar radiation, fungicide, weedicides and pesticides
5. It also helps to obtain expert of the harvest produce

Disadvantages of HDP

1. Less life span of the fruit
2. Difficult to manage the tree **canopy**.
3. Requires high techniques for the maintenance of fruit trees
4. High incidence of some diseases eg. **Sigatoka** leaf spot and fingertip in banana
5. High initial establishment cost of high-density orchard.

Factors affecting HDP

1. Cultivar
2. Systems of planting
3. Planting material
4. Nutrition and moisture
5. Economics of production

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49. Integrated Pest Management Techniques in Vegetable Crops: An Effective Approaches

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India is the second largest producer of vegetable crops in the world after China. Expansion of area under vegetables, off-season cultivation, and availability of cultivars with high yields and quality inputs, and advances in production technology are behind this success. These have, however, led to more complexities in pest problem which may be summarized as follows. Infestation of some new pests has been experienced during this period whereas, some others, earlier known as minor ones, have attained the status of major pests on some specific crops. The amount of damage caused by the pest complex of vegetables is enormous (Table 1). Farmers mostly rely upon chemical pesticides to protect the crop from ravages of these pests. Over reliance on pesticides has resulted in many ill effects viz., increasing cost of cultivation, pesticide residues on harvested vegetables, pests' resistance to pesticides and destruction of beneficial organisms including natural pollinators.

TABLE 1: List of vegetable crop losses caused by some important pests.

Damage crop	Name of pests	Yield losses (%)	Reference
Cole crops	Plutella xylostella	16.87 to 98.83	Shivalingaswami *et al.* (2002)
Chillies	Scirtothrips dorsalis	11.80 to 90	Shivalingaswami *et al.* (2002)
	Polyphagotersonemus latus	34.14	Shivalingaswami *et al.* (2002)
Brinjal	Leucinodes orbonalis	48 to 66	Shivalingaswami *et al.* (2002)
Tomato	Helicoverpa armigera	22.39 to 37.79	Shivalingaswami *et al.* (2002)
Okra	*Earias* spp.	22.79 to 54.04	Shivalingaswami *et al.* (2002)
	Amrasca biguttulla biguttulla	54 to 66	Shivalingaswami *et al.* (2002)
	Bemisia tabaci	54.04	Shivalingaswami *et al.* (2002)
Bitter gourd	*Dacus cucurbitae* and *Ducus dorsalis*	60 to 80	Shivalingaswami *et al.* (2002)
French bean	Liriomyza trifolii	15 to 70	Krishnakumar (1998)
Cucumber	Liriomyza trifolii	41	Krishnakumar (1998)
Tomato	Liriomyza trifolii	35	Krishnakumar (1998)

To overcome these problems integrated pest management packages have been developed and advocated against some important pests. In spite of their efficacy, these measures have gained poor acceptance to the farmers. The main constraints in adopting IPM packages by the growers are lack of technical knowledge, non-availability of alternate tools, complexities in implementation, reduced production in respect of quantity and quality in IPM plots. The price of fresh vegetables largely depends on cosmetic standard of the produce and any damage to it badly affects the price. There is no system in our country to reward the IPM farmers through incentives. In addition, technologies developed through top-down research are also responsible for low adoption of IPM in vegetable crops owing to their poor applicability under field condition. Mechanical measure like collection and destruction of different stages of pests and / or their damaged parts is generally recommended to keep the emerging pest population at check. Among the cultural measures trap cropping or barrier cropping has been recommended against some pests. Growing two rows of Indian mustard at the beginning after each 16 rows of cabbage to trap diamond back moth is widely recommended (Shankar and Raju, 2012). This process is very troublesome as among these two rows one is sown 15 days before and the other 25 days after cabbage planting, which makes the farmers reluctant in adopting the method. Another example is growing of marigold with tomato to trap *Helicoverpa* and leafminers. This method may be effective in case of determinate cultivars requiring no or short staking. Mass trapping using pheromone traps are often recommended as alternative to chemical control and this coupled with mechanical destruction of affected plant parts has been proved to be effective against brinjal fruit and shoot borer (Cork *et al.*, 2003) and sweet potato weevil. The main problem with pheromone traps is small field size, non-availability of quality products, seasonal variation in efficacy and inability to trap the females. Moreover, for obtaining

desirable result majority of the growers in an area should employ pheromone traps simultaneously. Use of biocontrol agents *i.e.* predators and parasitoids are considered as important tool for pest management. The economic threshold values fixed for different vegetable pests are usually results of experiments of a particular location and season, and cannot as such be used in decision making for pesticide application across the country. These values are subjected to change with location, season, climate, variety, date of planting / sowing, presence of natural enemies and other competitive fauna, cropping pattern etc. Generating ETL values for each and individual pest for different regions is a monumental task and requires huge technical manpower and funding. Very precise knowledge is required to relate the observed pest and natural enemy population with ETL for need based pesticide application, which most of the farmer lack. Adoption of IPM is generally slow in both the developed and developing world.

In India IPM programmes are mostly confined to projects and project reports, research journals, conference discussions, and some theoretical training and demonstration programmes organized by universities and state departments. Actual data on farmers' adoption of IPM programmes is not available. A multipronged approach is needed to encourage vegetable growers to implement IPM programmes which should include dissemination of technology through intensive on farm training, publication of practical manuals on IPM, catering growers' needs in decision making, supply of inputs at reasonable price, creation of marketing facilities for their produce, provision of incentives for IPM farmers etc. But the most important aspect is development of appropriate technologies suitable for field application. Therefore, IPM research needs to be focused towards this direction and existing IPM technologies require revalidation.

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50. Nursery Management of Vegetable Crops Under Protected Condition

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INTRODUCTION: Raising healthy and quality seedling under good nursery management practices in protected condition is an essential operation for successful vegetable production. Today there are many challenges like globalization of market, shrinking of land and climate change should arise in front of us. So to overcome this situation protected cultivation emerged one of the important practice. Protected cultivation is a technique wherein the microclimate around the plant is controlled fully, partially or modified to protect the crop from adverse weather. Protected cultivation is used for raising seedling in vegetable crops like tomato, brinjal, chilli, capsicum, onion, cauliflower, cabbage, broccoli, French bean, spinach, and also many cucurbits like cucumber, muskmelon, watermelon etc.

Importance of Vegetable Nursery in Protected Structure

- Year-round seedling cultivation

- Better seedling quality
- Off-season production
- Better root and shoot growth
- Least pest and disease incidence
- Weed free cultivation
- Proper seed germination, uniform growth, least seedling mortality

Components of Nursery Management System

Seedling Tray

Seedling raising in tray depends on many factors like seed size, economics, plant growth rates, and customer demands. Cell number varies from 72 to 800 cells per standard tray.

Growing Media

Mainly soil less media like cocopeat, perlite, vermiculite, saw dust, rockwool, peanut hulls, rice hulls or the mixtures should be used for growing vegetable seedling in protected condition. Among them cocopeat, perlite and vermiculite are mostly used which should be mix in a ratio of 3:1:1 before filling in the tray.

Seed Treatment

It is a common practice for healthy seedling production. Seed must be treated with *Trichodermaviride*4 g or *Pseudomonas fluorescens* 10 g or Carbendazim 2 g per kg before 24 hours of the sowing and also treat the seed with Azospirillum @ 40 g / 400 g of seeds just before sowing of the seed.

Irrigation

Watering must be done regular but additional watering should be avoided. It is given mainly in day time through fine sprinkler otherwise in night time it invites disease and pest.

Fertilizer Application

Fertilizer which is 100 % soluble in water should be applied. It is given either through drenching or foliar spray. Drenching with 0.2 % solution of water-soluble fertilizer (19-19-19) at two true leaves stage or foliar spray of 19-19-19 @ 3g/L.

Disease and Pest Management

Damping off is the most important and serious disease in nursery. Copper Oxy Chloride (3g/L), Carbendazim (1g/L) or systematic insecticide like Imidacloprid 0.3ml/L should be applied for control of this disease. Maintain hygienic condition and proper ventilation inside the structure is also a prevention method.

Hardening

The main objective of hardening to allows seedling to adjust new condition starting about one week before transplanting. It is done through by increasing light intensity or exposing transplants under full sunlight, reducing irrigation or watering and fertilizer application.

Limitation

- Initial cost for establishment of protected structure is very high.
- Lack of trained personal and skilled labour for operating different activities in protected condition.
- Marketing of seedling is also a big constraint for the farmers.
- Disease and pest damage incidences.

Conclusion: Seedling raise in tray reduce seed cost, uniformity, better quality of the products produced and also gives maximum return to the farmers. Rate of plant development, root structure, plant height and vegetative matter can be better controlled in protected condition than conventional method.

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FORESTRY

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51. Cultivation of *Melia dubia* (Malabar Neem): A Money-Spinning Tree of Short Duration

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Melia dubia (Malabar Neem in Hindi and *Malai Vembu* in Tamil) is a valuable and suitable tree for farm forestry and agro forestry in terms of generation of high income per unit area in the tropical and subtropical regions of country. Agro-forestry is a sustainable land management system which increases the overall yield of the lands; combines the trees and shrubs with agricultural crops and or livestock on the same unit of land, either simultaneously or sequentially. One of the major problems being faced by these days is less income per unit area per year against sudden increase agricultural land value. Planting fast growing tree species like *Melia dubia* fetches a handsome price in the market due to assured buyback, and also requires low maintenance expenditure resulting higher monetary returns. In addition, the trees also aid the planet by preventing temperature rise and checking gas emission into the atmosphere. *Melia dubia* is considered as the fastest growing tree and the wood of this tree is used mainly in plywood, pulp wood and timber industry. Melia is considered as a money-spinning tree of short duration as the returns from this tree are maximum in minimum time in comparison to other tree species. As there is a huge gap between demand and supply for wood, so planting of 300 to 400 trees per acre under farm forestry and agro-forestry can ensure a minimum profit of rupees one lakh per year per acre.

Cultivation

It grows on a variety of soils; however, it grows well in deep, fertile and sandy loam soils. Due to its fast growth it grows to a height of 40 feet within two years from its planting. It can be planted successfully at elevations ranging from 600–1800m from plains to hills due to its wider adaptability. It performs best in moist regions, where annual rainfall exceeds 1000 mm. However, it can also be successfully grown with artificial irrigation in dry region also. The seedlings are planted in the field during the rainy season. The pit size recommended for planting seedlings is 45 x 45 x 45 cm. Spacing of 3m x 3m, 5m x 5m and 8m x 8m is recommended depending on objective of plantation. Spacing of 3m x 3m gives better girth in shorter duration. Straight pole fetches good price in the market.

Seed Processing and Pre-Treatments

Seeds of *Melia dubia* mature during the month of January-February. The rate of germination of seeds is very poor. For increasing germination rate the drupes should be soaked in water for one to two weeks to decompose pulp. After removing pulp stones are dried in sunlight for two to three days prior to sowing.

Nursery

March-April is best time for sowing seeds in nursery. Cleaned and dried seeds can be sown in the open raised nursery beds, in drilled lines, 5 cm apart. Seeds should be sown in soil and farm yard manure medium in the ratio of 2:1 or 1:1 ratio. The shown seeds should be watered regularly, twice a day. At places where daytime temperature is not very high, or where nursery beds are in shade, the bed should be covered with a tarpaulin sheet to retain temperature in the medium as seeds germination fast at high temperature. Germination of seeds completes within 90 days.

Plantation Management

For fast growth of trees in plantations application of fertilizers is done depending upon type of soil along with regular irrigation. Initial growth is enhanced with daily irrigation and application of fertilizers once in three months for the first three years. The tree branches at 8-10 m from ground. Pruning side branches in every six months is recommended to get straight and round bole, without any knots and buttress.

Agroforestry Practice

Besides pure plantations *Melia dubia* can be grown under different agro-forestry systems at different spacings. Melia can support a variety of agricultural crops under agro-forestry. Ground nut, chilli, turmeric, blackgram, papaya, banana, melon, sugarcane, as inter crops with *Melia dubia* are being successfully cultivated. The species performs exceedingly well when planted on bunds of the agricultural fields and attains the harvestable size within shortest period.

Yield

Each tree is expected to yield 5-7 cu.ft. of timber at a

spacing of 3m x 3m and the farmers may get 15 lakh from one hectare of land after six years with current price of wood (Rs.300per cu.ft.). Nowadays, for quick return, famers usually cut the trees at the age of 3 for selling the wood to paper industries and wood around 75 tons/ha of land can be harvested. The paper industry procures the wood at around Rs. 4500 per ton.

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52. *Butea monosperma:* Flame of the Forest

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INTRODUCTION: *Butea monosperma* is commonly known as Palash belongs to the family Fabaceace. It is also known as 'Flame of forest'. The genus Butea named after the Earl of Bute, a patron of Botany and monosperma, meaning 'having one seed'. It is said that the tree is a form of Agnidev, 'The god of fire'. The Palash is sacred to the moon also and it is said to have sprung from the feather of falcon of an impregnated with the soma, the beverage of gods, and thus immortalized. It is used in Hindu ceremonies for the blessing of calves to ensure their becoming good milker. It is considered as multipurpose tree (MPT) as this tree provides shade, habitat for organism, soil improvement, income source for local habitat, firewood and variety of metabolic chemicals, which may be used in the form of home remedies and traditional medicine. Palash tree serves livelihood support to millions of poor farmers in states like Jharkhand, Chhattisgarh, Orissa, Madhya Pradesh and West Bengal.

Flame of the Forest

During the spring season, the Butea blooms at its peak and its look like a riot of orange and vermilion flowers covering the entire crown. These flowers, which are scentless, are massed along the ends of the stalks dark velvety green like the cup-shaped calices and the brilliance of the stiff, bright flowers is shown off to perfection by this deep, contrasting colour. Due to its natural orange-red look, it has got its name as "Flame of the Forest"

Description

Tree: *Butea monosperma* is a medium sized deciduous tree. It grows upto15 m tall, up to 43 cm dbh; trunk usually crooked and tortuous, with rough greyish-brown, fibrous bark showing a reddish exudate; branchlets densely pubescent.

Leaves: Leaves trifoliate; petiole 7.5-20 cm long with small stipules; leaflets more or less leathery, obtuse, rounded or emarginate at apex, rounded to cuneate at base, with 7-8 pairs of lateral veins, stipellate.

Flowers: Flowers in racemes, 5-40 cm long, near the top on usually leafless branchlets; calyx with campanulate tube and 4 short lobes; corolla 5-7 cm long, standard, wings and keel recurved, all about the same length, bright orange-red, more rarely yellow, very densely pubescent.

Fruits: Fruit an indehiscent pod, 4-6 cm, stalked, covered with short brown hairs, pale yellowish-brown or grey when ripe, in the lower part flat, with a single seed near the apex. Seed ellipsoid, flattened, about 3 cm long.

Phenology

- Deciduous tree - Leaves are shed during the dry season.
- Flowering - At the beginning of the rainy season, the leafless tree flowers abundantly and is very conspicuous in the forest.
- Leaf development - At the end of the flowering period, new leaves develop, which are initially a pale bronze-tinged green.
- Pollination - Birds and insects are the chief pollinators.

Locality Factor

Ecology	Tropical and subtropical climate It grows in the drier parts of India, often gregarious in forests, open grasslands and wastelands. The tree is very drought resistant and frost hardy
Altitude	0 - 1500 m
Mean Annual Rainfall	450 - 4500 mm
Mean Annual Temperature	4-49°C
Soil Types	It grows on a wide range of soils including shallow, neutral (pH 6.0 - 7.0) soils, gravelly sites, black cotton soil, clay loams, and even saline or waterlogged soils.

Distribution

Exotic range	Cambodia, India, Indonesia, Japan, Laos, Myanmar, Nepal, Sri Lanka, Thailand, Vietnam
Native range	China, Papua New Guinea

Seed Technology and Plantation Facts

Method of seed collection	Crown or Ground collection
Seed collection period	May
Number of seeds /kg	1400 - 1500
Pre-sowing treatment	Dried in sun, thrashed and winnowed to separate seed
Germination %	70-80%
Seed longevity	Moderately long lived
Season of sowing	May-June
Germination period	10-15 days
Season of planting	June- July
Spacing (Plantation)	3 X 3 m to 10 X 10 m

Tree Management

Butea monosperma is moderate in its demand for light. The trees pollard and coppice well and produce root suckers freely. They can also withstand heavy annual lopping. Well suited for silvopasture at wide spacing (10-15 m) in extensive tracts of grassland. Coppice shoots are also cropped in intermediate years for the larger leaves. Under dryland conditions and in its natural habitat, coppice management yields roughly 100 kg/tree of air-dry fuelwood every 5 years. If allowed to grow, trees attain a height of 3- 5 m and dbh of 15-20 cm in 10 years. Plantations can be established on irrigated as well as rainfed land.

Utilization

Fodder: The young leaves are good fodder for cattle due to the leaves are rich in nutrients, high digestibility values.

Fuel: Wood makes a fuel of moderate quality. The wood is burnt for gunpowder charcoal.

Fibre: A coarse fibrous material obtained from the inner bark is used for cordage, caulking the seams of boats and making paper.

Timber: The soft and not durable wood is light, about 570 kg/m^3 air dry, white or yellowish-brown when fresh.

Gum or resin: A red exudate is obtained from the bark, hardening into a gum known as 'butea gum' or 'Bengal kino'. It can be used as a dye and as tannin.

Dyestuff: A bright yellow to deep orange-red dye, known as butein, prepared from the flowers is used especially for dyeing silk and sometimes for cotton. This dye is used by Hindus to mark the forehead.

Lipids: The seeds yield a clear oil.

Poison: Seeds show bactericidal and fungicidal activities.

Medicine: The flowers are useful in the treatment of liver disorders and seeds act as an anthelmintic. An astringent gum oozing from the cut stem has medicinal properties as a powerful astringent and is applied in cases of diarrhoea.

Lac culture: The tree is an important host for the lac insect (*Laccifer lacca*), which produces shellac in India. Of all the lac trees, it yields the most lac stick per hectare.

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53. Cryopreservation for the Long-Term Conservation of RET Medicinal Plants

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INTRODUCTION: Medicinal plants form an important component of Indian system of medicine, may it be Ayurveda, homeopathy or allopathy. India being one of the most bio-diverse sub-continent is home to majority of medicinal plant species. With mankind becoming more health conscious in the recent times, there has been a massive increase in global herb trade which has indirectly threatened the survival of many species. Habitat destruction owing to developmental activities has further worsened the scenario. This alarming situation has necessitated the need to conserve the RET (Rare, Endangered and Threatened) medicinal plants to make them available for the future. Thus, there is a need to device conservation strategies for long term conservation of these species under controlled and safe conditions without losing their genetic integrity. Cryopreservation has emerged as one of the most reliable *ex situ* conservation measure which can facilitate the long-term conservation of prioritized wild RET species.

Cryopreservation

Cryopreservation is the technique used for long term conservation of plant genetic material which involves the storage of living cells, tissues or organs at ultra-low temperature of liquid nitrogen at −196 °C. At this temperature, all the metabolic activities of the cell get arrested and the cells will not undergo any genetic changes. This allows the storage of germplasm under suspended growth for very long period of time. Different types of tissues are amenable to cryopreservation viz., seeds, pollen, zygotic/somatic embryos, embryonic axes, embryogenic cell suspension, meristems or shoot tip cultures and winter buds. Advantages of this technique is that the cryopreserved cells are stored in a small volume, require very limited maintenance and samples are not continuously exposed to the risks of contamination and operator errors, due to frequent manipulations of the plant material. The principle behind cryopreservation is to bring the cells or tissues to a zero-metabolism stage by subjecting them to ultra-low temperature in the presence of cryoprotectants. The initial and most important step of cryopreservation is dehydration of the explant to reduce the water content to prevent freezing injury. Cryopreservation can be achieved either by classical freezing method or by vitrification-based methods. Classical techniques have been successfully applied to undifferentiated culture systems such as cell suspensions, calluses and apices of cold-tolerant species whereas vitrification-based procedures are used mainly for organized tissues like shoot tips and embryos.

Cryopreservation in RET Medicinal Plants

Cryopreservation is one of the most reliable methods to conserve rare, endangered, threatened plant species. Low temperature storage has been reported to be effective for cell cultures of medicinal and alkaloid producing plants such as *Rauvollfia serpentina*, *Digitalis lanata*, *Atropa belladonna*, *Hyoscyamus spp* (Bajaj *et al.* 1988). Two cryopreservation techniques (encapsulation-dehydration and encapsulation- vitrification) were applied for in *vitro* conservation of *Ziziphora tenuior* L, a rare species with a promising medicinal potential that grows wild in the southern part of Jordan. Sharma and Sharma, (2003) demonstrated the successful cryopreservation of shoot tips of *Picrorhiza kurroa,* an endangered medicinal plant, using the vitrification technique. The protocol involved the preculture of shoot tips at 4°C for 2 days on hormone free MS medium containing 5% DMSO followed by immersing in PVS_2 solution for 15 min at 0°C. After vitrification, the shoot tips are directly immersed in liquid nitrogen. The protocol enabled to conserve this threatened species for a long period of time. Using encapsulation-dehydration technique, shoot tips of the rare and endangered species *Cosmos atrosanguineus* was successfully cryopreserved with 100% survival and 35% shoot regeneration (Wilkinson *et al.* 2003). *In vitro* shoot tips of *Dioscorea deltoidea* Wall., an endangered medicinal plant, were successfully cryopreserved by Mandal and Dixit, 2007 using the vitrification and the encapsulation-dehydration techniques with subsequent high frequency plant regeneration. Study showed that the cryopreserved shoot tips maintained their viability up to one year of storage in LN.

Suk *et al.* 2009 studied cryopreservation of adventitious roots of *Panax ginseng*, the source of commercially produced ginsenosides using desiccation and vitrification technique. When only desiccation was applied, the survival was <14%, in contrast, vitrification showed 90% survival and 32.5%

root formation efficiency after cryopreservation. These cryopreserved root tips were used to re-establish adventitious root cultures in flasks and bioreactors. Production of triol and diol ginsenosides in the bioreactor cultures was also enhanced after cryopreservation, by 41.0% and 89.8%, respectively. These results suggested that the vitrification method is successful for cryopreservation of *Panax ginseng* adventitious roots.

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FOOD PROCESSING AND PRESERVATION

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54. Need for Development of Food Processing Technologies in India

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INTRODUCTION: India ranks second in production of fruits and vegetables after China in the world. Even though the production is high, large section of the population is deprived of the required amount of food for a healthy living so many parts of the population is malnourished due to unavailability of food or due to low purchasing power of the population. This condition can be prevented if all the foods produced in the country are available to the people but there is a problem of huge post-harvest loss of 20-40% of total production. If this loss could be mitigated then the current problem of food can be prevented. In order to prevent this postharvest loss, we have to give care during harvesting, handling, storage or it can be converted into other processed products in order to prevent deterioration of food until it reaches the consumer.

Status of Food Processing in India

Processed food industry in India made a contribution of 6.3% of the GDP, and 13% of export and 6% of the capital investment. India produces 600 million tonnes of farm produce annually. Due to lack of proper infrastructure for processing and postharvest management, about 25-40% of fresh fruits and vegetables goes waste and the cumulative annual loss is as high as Rs.3000-4000 crores in India. Since fruits and vegetables are perishable but a major source of vitamins and minerals, they need to be preserved and processed into various value-added products. It includes a set of chemical, physical and microbiological techniques and technology to convert fruits and vegetables into other form of food. Processing provides customers a wide variety of food available and consequently they have a more varied and balanced diet. Besides this, another advantage is that they are safer from a microbiological point of view than fresh or unprocessed foods. If the surface of fruits and vegetables are moist or the outer surface has been damaged, growth of microorganisms may take place between harvesting and processing or consumption of the harvested produce. Therefore, adequate control of temperature and humidity will reduce such growth and extend the period of availability of the harvested produce. In India, the importance of food processing was realised during the World War II and the food processing industries in India have been gradually developing and processed foods have become popular but the quantity of processed food products are insignificant compared to their high potential since less than 1.5% of total fruits and vegetables are processed as against 70% in Brazil, 60-70% in USA, 83% in Malaysia, 30% in Thailand and 70% in Philippines. India has a good scope for processing horticultural crops since a good income can be earned through export since there is a good demand of processed products from India like powdered ginger, mango pulp, mango pickle, dried cashewnut etc. Practically any fruit and vegetable can be processed, but some important factors which determine whether it is worthwhile are:

1. The demand for a particular fruit or vegetable in the processed form
2. The quality of the raw material *i.e.* whether it can withstand processing
3. Regular supplies of the raw material

For example, a particular fruit may be very tasty eaten fresh but when it goes to the processing centre it may fail to stand up to the processing requirements due to variations in its quality, size, maturity, variety etc.

Methods of Food Processing

There are numerous methods of food processing. It may be done by reducing moisture content of the food (drying and dehydration), by concentration of the food, by use of low temperature and high temperature, by using sugar, salt, vinegar, or other food additives, by fermentation method or by using irradiation methods.

Applicability of Feasible Processing Methods in India

Even though there are varied methods for processing of food for prevention of food deterioration, it is essential to consider the feasibility of the processing methods and the growers. If the processing method is complex or costly, many cannot implement the method. Since most of the Indian farmers are poor, the processing methods for their produce should be standardized and demonstrated. In this way, post-harvest loss can reduce in some ways as well as increase income of the farmers. In India, preservation of food by solar drying is most common and cheapest way of food preservation. So, more techniques should be standardized regarding solar drying to enhance the quality. In the same way, more preservation methods using sugar, salt and other cheap chemicals should be emphasized so as to encourage the poor producers to take up entrepreneurship home scale or large scale. Considering preservation method by irradiation and freezing in the context of the Indian will not prove feasible even though it ensures high quality and more storage life but such methods are not affordable. So, preference for research on preservation methods should be given priority on the methods which are easy as well as cost effective.

Problems in Food Processing

Food processing industry in India has been recognised as a sunrise industry. The important sectors for food processing industries include fruits, vegetables, milk and milk products, meats, poultry, fisheries as well as packaged foods. Since the processing level in India is too small compared with other developed countries, there is enormous scope and opportunity. It also provides opportunity for growers and stake holders in agricultural sectors through processing for value addition and export. Inspite of the good scope on processing, there are problems of inadequate supply of raw materials, inadequate infrastructure, inadequate investment in organized sector, inadequate trained human resource, lack of quality testing and certification laboratories, short marketing channels, high cost of working capital and taxation etc which hinder the development of processing industries in India.

Conclusion: Research should be done on easy and cost-effective processing methods of varied food so as to encourage the poor Indians to take up the processing work in order to reduce the post-harvest loss of agricultural and horticultural crops to contribute to the GDP and development of the country. Effective demonstration should be initiated to growers and effective training should be given to them to make them self-reliable, self-sustainable and self-employed. For this result, scientists and officials of district KVK should work in coordination for the encouragement of the rural producers to implement processing at various level to bring development of the country.

a.Mango pulp


b. Raisin(dried grape)


c. Fruit candy

18578

55. Nisin as a Bio Preservative in Food Industry

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In recent era, consumers are consistently concerned about their food habits and do not prefer the use of synthetic chemicals in the form of preservative as they impose many health problems. Use of biopreservatives such as bacteriocins can act as an immerging greener technique that might solve this issue in the near future. Bacteriocins are secondary metabolites, principally proteins produced by certain strains of bacteria that are able to inhibit the growth of similar or closely related bacterial strains. Bacteriocins possess antibiotic properties, but are normally not termed antibiotics. They differ from most antibiotics in being proteinaceous, ribosomally synthesized and generally possessing a narrow specificity of action against strains of the same or closely related species.

Several bacteria have ability to produce bacteriocins as shown in the Table. Nisin ($C_{143}H_{230}N_{42}O_{37}S_7$), produced by certain strains of *Lactococcus lactis* subsp. *lactis* is the best studied bacteriocin that obtained GRAS status in 1966 by FDA. It has been used as a food preservative for over five decades. It was discovered in 1928 by Rogers and Whittier. Nisin can act as an effective antimicrobial agent and is able to control the growth of several microorganisms (Schillinger *et al*., 1996). It possesses anti-microbial property due to its small peptide chain, consisting of 34 amino acid residues, with a molar mass of 3500 Da.

S. No.	Bacteria	Bacteriocin produced
1.	*Lactococcus lactis*	Nisin
2.	*Bacillus subtilis*	Subtilin
3.	*Staphylococcus epidermidis*	Epidermin
4.	*Staphylococcus gallinarum*	Gallidermin
5.	*Pediococcus acidilactici*	Pediocin
6.	*Micrococcus varians*	Variacin
7.	*Escherichia coli*	Colicin

It belongs to the lantibiotic family as it contains uncommon amino acids lanthionine (Lan), methyllanthionine (MeLan), didehydroaminobutyric acid (Dhb) and didehydroalanine (Dha).

Mode of Action

Nisin is more effective against Gram-positive bacteria including strains of *Staphylococcus, Lactococcus, Micrococcus, Streptococcus, Pediococcus, Listeria, Lactobacillus* and *Mycobacterium*. Particularly spores of *Clostridium* and *Bacillus* spp. are susceptible to nisin (Morris *et al*, 1984). It is interesting to note that generally nisin is not active against Gram-negative bacteria, virus and fungi. Mode of action of nisin against microbial spores and vegetative cells is owing to its ability to degrade cell membrane. Nisin forms pores in the cell membrane that disrupts the pH equilibrium causing leakage of ions resulting in cell death. It also interferes with cell wall biosynthesis, due to its tendency to bind with lipid II, a peptidoglycan precursor, that inhibits the cell wall biosynthesis (Breukink and Kruijff, 2006).

Application of Nisin in Food Industry

Bacteriocins can be applied in several ways. They can be added in purified or semi-purified form as food preservatives. Various foods can be inoculated with LAB that produce bacteriocin in the products leading to its preservative effect. Further, a previously fermented product with a bacteriocin producing strain can be used as an ingredient in food processing. Addition of 400 IU/ml nisin in *lassi* can enhance its shelf life and organoleptic property. Nevertheless, the microbial level and nutritional quality also has been found to increase in the presence of nisin. Nisin when added to Serro cheese has shown effective antimicrobial property against *S. aureus* (Pinto *et al*., 2011).

Advantages of Nisin

Nisin is an antimicrobial polypeptide that can inhibit a broad range of microorganisms. It can be used as an effective preservative in beverage, meat, milk industry. Owing to its GRAS status it is considered as a safe additive in foods. In the U.S., nisin is used to inhibit outgrowth of *Clostridium botulinum* spores in pasteurized process cheese and meats at levels not exceeding good manufacturing practice. Nisin is also approved for liquid egg products, dressings, sauces, canned foods and frozen desserts.

Detrimental Effect of Nisin

The increase of nisin tolerance can be achieved by expression of nisin resistance protein (NSR) in host strains (Liu *et al*. 2005). Nisin alone, is not effective on gram-negative bacteria like *E. coli*, yeasts, and molds. Although, nisin has got the GRAS status, it is worth to note that it is not currently approved as an allowable ingredient in organic food production. According to the latest Organic Materials Review Institute list, the National Organic Standards Board considers it a prohibited processing ingredient and any organic food containing added nisin will lose its organic

status (OMRI, 2013).

Conclusion: Nisin has proved to be an efficient antimicrobial agent against many microorganisms. It is the best studied and only commercially available bacteriocin, which got the GRAS status (Generally recommended as safe). It belongs to the lantibiotic family and has a broad range of inhibitory action. It has several uses in the meat, fish and dairy industry. Mostly, it is used in the dairy products such as ghee, lassi, yogurt, curd etc. as a permitted preservative. Interestingly, at proper dose it does not affect the starter culture, further, it inhibits the harmful microorganisms and enhances the quality of the product both organoleptically as well as nutritionally.

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PLANT BREEDING AND GENETICS

18074

56. Approaches to Mitigate the Adverse Effects of Climate Change on Vegetable Crops

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INTRODUCTION: Climate can be defined as statistics of weather of an area averaged over long periods of time. The change in different climatic parameters like temperature, precipitation, relative humidity and atmospheric gases composition leads to climate change. Climate change is one of the most challenging problems in current global scenario. Human activities are directly or indirectly responsible for climate change as they are altering the global atmospheric composition. Vegetable cultivation is also heavily affected by climate change and it is presently one of the most challenging problems for vegetable cultivation. The erratic rainfall patterns and unpredictable high temperature due to climate change leads to reduction in crop productivity. There are several strategies to mitigate the harmful impact of climate change on vegetable crops like change in sowing date, fertigation, use of grafting techniques, plant growth regulators & protected cultivation and plant breeding approaches. Other crop management practices like mulching, use of shelters and raised beds are also effective as they conserve soil moisture.

Evidences of Climate Change

There are several drastic events that are happening in the environment due to global climate change like:

- Rise in Sea level
- Increase in global temperature
- Warming of oceans
- Shrinking of glaciers
- Declining Arctic sea ice
- Ocean acidification
- Decreased snow cover
- Scientific Consensus

Impact and Management of Climatic Factors

The major climatic factors include:

- Temperature
- Light
- Humidity & rainfall
- Wind direction & wind velocity
- Greenhouse gases

These are discussed below one by one

Temperature: All crop plants requires an optimum temperature for their growth if there is any change in the temperature below or above this optimum range it adversely affects the germination, flowering, pollination, fruit setting as well as disease and insect pests incidence. Photosynthesis, respiration and transpiration are the important plant functions which affect the growth and development and determine the yield and quality of vegetable crops. Among all the vegetables, *Solanaceous* crops are adversely affected by high temperature like for example a rise in temperature above 21°C causes sharp reduction in tuber production and above 30°C results into complete inhibition of tuber formation. Similarly, in case of tomato for proper fruit setting proper night temperature is must. For fruit setting in tomato optimum night temperature must be 16-18°C. Temperature also influences the red color development in tomato and 21-24°C is the ideal temperature range but its production drops rapidly above 27°C. High temperature above 40°C reduces bulb size and 3.5°C above 38°C reduces yield in onion. In tomato Pusa Sadabahar, Pusa Sheetal and Pusa Hybrid-1 found tolerant to high and low temperatures. At high temperature Pusa Vrishti (Carrot) and Pusa Chetki (radish) can develop roots whereas Pusa Meghna (Early cauliflower) can form curd.

Light: It is a crucial factor which affects growth and development of crops. Light intensity & duration period requirement varies with different vegetable crops for example Potato, peas and beans, cucurbits and corn require high light intensity whereas onion, cabbage, cauliflower, carrot and spinach require low light levels. Similarly, some vegetables are short day like onion, potato, sweet potato, cowpea and some are long day radish, carrot, turnip, beet, lettuce, spinach and some are day neutral like tomato, brinjal, chilli, capsicum, watermelon, muskmelon, cucumber. Photoinsensitive varieties of Dolichos bean are Arka Jay, Arka Vijay, Arka Sambram, Arka Amogh, Arka Soumya and of cowpea are Arka Garima, Arka Suman and Arka Samruddhi.

Humidity & Rainfall: Humidity refers to the moisture in the atmosphere which is affected by rainfall and temperature. Transpiration refers to the water loss in the form of vapors from the aerial parts of plant and it depends upon humidity. High humidity with warm temperature favor disease incidence while low humidity and high wind velocity result into higher transpiration loss of water. Excess rainfall causes flooding while declining rainfall or reduced availability of irrigation water leads to draught stress which reduces quantity as well as quality of vegetables. In tomato Arka Vikas, in onion Arka Kalyan and in chilli Arka Lohit are examples of some draught tolerant varieties.

Wind Direction and Wind Velocity: Wind is an important climatic factor which determines transpiration loss of water in plants. It affects atmospheric humidity so the plant growth. Wind direction is an important parameter which is taken into consideration when laying out field for vegetable cultivation *i.e.* for orientation of planting rows. High wind causes lodging of plants while cold wind causes frosty condition and dry wind results water stress conditions. To solve high wind velocity problem a few rows of tall crops are planted in between of low growing vegetable crops (interplanting) to prevent plants from heat stress. Vegetables are very responsive to wind protection. To prevent vegetables from strong wind tall plants which act as windbreaks are often planted around the cultivated field across the wind direction. Windbreaks not only reduce wind speed but also provide positive returns like improved water management, increased yield and quality, earlier crop maturity and marketing. In protection of windbreak muskmelon gives early and heavy fruiting, cabbage tenderness and yield improves, broccoli leaf area increases, potato sprouts and matures early and tomato shows reduced sandblast injury, less flower abortion and greater fruit set with increased yield & quality.

Greenhouse Gases: Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluorinated gases, water vapors are included under the greenhouse gases. Almost 100% of the observed temperature increase over the last 50 years has been due to the increase in the atmosphere of greenhouse gas concentrations. Carbon dioxide is the principal driver of climate change. C3 plants are benefitted with elevated atmospheric CO_2 concentration. Tomato plants grown at 550 ppm CO_2 produce 24% more fruits. Onion bulb yield as well as sweet potato tuber yield also increased under influence of elevated CO_2 levels. But there are many adverse effect of elevated atmospheric CO_2 concentration due to associated global warming. In Capsicum high temperature at flowering time results in abscission of buds, flowers and small fruits. Temperature above 30°C causes flower and fruit drop and so decreases fruit set and fruit yield in tomato.

Conclusion: There is an adverse effect of climate change on vegetable productivity & quality. Climate change causes decrease in crop yield but it can be reduced if one adapts advanced management practices like drip irrigation, protected cultivation, mulching, grafting & breeding approaches of developing climate resilient cultivars to mitigate the negative impacts of climate change.

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57. Speed Breeding: An Avenue to Another Green Revolution

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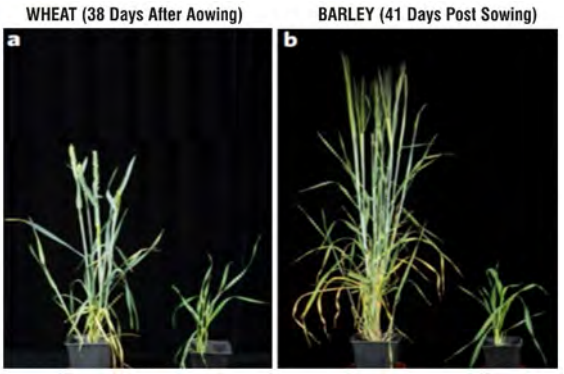
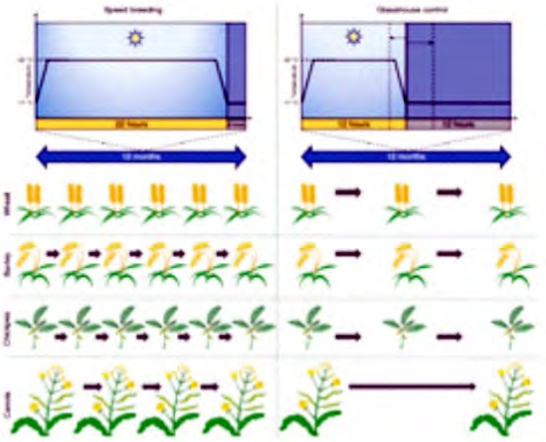
Speed breeding technology reduces the breeding cycle and quickens crop research through speedy generation advancement. It involves lengthening the duration of plants daily exposure to light with short dark period, combined with early seed harvest, in so doing it lessens the generation times for certain long-day and day-neutral crops. This revolutionary technology sows seed of a new green revolution. It was first started by Dr. Ian Delay and Dr. Mark Dieters at the Jones Innes Centre, University of Queensland, Australia. The concept of speed breeding was inspired by efforts of NASA trying to grow crops in space. The original protocol of speed breeding was first described and implemented for spring wheat and peanut.

Speed breeding enhances plant development for research purposes, including phenotyping of mature plant traits, mutant analysis and transformation studies. Using of extra lighting (LEDs) in a glasshouse environment allows rapid generation cycling through single seed descent (SSD) and plant population can be scaled-up for large crop improvement programs. Under normal glasshouse condition where there is natural variation of light a plant breeder can achieve 2-3 generations of a crop. Whereas, speed breeding can produce six generation per annum for spring wheat (*Triticum aestivum*), durum wheat (*Triticum durum*), barley (*Hordeum vulgare*), chickpea (*Cicer arietinum*) and pea (*Pisum sativum*), and four generations for canola (*Brassica napus*).



b) Speeded plant development under speed breeding condition (left) compared to control conditions (right). (Amy, W. *et al.* 2018)

Plants grown under speed breeding advanced to flowering in almost half the time of those grown in natural glasshouse condition. It has been reported that plant achieved anthesis in 35-39 days (wheat) and barley (37-38 days) while *Brachypodium distachyon* took 26 days to reach heading. In natural glasshouse conditions the plants were at their early elongation stage or three-leaf growth stage. It has been proved that seeds produced through this technology are viable. Crosses between wheat under speed breeding produce viable seeds, including crosses between tetraploid and hexaploid wheat.



a) Speed breeding quickens generation time of major crop plants. (Amy, W. et al. 2018)

Cases of Successful Analysis of Adult Phenotypic Data of Wheat and Barley under Speed Breeding

- A successful case study in wheat was conducted for trait associated with ethymethane sulfonate induced mutation of the awn suppressor B1 locus and Green revolution reduced height (Rht) genes.
- Consistent results were found during artificial inoculation of disease with Fusarium graminearum which causes Fusarium head blight (FHB) in suscepticle and resistant wheat varieties.
- Effect of loss of function of flowering locus T-B1 (wheat) in the F5 recombinant line of Paragon x W 352 was evaluated. The expected late flowering in the inbred was observed.
- Wheat carrying pairing homoelogous 1(Ph1) locus and wheat-rye hybrid lacking Ph1 were grown under speed breeding. No difference was observed in evaluating chromosome pairing and recombination in meiocytes at metaphase I.
- The potential for speed breeding in conjunction

with genetic transformation was investigated in barley. Immature seeds were harvested and transformed. Comparable transformation efficiency was found between the speed grown and normal plants.

Crops which have shown to respond well to extended photoperiod viz. sunflower, pepper, radish etc. are likely to reduce generation time. Direct applications of speed breeding protocols in short-day species such as maize or rice are not likely to be successful. Through SSD speed breeding can be used to breed a fixed population which facilitates genetic gain and also improved the cultivars. It can also be used to introgress genes or haplotypes into elite lines using MAS (Hickey *et. al.*, 2017). A combination of the recent advances in genomic tools and resources with speed breeding will provide a strong incentive for plant breeders and plant biotechnologists to perform on the crop plants directly. Speed breeding as a platform can be pooled with lots of other technologies such as CRISPR gene editing to acquire to the end result faster.

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18459

58. Development of Heterotic Pools in Germplasm / Genetic Stocks and Inbreds, their Improvement for Increasing Heterosis

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What are Heterotic Pools?

- Melchinger and Gumber (1998) defined a heterotic group "as a group of related or unrelated genotypes from the same or different populations, which display similar combining ability and heterotic response when crossed with genotypes from other genetically distinct germplasm groups."

Why Heterotic Pools?

- To get higher mean heterosis and hybrid performance.
- To reduce the specific combining ability (SCA) variance and a lower ratio of SCA to general combining ability (GCA) variance. Thus, early testing becomes more effective and superior hybrids can be identified and selected mainly based on their prediction from GCA effects.
- Assigning lines to heterotic groups would avoid the development and evaluation of crosses that should be discarded, allowing maximum heterosis to be exploited by crossing inbred lines belonging to different heterotic groups.

Methods to develop Heterotic Groups

Pedigree Analysis

i) The heterotic pattern increases the efficiency of hybrid development, inbred recycling and population improvement.

Ex.

ii) The Reid and Lancaster groups were identified based upon pedigree and geography analysis of inbred lines used in the Corn Belt.

iii) Wu (1983) attempted to classify inbred lines into 4 or 5 groups based on pedigree analysis and to predict heterotic patterns used in China.

Quantitative Genetic Analysis

- Diallels or factorial designs have been used when the number of populations or groups was small in tropical (Vasal et al., 1999) and temperate corn.
- In the case of large number of accessions, it is not feasible to make diallel. Multistage stage procedure to identify heterotic groups suggested by Melchinger and Gumber, 1998.
- Basis of grouping the germplasms into different heterotic groups was specific combining ability (SCA) effects for grain yield.
- Cluster analysis based on SCA can be used to classify inbred lines into heterotic groups.
- Ex- Fourteen maize inbred lines, used in maize breeding programs in Iran, were crossed in a diallel mating design for investigation of combining ability of genotypes for grain yield and to determine heterotic patterns among germplasm sources, using both, the Griffing's method and the biplot approach for diallel analysis (Bidhendi et al., 2012).

Geographical Isolation Inference

- The geographical origin of the two populations contributed to the high grain yield of the cross.
- Ex- In the earlier stage of hybrid rice development in China two heterotic groups that is early season indica from southern China and mid or late-season indica from Southeast Asia were identified for three-line hybrid rice based on wild abortive (WA) male sterile cytoplasm (Yuan 1977).

Use of Molecular Markers

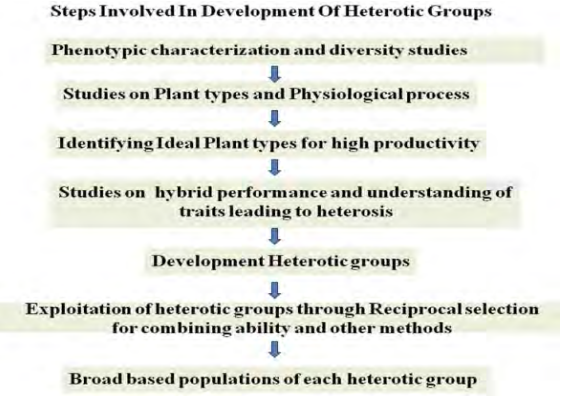
- Genotyping and cluster analysis of extracted genotypic DNA from the mutants and respective parents from their young leaves (1 to 2 weeks after seed germination), using the Cetyltrimethyl ammonium bromide (CTAB) method (Hoisington et al., 1994).
- These genotypes were further genotyped using twenty-one Simple Sequence Repeats (SSR) markers on GenBank data base (Yu et al., 2000).
- Molecular marker data provide a more reliable differentiation of genotypes, since these data are less affected by environmental effects.
- Additionally, researchers agreed that field experiments are still needed to validate groupings of germplasm based on molecular marker data (Melchinger and Gumber, 1998; Barata and Carena, 2006).
- SSR markers are a valuable complementation to field trials for identifying heterotic groups and can be used to introgress exotic germplasm systematically.

Criteria for the Identification of New Heterotic Groups and Patterns

Several criteria have been suggested to choose promising heterotic groups:

- High mean performance and large genetic variance in the hybrid population in the target region(s)
- High per se performance and good adaptation of the parent populations and
- Higher ratio of the variance due to general (σ2 GCA) versus specific combining ability (σ2 SCA).
- Low inbreeding depression in the source materials for the development of inbreds; and a stable CMS system without deleterious side effects, as well as effective restorers and maintainers, if hybrid breeding is based on cytoplasmic male sterility.

Steps involved in the Development of Heterotic Pools



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59. Detection Methods of Apomixis

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1. **Phenotypic identification:** a known heterozygous maternal parent and its progeny (grown from seed) with no observed segregation were used for classification. This method may involve the least work for detection of apomixis but is also the least reliable. Codominant or incompletely dominant alleles are necessary for correct classification of heterozygotes. In the absence of pseudogamy, careful emasculation and isolation of the maternal parent might also give proof of apomixis. In this case, if fertile seeds were created within the absence of spore, apomixis is likely to present. In addition, the assembly of a high proportion of irregular, sterile pollen grains are a traditional, reliable apomixis indicator, but for autogamous plants only.
2. **Cytoembryological Detection:** emphasizes the observation of the developing spores and embryo to visualize whether or not the reduction of genetic material happens and to observe segregation of chromosomes in the formation of the macrospore, and to rule out the likelihood of gametic fusion. It can be quite laborious but does enable the detection and classification of the form of apomixis. All reduced forms begin with traditional meiosis whereas unaltered forms could begin with apohomotypic, semiheterotypic, pseudohomotypic, or mitotic divisions replacing normal meiosis. These were determined by plating and marking of the relevant cells in numerous stages and determination of ploidy level for each macrospore and for the encompassing tissues. The stains used in this method are a safranin-fast green stain or aniline

blue.

3. **Microbiological Methods:** ways like the growth regulator (auxin test) take a look at, biological science tests, and ovule culture tests have proven useful in showing the features of plants showing apomixis. The auxin test won't be able to demonstrate the estimation of the frequency of apomixis in *Poa pratensis* (a facultative apomictic crop). The evaluation uses an artificial growth regulator (auxin) placed on the inflorescence before anthesis, which induces parthenogenic apomixis in plants. These individual plants can develop grains that are with mature embryos however no endosperm, whereas the alternative happens for non-parthenogenic plants. "The growth regulator (auxin) test provides a speedy, simple and precise method of estimating the frequency of parthenogenesis among aberrant progeny".
4. **Molecular and conventional Markers:** accumulated understanding of each sporophytic and gametophytic apomictic plant systems has sighted the concept of exploitation of molecular markers in genetic studies of apomixis. The use of typical and molecular markers in examining apomixis in plant analysis has followed 3 main approaches.

- **1st Approach: Mapping** and Gene Discovery to Identify Loci Controlling Apomixis in Apomictic Plants

  Molecular markers (RFLPs, RAPDs and AFLPs) are screened onto segregating apomictic populations and their respective parents using different mapping strategies (*i.e.* comparative mapping, bulk segregant analysis, and selective mapping) to detect any polymorphism that may be present. If polymorphism arises a lot of markers were screened to work out for the presence of linkage and to assist producing a map of the particular genomic region related to apomixis. The problem with this method, however, is that there were few traits specifically joined to apomixis that may be used as markers. Sherwood (2001) stated that no known effects were present on plant characteristics by apomictic genes.

- **2nd Approach:** Involving the Use of Molecular Markers Is Using Well-Characterized Sexual Model Systems

  The sexual model systems such as *Pennisetum glaucum* and *Zea mays* to identify genes which, if mutated or deregulated, result in phenotypes similar to the elements of an apomictic pathway. Caution ought to be employed in the interpretation since there wasn't enough review given on chromosomal rearrangements, fragment deletions between the markers surveyed, and the apomictic gene itself. *Pennisetum* has been chosen as a model system as a result of the robust expression of the apomictic attribute that persists in hybrids and genetic material appropriate for molecular studies involving molecular markers (RAPDs and RFLPs) was available. "The victorious use of those markers to survey different species of *Pennisetum* genus indicates that apomixis may be an attribute that can be followed across species by the molecular way". This concept of examining species among a genus may result in determining different markers and also the gene(s) that control apomixis.

- **3rd Approach:** Conventional Markers Can Be Used for The Analysis of Progeny After A Hybridization Event Between A Cross of a Facultative Asexual Species and Sexual Species

  The use of markers is essential since three different sexual 'off-types' are frequently observed in the progeny of apomicts: (1) BIII (2n + n) hybrids, (2) BII (n + n) hybrids and (3) polyhaploids. Unlinked, monogenically inherited traits have been used as conventional markers to distinguish maternal apomictics (asexual plants) from sexual (sexual off-type) plants. These markers are useful in a situation where "if the asexual female parent is homozygous for a recessive trait and the pollen parent is homozygous dominant, asexual female parent marker presence and its uniformity in the progeny would suggest maternal inheritance." Therefore, the use of traits as homozygous or heterozygous markers has allowed the identification of anomalous progeny from the asexual female by sexual male parent species crosses.

- **4th Combined:** Use of Methods: employing a combination of over one methodology of distinguishing the characteristics of an apomictic plant species. It is illustrated within the plant species of *Pssoa pratensis* (Kentucky bluegrass). To differentiate between aberrant progeny and normal in cross-fertilized species of *Poa pratensis*, flow cytometry, and silver stained RAPD (ssRAPD) markers were utilized to assist and verify ploidy level and mode of reproduction in progeny.

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60. Marker Assisted Selection: Approach for Crop Improvement

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Marker Assisted Selection (MAS) is an indirect selection procedure where a trait of interest is selected not based on the trait itself but with help of a molecular marker or genetic marker linked to it. It allows indirect selection for a primary trait (which is trait of economic interest) by direct selection for a secondary trait (marker). Conventional screening methods are laborious, costly or environmentally dependent. This methodology of selection is independent of growth stage, environment and Genotype X Environment interaction. In addition, an early stage (before maturity) MAS can be carried out before production of next generation.

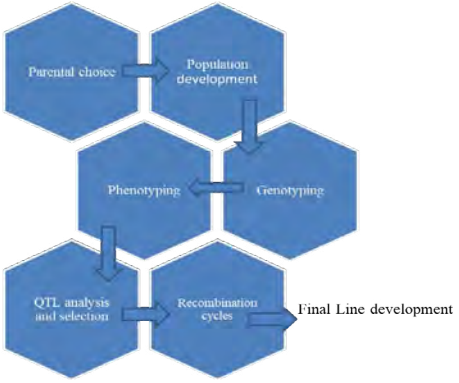

FIG.: General Outline of MAS

Advantages of MAS

1. It offers unique opportunity to circumvent many traditional issues related with phenotypic selection for traits of interest.
2. It increases the performance and feasibility of a breeding program by selecting genotypes for target genes or quantitative trait loci (QTL)
3. It saves time by reducing population size for phenotypic selection and speeds up the breeding projects.
4. Reduces number of generations in a backcrossing program.

Consideration for the use of DNA Markers in MAS

1. Reliability *i.e.* markers must be tightly linked preferably less than 5cM genetic distance (flanking markers improve reliability)
2. DNA quantity and quality
3. Technical procedure
4. Level of polymorphism
5. Cost

Potential of MAS

1. Disease and pest resistance
2. MAS for genes/QTL
3. MAS for quantitative traits like yield and abiotic stress tolerance

Various Marker Assisted Breeding Schemes

I. Marker assisted backcrossing
II. Gene pyramiding
III. Early generation selection

1. Marker assisted backcrossing: It is the most frequently used scheme which involves transfer of a limited number of loci (*e.g.* transgene, disease resistance loci etc.) from one genetic background (donor parent) to another (recurrent parent). Donor parent (gene of interest *e.g.* resistance gene for a disease) and recurrent parent (agronomic superior variety *e.g.* high yielding) cross is designed to achieve a desired result. It is further divided into 3 steps:

a) Foreground selection- This is performed to select genotypes with gene of interest (from donor parent) done with the help of foreground markers. These markers are tightly linked to the gene loci.

b) Background selection- is adopted to recover genomic region of recurrent parent. A large number of markers are used for screening foreground selected genotypes. These markers must span and represent each chromosome of recurrent parent for more efficient selection.

2. Gene pyramiding: It is widely used for combining multiple genes for a particular trait. Pyramiding is extremely tough to achieve using conventional methods. The scope of gene pyramiding arose with the need to develop durable disease resistance against different races.
3. Early generation selection: It is conducted at F2 and F3 stage. Plants with desirable genes/ QTL are selected and plants with undesirable gene combination can be discarded. The alleles can then be 'fixed' in the homozygous state. This allows advantages for later stages of breeding program because resources can be used to focus on fewer lines.

Successful Examples

1. Pearl millet (HHB 67 improved)
2. Rice (Improved Samba Mahsuri, Swarna-Sub1A)
3. Maize (Vivek QPM9)

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61. GMO and its Regulation

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INTRODUCTION: GMO, is answer to the problems of agricultural stability in future, or it itself can become problem in coming times, this conundrum only with time can get clear. The word "modified" in GMO can relate with those varieties too which have been developed through traditional breeding methods in which few genes have been incorporated or genetic alternation has been done with one or the other methods because eventually genetic alteration modify their genetic constitution too. So why only GMO is questioned for it's possible risk to future. Why GMO has been mistakenly tagged as Franken food? If we consider the results of scientific researches it would become more clearly to us, that yes there is risk, but not to the level that we should completely discard GMO. Is the way used in traditional plant breeding for genetic manipulation is naturally safe enough to be excluded from the rigorous and strict regulations GMO faces, as both are product of artificial manipulation and in either case the genetic constitution is being altered. GMO are believed to lead to uncontrolled and unpredictable alteration in the genome which can be potential risk to animals, environment and humans too. Hence to overcome future risks strict regulatory frameworks are followed both at national level in different countries as well at international also. From crops, animals to micro-organisms, scientists have genetically engineered all of them to what we now call as genetically modified organisms. It started in year 1983, when first genetically modified plant was developed by using an antibiotic-resistant tobacco plant. The year 1994 witnessed the first GMO food *Flavr Savr*, a tomato variety possessing delayed ripening using antisense RNA technology. These remarkable achievements paved way for other GMO crop and food in future. Soon in 1995, Bt (*Bacillus thuringiensis*) Potato became first pesticide resistance crop in USA. But there were other crops too which were in waiting list of getting marketing approval like canola with modified oil composition, Bt maize, cotton resistant to the herbicide bromoxynil, Bt cotton, glyphosate-tolerant soybeans, virus-resistant squash, and another delayed ripening tomato. In year 2000, Golden rice, a GMO rice rich in vitamin A was developed with a social purpose of overcoming Vitamin A deficiency in developing countries. In 2009, goat had been genetically modified to produces an anticoagulant antithrombin. It is sold by brand name ATryn, and produced from goat's milk. It is approved drug for hereditary antithrombin deficiency disease both in US and in Europe. Bt goat is not the first animal to be genetically modified; it is zebra fish. GloFish is a fluorescent fish available in pet stores in different colors. The first modified animal GM food, AquAdvantage a salmon was approved for human use in 2015. The list of GMO will keep on increasing with advancement of technology.

Biosafety Framework in India and at International Level

The main objective of Biosafety in India is to protect human, animal and environment from unwanted unintended biohazards of GMO. Biosafety mechanism in India is regulated by Ministry of Science and Technology (DBT) and Ministry of Environment and Forest (GEAC). Genetic Engineering Appraisal Committee (GEAC) and Department of Biotechnology (DBT) together controls research, trial related to GMO and even storage of GMO seeds. DBT choose members of GEAC. And function of GEAC is to implement legal actions, frame guidelines for GMO regulations as suggested by authority. There are other regulatory bodies too, work in coherent with each other to successfully fulfill the prime objectives of GMO regulation in the country like, State Biotechnology coordination Committee (SBCC), District Level Committee (DLC), Review Committee on Genetic Manipulation (RCGM), Institutional Biosafety Committee (IBSC) and Recombinant DNA Advisory committee. In all this, GEAC is apex committee, as it has authority to permit/prohibit use of GMO. The main functions of statutory bodies in relation with GMO regulation has been given in table below:

Statutory bodies related to GMO regulation in India	Function
RDAC	Advisory role to R-DNA products
RCGM, IBSC & GEAC	Role of approval to R-DNA products
GEACC	Authorizes use of use of GMO and products, large scale field trials and commercial applications
SBCC	Monitor activity of GMO and in case of violation can take actions in every state of India
DLC	Monitor bisoafety related issues
RCGM	Conduct meeting every month

Another regulation on GMO in India is shared by set Rules; Rules for the Manufactured, Use, Import and Storage of Hazardous Microorganism/ Genetically Engineered Organism and Cells, 1989(Rules 1989), notified under Environmental Protection Act 1986, FSSA Rules, 2009, Biological Diversity Rules, 2004, The Seed Policy, 2002, The Seeds Rule, 1968, PPVFRA Rules, 2003. Like India, some other countries also have their own GMO regulation authorities, like EFSA look after member states of EU (European Union), FDA and EPA in United States etc. **The GMO products are mainly result of transgenesis but with time, new technologies also have come up, like, cisgenesis and intragenesis which are in fact alternatives to trangenesis. And these new technologies are in scrutiny too. The EFSA** (European Food Safety Authority) **in April, 2011 evaluated these technologies for their risk to human/animals as well environment. A New Technique Working Group (NTWG) has been established in October 2007 to find other new techniques which product can possibly be a GMO and in this regard total of 8 new techniques have enlisted by the NTWG which are** (1) zinc finger nuclease technology (ZFN), comprising ZFN-1, ZFN-2 and ZFN-3 as defined in the current draft of the report; (2) oligonucleotide-directed mutagenesis (ODM); (3) cisgenesis (comprising cisgenesis and intragenesis); (4) RNA- dependent DNA methylation via RNAi/siRNA; (5) grafting; (6) reverse breeding; (7) agro-infiltration; (8) synthetic biology. According to EFSA, following conventional breeding techniques are considered most relevant for the comparison with cisgenic and intragenic plants: sexual crosses within species, bridge crosses, wide crosses using embroy rescue, translocation breeding, somatic hybridization (protoplast fusion), somaclonal variation. At International level, GMO regulation is done on two prime objectives: 1) to frame guidelines on safety and risk of GMO: overseen by Cartegena Protocol on Biosafety under Convention of Biological Diversity, the International Treaty on Plant Genetic Resources for Food and Agriculture under Food and Agriculture Organization (FAO), EFSA; 2) to facilitate free trade and this objective is administered by WTO (World Trade Organization), and Codex Alimentarius of FAO, TBT (Technical Barrier to Trade Agreement), SPS (Agreement on the Application of Sanitary and Phytosanitary Measures), TRIPS (Trade-Related Aspects of Intellectual Property Rights), Article XX of the General Agreement on Tariffs and Trade (GATT).

Conclusion: Potential of GMO to stabilize agricultural production today and tomorrow is so stupendous that the plant breeders cannot reject it thoroughly and having said that, flipping the coin to other side, and gauging GMO risk to human and environment no one can accept it on full scale. So, we cannot disown GMO completely, and hence strict regulations on GMO are followed, and as a consequence time taken by GMO products to reach market increases and cost too, which in turn discourages private/public sector to do investment in GMO projects. Regulation on any new technology is good; the objective behind the regulation cannot to be taken as granted. Because here, we are talking about future, and as well said proverb "protection is better than cure" regulation on GMO crop should be done, to avoid any mishap in future but baseless controversies which doom the hard work of scientist in no time should be taken seriously moreover by the GMO regulatory authorities. Understanding that regulation is important, now this really a peak time for scientific community to come up with a better plan, and make not only intellectuals understand safety issues of GMO but common people also. At the end GMO are meant for people, and if the controversies keep growing up, people will not accept GMOs in future. From DHM 11, Golden rice to Bt brinjal and many more which are result of many years of hard work of scientist and huge money of investors, are still not in use. Apart from all the controversies GMO technology faces, we cannot ignore this fact too, that it has a lot of positive effects too. In future, it has a lot to offer to us, but today what we need to spread thorough cognizance about GMO to society and its consumers and insures proper regulations.

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62. Role of Genomics and Bioinformatics in Crop Improvement

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In recent years, major advances in the field of molecular biology, genomics, proteomics have led to development of large amount of biological information. This spate of genomic data has in turn, led to demand for computerized tools and databases to index, store, organize, integrate and analyze the data. This data will continue to increase as DNA sequencing and genotyping has also undergone a great change in the last decade, from simple and less precise PCR based microsatellite markers (SSR), towards highly parallel, precise and less time consuming SNP based markers system using genotyping arrays from the most recent genotyping by sequencing (GBS) approaches and hence more precise, informative, user friendly data management tools will be required for processing and analyzing large genomic datasets and gaining functional insights into plant genomes. Bioinformatics can furnish a solution in processing the growing amount of biological information by addressing biological data collection and warehousing, data mining, database searches, analysis, interpretation, modeling and prediction. It can help plant breeders in resolving breeding challenges by development of novel plant diagnostic tools. Thus, bioinformatics is a multidisciplinary branch of science which deals with molecular biology (DNA, RNA and amino acid sequences, protein structures and protein domains), computer science, mathematical algorithms and statistics to solve the problems of mankind.

In the past few decades, the increased application of genomics in agriculture has helped to alleviate the dual problem of producing food grains for the ever-increasing population and unprecedented climate change. Crop genome sequences of the major food crops provide an important foundation for identifying agronomically relevant variation. In the past few years, genome sequencing of most of the crops, more recently chickpea and groundnut have been completed successfully also draft genome assemblies of the remaining major crops and their wild relatives are now available due to the decreasing cost of DNA sequencing and availability of other bioinformatics tools. These has led to capture crop genetic diversity which represents a substantial opportunity for breeders in crop improvement. Initially to generate superior genetic recombinants, breeding was based on repetitive phenotypic selection and crossing. But now as genome sequences are available, all genes and genetic variants contributing to heritable agronomics traits can be identified at the genotypic level. Genomics plays an increasingly important role in all aspects of crop breeding, such as quantitative trait loci (QTL) mapping and genome-wide association studies (GWAS), where genomic sequencing of crop populations can allow gene-level resolution of agronomic variation. For example, advances in genomics-based breeding allow the identification of genetic variation in crop species, which can be applied to produce climate resilient crops.

In agriculture particularly in plant breeding, large amount of phenotypic as well as genotypic data is generated and it is very difficult to handle, process, analyze and interpret it. Hence bioinformatics can play a pivotal role to compile and analyze these complex data efficiently. Collection and storage of plant genetic resource and wisely application of bioinformatics help to produce stronger, more drought, disease, insect resistant and climate resilient crops. Bioinformatics can also be useful in locating and mapping of genes for a trait of a high significant value with the help of genomics, expression analysis and functional genomics. Together with the design and construction of transgenic plants bioinformatics will allow identification of new target genes that will help in improving quantitative and qualitative traits in major crops of the world. It can also be helpful in preparing catalogue of all the cultivated as well as wild species and their wild relatives of all the crops along with their distinct phenotypic and genotypic characteristics.

Examples of some Genomic Database and Tools Relevant to Crop Improvement

1. Plant Genome and Information Center, USDA: http://www.nal.usda.gov/pgdic
2. European Bioinformatics Institute: - http://plants.ensembl.org/
3. Arabidopsis Genome Initiative (AGI) http://genome-www.stanford.edu/Arabidopsis/AGI
4. Oryzabase: http://www.shigen.nig.ac.jp/rice/oryzabase/
5. Gramene: http://www.gramene.org/
6. Rice Informatics Consortium: - http://iric.irri.org/
7. Rice Genome Annotation Project: - http://rice.plantbiology.msu.edu/
8. Triticeae toolbox: - https://triticeaetoolbox.org
9. SSR Primer: - http://flora.acpfg.com.au/ssrprimer2/

10. Integrated Breeding Platform: - https://www.integratedbreeding.net/
11. Graingenes: - http://wheat.pw.usda.gov/
12. Wheat Information System: - http://wheatis.org/

SEED SCIENCE

18460

63. Basics of Seed Priming: Role in Germination and Stress Tolerance

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INTRODUCTION: Rainfed agricultural system contributes about 64% of net cultivated area of India where occurrence of periodic stresses is a common phenomenon. Even the in the irrigated systems, ensuring a good germination, proper seedling vigour and optimum yield levels is a challenge when any biotic or abiotic stress conditions prevail. Here the role of seed priming comes into play, it creates a stress memory in the seeds and help the seed to tolerate the stress in a better way. The definition of seed priming as given by USDA, "Pretreatment of seeds by various methods in order to improve germination rate, germination percent, uniformity in emergence by controlling water available to seed. The pretreatment initiates early stages of germination but doesn't permit radicle protrusion and then are dried until needed."

Principles of Seed Priming

There are three district phases of germination where phase I, II are reversible, and phase III including radicle protrusion is irreversible. In case of unprimed seed, seed hydration status increase in phase I to start metabolic processes in phase II. Then again water content rises in phase III when radicle protrusion occurs. But in case of primed seed, seed is dehydrated before the phase III sets in and stored until needed. Rehydration occur when seed is sown.

During the course of priming, several metabolic processes triggered in phase II due to hydration such as DNA repair, modification hormonal status etc. When stress is given by the means of dehydration, some stress responses also sets in such as up regulation of scavenging enzyme genes, reactive oxygen species signaling *etc*. All these considered as priming memory and stress memory imprint. When these memory help seeds to germinate faster or tolerate stress, it is termed as employment of acquired or imprinted memory.

Types of Priming

In different types of priming methods, hydro priming is the simplest one. As the name indicates, it's the soaking if seed with water for specified time and drying back. Besides being cheap and easy, disadvantages like over priming or under priming are of great concern. Commercial form of hydro priming is known as drum priming, while hydro priming on farmers end is known as OFP. Osmopriming is a modification over hydro priming. Here imbibition rate is controlled by adjusting the water potential of the solution by adding salts like NaCl, PEG etc. Here in the figure, we can visualize the change in imbibational pattern as influenced by the water potential of solution. Solution of intended osmotic pressure can be made using ready reckoner as suggested by USDA. For example, for preparing a priming solution that has a water potential of -0.7 Mpa can be prepared with 150 mM NaCl solution or 20% w/w PEG-8000 solution. Priming with growth regulators or promoters like ABA, Auxins etc are known as hormone-priming. Priming with growth regulators have direct impact on metabolism. While some nutria-priming treatments are involved in alteration of nutrient uptake and transport. Priming with bio inoculants is known as bio priming. Bio priming improves plants defense response in case of biotic stress. In the figure, difference in Rice seedling vigour is noticeable when seeds primed with Trichoderma viridae are subjected to blast inoculation.

Mechanisms Involved in Priming

Priming increases GA_3: ABA ration thus advancing germination. Aquaporin activity is increased. Aquaporin is an integral membrane protein that provides channel for water movement into the cell. Up regulation of genes coding aquaporin in response to priming stress, help in better water absorption even under stressed condition. In most of the seeds, cells are freeze at G_0 or G_1 phase checkpoint. Priming has been reported to increase amount of S cyclin and decrease M cyclin by genetic regulation for activating CDK to push cells in S phase but stop in the G_2 checkpoint. Cells in S or G_2 phase can readily enter in to mitotic phase when hydration restores. Complete proteome analysis of several crops reveled that priming increases the no. of transporters in cell

membrane thus assisting nutrient uptake. While the CDK dependent differentiating mechanisms for Na and K are also been found on osmoprimed seeds which help in increased K uptake in saline soil while excluding Na imposing salt tolerance. Oxidative damage is common to plants whenever any abiotic stress occurs. Priming itself is a mild stress owing to production of ROS during dehydration process which induces stress responses through complex signaling cascade. Late Embryogenesis Abundant proteins (LEAs) are simply the proteins that occurs in the late phase of embryogenesis. Stress response proteins, heat shock proteins also come under LEA. From the Proteomics analysis of seed germination process, it has been found that during the course of protein 35 kD proteins decrease to 0 while 20 kD proteins increases from 0. By the process of priming, here is visible head start in state transition, both have to start from here in the time of germination not here thus reducing time taken. It is often said that past experience helps in facing the future. The statement holds true in case of primed seeds too. It has been found that acquired priming memory and stress memory during priming is recruited on 2nd hydration. Here memory like this this this, help in seed germination and stress tolerance upon second hydration.

Limitations

Every technology has its own prospects and constrains. In spite of several advantages, a few problems also exist priming technology. Like, we have already seen in several research findings that over priming and under priming is a problem. So, more research works should be done to standardize the procedures for crops and varieties. Problem of storage life in primed seeds may be combated with low temperature and controlled environment storage or packaging. During dehydration, many crops may lose its viability and vigour due to lack of desiccation tolerance like pulses. The technology is not very much successful in pulses.

Conclusion: Seed priming is very successful in many field crops like rice, wheat, maize etc. and it's an excellent method to alleviate stress especially in rainfed and problematic soil conditions. It's very cheap and easy method and can be done by farmers himself with a little bit of training. Seed industries are also using the technique due to its high B: C ratio. Response of priming treatments are variety and crop specific. So needs more experimentations for making recommendations to farming community. In depth study of stress memory imprint is needed as till date the knowledge is incomplete. Interactions of priming agents and methods and also with other agronomic practices are yet to be tested. At last but not the least, seed priming being a cheap tool which is economically viable, ecologically sustainable and socially acceptable, is expected to bring smile on farmers face.

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64. Seed Bio-Priming: Technique to Make Super Seeds

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Agricultural pests such as harmful insects, weeds and pathogenic microorganisms are threat for food production. Agriculture pests needs to be managed to ensure food, feed and fiber production both quantitatively and qualitatively. Consider on an average, crop loss of 20 per cent and the present gross value of our agriculture produce as Rs, 7 lakh crores, the loss comes to Rs. 1,40,000 crores (Kumar and Gupta, 2012). Even if we could save 50 per cent by using plant protection, it will add Rs. 70,000 crore additional income to farmer's family.

Besides plant protection in general and management of crop disease in particular, play an important role in meeting the future demand for both food quality and quantity. Beyond good agronomic and cultural practices, growers often rely heavily on chemical pesticide for management of diseases. Biological control has become an attractive alternative strategy for the control of plant diseases to reduce the excessive use of agrochemicals and its health hazards.

Seed bio-priming is a pre-requisite for rapid, uniform germination of seeds, optimum plant stands in the field, growth promotion and to overcome the infection at seedling stage besides effectively mediate resistance induction against diseases. Bio-priming process has potential advantages over simple seed coating with biocontrol agents. It is an ecological approach of using either bacterial or fungal antagonists against the soil and seed-borne pathogens.

Bio-priming is a new technique of seed treatment that integrates biological (inoculation of seed with beneficial organism to protect seed) and physiological aspects (seed hydration) of disease control.

Principle behind Seed Bio-Priming

When a dry seed is kept in water, the uptake of water occurs in three stages. Stage I is imbibition where there is a rapid initial water uptake due to the seed's low water potential. During this phase, proteins are synthesized using existing mRNA and DNA and mitochondria are repaired. In stage II there is a slow increase in the seed water content, but physiological activities associated with germination are initiated, including synthesis of protein by translation of mRNAs and synthesis of new mitochondria. There is a rapid uptake of water in stage III where the process of germination is completed culminating in radicle emergence.

Stage I and II are the foundation of successful seed bio priming where the seed is brought to seed moisture content that is just short of radicle protrusion. The pattern of water uptake during priming is similar to that during germination but the rate of uptake is slower and controlled.

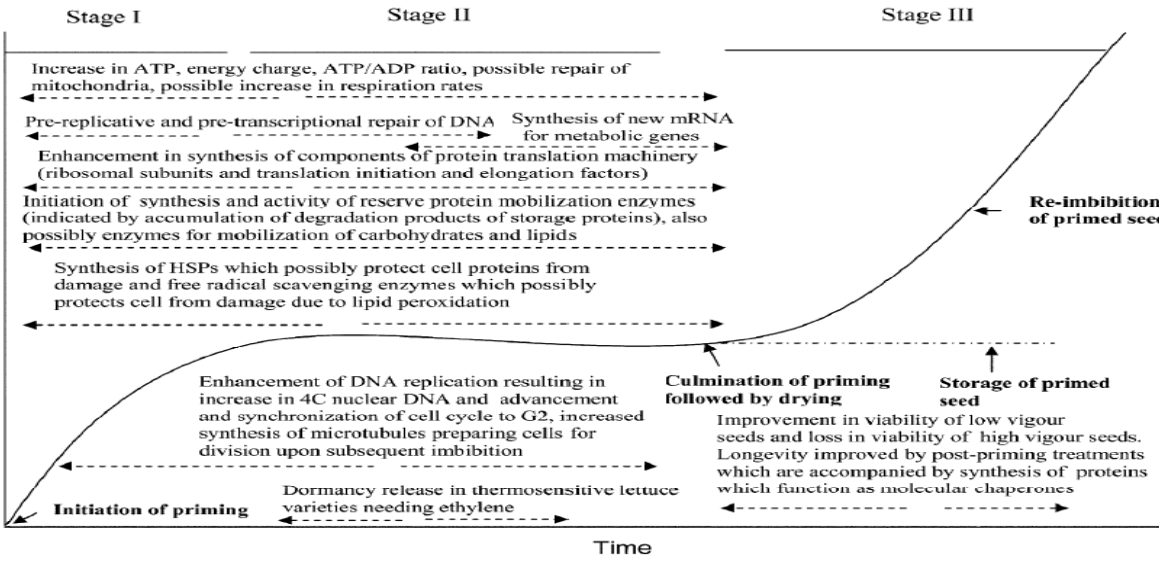

FIG. 01: Pattern of water uptake and metabolic events during seed priming

Mechanisms involved in Bio-Priming

- Increased production of defense enzymes: Increased activity of phenylalanine ammonia lyase, poly phenol oxidases, peroxidase enzymes in treated seeds may result in the activation of defence genes, which in turn may lead to increased production of antimicrobial compounds like phenolic such as lignins which may be toxic to the seed-borne pathogens, and this may contribute to disease resistance. PAL involved in production of phenolic compounds which oxidized into quinone and lignin in presence of poly phenol oxidase, which are highly toxic to pathogens than phenols. Peroxidase helps in the cross linking of cell wall protein hence it makes plant cell wall more thicken make pathogens entry more difficult.
- Activation of host defense genes: biocontrol agents act as a elicitor for thereby they elicit the plant defense genes, it trigger host defense it accompanied by development of induced systemic resistance (ISR) in plants, hence plants become resistance to pathogens.
- Production of phytohormones and phytoalexins: some of the biocontrol agents such as PGPR's known to produce phytohormones such as indole acetic acid (IAA), gibberellic acid (GA3) etc., which helps in cell multiplication and cell differentiation thereby plant grow quickly and escaped from the diseases. Some biocontrol agents involved in the solubilization of phosphorous, chelating iron and make availability of more nutrients to the plants, hence plant become more robust which resist infection.
- Proliferation of the population of BCA: they multiple on the surface of seeds acts as a protective barrier for pathogens during germination. After that they colonize around the rhizosphere compete with pathogenic microorganisms for space, food and they also produce some secondary metabolites such as antibiotics and bacteriocins, which are toxic to pathogenic microorganisms.

Advantages of Bio-Priming

- It can be used as an alternative method to seed treatment with chemicals.
- Effective against both seeds borne and soil borne diseases.
- There may also possibly have been the result of synergism f priming effect with BCA.

Conclusion: Bio-priming seed can provide a high level of protection against seed and soilborne pathogens. This protection was generally equal or

superior to the control provided with fungicide seed treatment. So, it could be suggested that bio-priming (combined treatments between seed priming and seed coating with biocontrol agents) may be safely used commercially as substitute for traditional fungicide seed treatments for controlling seed and soil-borne plant pathogens. Besides, bio-priming also improves seed germination, seedling establishment and vegetative growth. This has explored up new dimension of biological control for preventive as well as remedial for seed-borne infection by bio-agents. Thus, bio-priming can be exploited by seed companies and organic farmers in the sustainable agriculture, which would be more economical and environmental-friendly.

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POST-HARVEST MANAGEMENT

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65. Fundamentals of *Dhal* Milling Processing

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India's food grain production was estimated for 2017-18 as 284.83 million tonnes out of which pulse production was 25.23 million tonnes. Pulses are major source of protein in Indian vegetarian diet and provide most of the essential amino acids. Pulses are consumed as split cotyledons (*i.e.* dhal) after milling. In India, dhal milling is the third largest food grain processing industry after rice and wheat milling. It is also the largest producer of pulses in the world as well as the producer of the largest number of variety of pulses.

There are about 6000 large scale dhal mills spread all over the country with capacities of 8-10 tonnes per day, processing about 10 million of different variety of pulses. Milling of pulses means removal of outer husk and splitting the grain into two halves. In other words, milling of pulses essentially consists of the removal of the tightly bound external "husk" from the grain and recovery of the cotyledon in the form of the '*Dhal*'. The average yield of dhal in the commercial mills is about 75% and the rest of the grain materials about 25% are retained in the form of various types of by-products.

Pulses provide a key source of protein in cereal-based Indian dietary. The increase in population and stagnation of the pulse production in India has resulted in the reduction of its per capita availability from 27.5 kg in 1959 to merely 17.2 kg in 2012-15 as compared to recommended annual requirement of 23.5 kg for balanced diet.

If it is assumed to have at least 50 g per capita requirement, then the production should be about 20 million tonnes. It may not be feasible to increase the current level of production to such extent. The second partial solution will be to minimize the losses in present dhal milling method. It would be profitable to have dhal milling industry instituted in village so that proper milling is done soon after harvest and stored in the form of dhal rather than whole pulses. Dhal seems to have better storage life than whole pulse as due the split is more dried and have more exposure to the air. This will save the burden of additional cost on customers in village, which is involved due to transportation of raw materials to urban area and finished product back to villages.

In India the dehusked split pulses are produced by traditional method of milling *i.e.* hand-operated stone roller. In Morden milling methods, certain chemicals are also added to these pre-treatments to increase the total yield of dehusked and split pulses and reduce losses occurring in traditional milling practices. On the basis of milling characteristics, pulses are broadly classified as easy to mill and difficult to mill. The difficult to mill pulses offer resistance to milling due to the presence of layer of gummy substances between husk and kernel. Few steps follow for wet milling of pulses: cleaning, grading, soaking, mixing with red earth, conditioning, dehusking and splitting (mixture of husk, broken and powder), grading (separation of *Dhal* and broken), polishing, packaging.

Pre-milling treatments are required to remove husk without loosening any edible portion. The husks of most pulses are attached with cotyledons through a layer of gums. The tackiness of which is due to their chemical make-up. Because of the presence of gummy layer, some pulses are grouped as difficult to mill (pigeon pea, black gram, green gram etc) and others as easy to mill (lentil, Bengal gram, peas etc).

The recovery of dhal varies with the type of pulses and techniques adopted by the millers such as methods of pre-treatment and type of milling method (*i.e.* dry milling and wet milling of pulses) used. Mainly pre milling treatments are used for increasing the dhal recovery and reducing the losses. Generally the husk is tightly attached to the cotyledons in pulses. Hence the pre-treatment for loosening of the husk prior to milling is desirable. There is a need of pre-milling treatments for primary or secondary processing of the agricultural products grown by the farmers of the region because pre milling treatments are used for increasing the dhal recovery and reducing the losses.

Oil is used prior to or during drying (mostly sun drying) to facilitate loosening of husk. Use of oil is arbitrary and varies from place to place and there are no standard criteria. Excess oil results in increased cost of processing while less oil results in inadequate loosening of husk. Insufficient or excess application of any of the above factors cause heavy losses due to breakage or powdering of the grain kernel thereby is lowering the pulse recovery and finally the net availability of pulses.

PLANT PATHOLOGY

18361

66. Plant Disease Resistance Genes: and Their Potential Applications

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Plant disease resistance genes (R genes) encode proteins that find out pathogens. R genes have been utilized in resistance breeding programs for decades, with varying degrees of success. Latest molecular research on R proteins and downstream signal transduction networks has provided energizing bits of knowledge, which will enhance the use of R genes for disease control. Definition of conserved structural motifs in R proteins has facilitated the cloning of useful R genes, including several that are functional in different crop species and provide protection to a relatively wide range of pathogens. Numerous signal transduction components in the barrier organize have been characterized, and a few are, and several are being exploited as switches by which resistance can be initiated against diverse pathogens.

In spite of considerable advances in plant disease control procedures, our worldwide sustenance supply is as yet compromised by a large number of pathogens and pests. Plant disease can significantly lessen crop yield and the effect of disease epidemic is particularly acute in developing nations. Pesticides give successful insurance however their pertinence can be undermined by unfriendly natural impacts and by the rise of safe pathogen strains. Substance controls are frequently past the methods for ranchers in creating countries. Thus, much exertion has been contributed towards understanding intrinsic obstruction instruments in plants. Plants can initiate a powerful munitions stockpile of inducible resistance reactions, included hereditarily customized suicide of tainted cells (the easily affected reaction, HR), just as tissue fortification what's more, anti-microbial creation at the site of disease.

These neighbourhood reactions can, thus, these local responses can, in turn, trigger a long-lasting systemic response (systemic acquired resistance, SAR) that primes the plant for resistance against a broad spectrum of pathogens. Although many energizing bits of knowledge have risen up out of late research on plant defence signalling, our by and large comprehension of the procedure is as yet fragmentary. For example, despite everything we know almost no about the basic premise of pathogen acknowledgement. Indeed, we are more uncertain than before about what R proteins really perceive (Avr proteins, adjusted guardees, or edifices that incorporate both?). Besides, numerous holes stay in our models of the defence signal transduction arranges and these must be spanned before we can plan really balanced methodologies to enact the system. All things considered, valuable applications are as of now being created from our generally constrain information base and others will without a doubt pursue as our dimension of essential comprehension develops. For the time being, we expect that extra helpful R qualities will be cloned and that models of opposition flagging created in Arabidopsis will keep on being assessed for pertinence in crops. We likewise envision the use of utilitarian genomic instruments to disease resistance, which will incredibly quicken the pace of discovery and provide new insights into co-operation between safeguard flagging and other plant forms.

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67. Cow Urine for the Plant Disease Management

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In India, Cow (Kamadhenu) has been considered as a sacred animal. Several medicinal properties of CU have been mentioned in Susruta and in Charak (sloka-100). CU is compared to nectar in Rigveda. Cow urine (CU) (gomutra) is described as an effective medicinal substance/secretion of animal origin with innumerable therapeutic uses in different ayurvedic texts (Sushruta Samhita, Ashtanga Sangrah and Bhav Prakash Nighantu). of CU possess different antimicrobial activity in its different fractions due to the presence of certain components like volatile and nonvolatile ones and presence of urea, creatinine, swarn kshar (aurum hydroxide), carbolic acid, phenols, calcium, and manganese has strongly explained the antimicrobial and germicidal properties of CU. Amino acids and urinary peptides present in the CU may enhance the bactericidal effect by increasing the bacterial cell surface hydrophobicity. The phagocytic activity of macrophages is also enhanced by CU. Phenols present in higher amounts in fresh CU than CU distillate (CUD) makes it more effective against microbes. Few biogenic volatile inorganic and organic compounds such as CO_2, NH_3, CH_4, methanol, propanol and acetone, and some metabolic secondary nitrogenous products are also formed after photo activation and Photo-activated CU (PhCU) becomes highly acidic in comparison to fresh CU which increases the bactericidal action due to a significant decrease in pH, presence of inorganic phosphorus, chloride and dimethylamine may also play an important role, along with increased formation of some reactive compounds like formaldehyde, sulfinol, ketones and some amines during photo-activation and long term storage. It prevents the development of antibacterial resistance by blocking the R-factor, a part of plasmid genome of bacteria. The antifungal properties of the cow urine are due to the presence of phenolic acids (gallic, caffeic, ferulic, o-coumaric, cinnamic, and salicylic acids) and antioxidant property of uric acid and allantoin present in CU. The biochemical estimation of cow urine revealed that it contains sodium, nitrogen, sulphur, Vitamin A, B, C, D, E, minerals, manganese, iron, silicon, chlorine, magnesium, citric, succinic, calcium salts, phosphate, lactose, carbolic acid, enzymes, creatinine and hormone. Application of cow urine besides improving the soil texture and working as a plant hormone also been reported to correct the micronutrient deficiency, being organic in nature it is also likely increase the fertilizer use efficiency. The uric acid in the urine acts as fertilizer and hormone. Cow urine has antibacterial, antifungal, antiviral properties; hence it is most effective secretion of animal origin with multitudinous therapeutic values it also purifies and enhances soil fertility. Seed treatment with cow urine was found effective for managing the plant pathogens like *Fusarium oxysporium* var. *trifoli, Rhizoctonia solani Kuhn*, *Pythium aphanidermatum* and *Sclerotium rolfsi* etc. by several scientists. Cow urine is used for preparation of number of bio-enhancers and bio-pesticides, which are effective in improving soil fertility, quick decomposition of organic wastes and management of large number of pests and diseases in varied group in organic farming. Organic formulations *viz* cow urine, neem extract, vermiwash, fish wash could be a potent source to move forward soil fertility, crop productivity and quality and additionally control of pest and diseases.

Conclusion: The use of cow urine is a cost effective and ecofriendly approach to control phytopathogenic fungi. Combined with manures and fertilizer frequent use of cow urine can address many challenges of agriculture and will be pave way for sustainable agriculture. Therefore, it seems that cow urine under livestock based integrated farming system a better supplement for nutrient management.

18491

68. Quinolone Group of Fungicide for Plant Disease Management

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INTRODUCTION: Quinoline is a group of newer chemical compounds used in agriculture as fungicides. Quinoline was first extracted from coal tar in 1834 by German chemist Friedlieb Ferdinand Runge, he called quinoline *leukol* ("white oil" in Greek). Coal tar remains the principal source of commercial quinoline. In 1842, French chemist Charles Gerhardt obtained a compound by dry distilling quinine, strychnine, or cinchonine with potassium hydroxide, he called the compound *Chinoilin or Chinolein*. Quinoline is a heterocyclic aromatic organic compound. It has the formula C_9H_7N and is a colourless hygroscopic liquid with a strong odour. Aged samples, if exposed to light, become yellow and later brown. Quinoline is only slightly soluble in cold water but dissolves readily in hot water and most organic solvents. Its principal use is as a precursor to 8-hydroxyquinoline, which is a versatile chelating agent and precursor to pesticides. Quinoline is readily degradable by certain microorganisms, such as *Rhodococcus* species Strain *Q1*, which was isolated from soil and paper mill sludge. Quinolines are present in small amounts in crude oil within the virgin diesel fraction. It can be removed by the process called hydrodenitrification. The quinoline skeleton is often used for the design of many synthetic compounds with diverse pharmacological properties such as, anti-inflammatory, antimicrobial agents, cytotoxic activity, antidotal and antibacterial, antitumor activity, antimalarial. Additionally, quinoline derivatives find use in the synthesis of fungicides, virucides, biocides, alkaloids, rubber chemicals and flavoring agents. Oxidation of quinoline affords quinolinic acid, a precursor to the herbicide sold under the name "Assert". Quinoline is often reported as an environmental contaminant associated with facilities processing oil shale or coal, and has also been found at legacy wood treatment sites. Quinoline has significant potential for mobility in the water environment, which may promote water contamination.

Quinoline Fungicides

- Ethoxyquin
- Halacrinate
- Quinoxyfen
- Quinacetol
- Quinofumelin
- 8-hydroxy quinoline sulfate
- Ipflufenoquin
- Tebufloquin

Quinoxyfen

Quinoxyfen is a protectant fungicide from the chemical class, the quinolines, with specific activity against powdery mildew. Technical grade quinoxyfen is a white to off-white odorless solid material containing more than 99% quinoxyfen. Products containing quinoxyfen are sold under trade names such as Fortress, Orka, Legend and Quintec fungicides. Quinoxyfen is toxic to aquatic organisms but practically non-toxic to birds, honeybees, or soil dwelling organisms. Quinoxyfen is stable under storage conditions. Exposure to elevated temperatures can cause product to decompose. Generation of gas during decomposition can cause pressure in closed systems. Quinoxyfen inhibits the formation of *Erysiphe graminis* appressoria. It is a systemic fungicide with additional vapour phase activity, which aids redistribution in all crops. When applied at the first node stage of cereals, it is rapidly absorbed by the plant. The activity of quinoxyfen has been attributed to its ability to disrupt a number of signalling processes that are important in the early stages of powdery mildew development (BCPC, 2000, pp 841).

The presence of multiple targets reduces the probability that resistance will develop. No cross-resistance with other mildewicides (azoles, morpholines, pyrimidines) has been noted – this may be due to the ability of quinoxyfen to block a number of pathways in the pathogen's lifecycle. The fungicide can be tank mixed with a curative fungicide from the following compatible products: cyproconazole, epoxiconazole, fenpropidin, fenpropimorph, flusilazole, prochloraz, propiconazole, tebuconazole or tridemorph. Laboratory and field trials have shown that quinoxyfen has no detrimental effect against beneficial, non-target species and is, therefore, a suitable fungicide for use in IDM programs (BCPC, 2000, pp 371).

Crop Uses

- Barley, cucurbits, hops, melons, oats, peppers, pome fruits, rye, strawberries, triticale, vines, wheat

Dose

- Cereals: 150-300 g ai/ha
- Fruit: 25-50 g ai/ha; 75-100 g ai/ha

Mode of Action

Microbiological studies have shown that the inhibition of mildew may be through disruption of early cell signaling events that control morphological changes leading to infection. Microscopically, it has been shown to interfere with pre-infection developmental stages by suppressing germination, early germ tube development and/or appressorium formation.

After application, quinoxyfen penetrates into the plant tissue (*i.e.* leaves, fruit) and binds to cuticular waxes. Disruption of signal transduction by targeting of G-proteins. Redistribution occurs primarily through local vapor movement. In short, quinoxyfen is a very "active" active ingredient.

Its mode of action is one of a kind and unique only to quinoxyfen. These qualities, combined with outstanding efficacy, can only make current mildew program stronger. Quinoxyfen is an excellent rotational product with 1) products from other fungicide classes such as sterol inhibitors and sulfur and 2) other extended residual products.

Formulations

Quinoxyfen is a protectant fungicide. In order to provide both protective and curative control, some formulations have been developed consisting of quinoxyfen with a curative fungicide. Quinoxyfen is available in the following formulations.

Sr. No.	Formulation	Active ingredient content
1.	Suspension concentrate (SC), containing only Quinoxyfen as the active ingredient	250 g/L Quinoxyfen 500 g/L Quinoxyfen
2.	Suspension concentrate (SC), containing a mixture of Quinoxyfen and Cyproconazole, Quinoxyfen and Fenarimol	200 g/L Quinoxyfen + 60 g/L Fenarimol 75 g/L Quinoxyfen + 80 g/L Cyproconazole
3.	Emulsion, oil in water (EW), containing a mixture of Quinoxyfen and Fenpropimorph	66 g/L Quinoxyfen + 250 g/L Fenpropimorph.

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69. Phylloplane Bacteria: A Natural Fighter in Eco-Friendly Plant Protection

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The phyllosphere term is used in microbiology to indicate the total above ground portions of plants which is habitat for different microorganisms. The term phyllosphere was coined by Dutch microbiologist Ruinen. J in 1961.

Phyllosphere can be divided into: 1. Caulosphere (stems) 2. Phylloplane (leaves) 3. Anthosphere (flowers) 4. carposphere (fruits)

Among these Phylloplane is the surface of leaves which considered as the habitat of different microorganism. Different microorganism other than bacteria are also inhibit in phylloplane. These are: 1. Fungi. (*Phoma, Alternaria, Cephalosporium, Aspergillus, Cladosporiu-m, Curvularia* etc.) 2. Yeast. (*Candida albicans, Saccharomyces cerevisiae, Torulopsis colliculosa* etc)

Kerling (1958) suggested the term phylloplane. According the study of Vorholt,2012; The total extent of upper and lower surface of leaves could harbor 10^{26} bacteria.

Some example of phylloplane bacteria that are found till now are:-Erwinia amylovora, E. carotovora var. carotovora, E. Ananas, E. carotovora var. chrysanthemi, E. herbicola var. herbicola, Escherichia coli, Achromobacter anitratus, Agrobacterium radiobacter, Arthrobacter globiformis, Pseudomonas acidovorans, P. aeruginosa, P. fluorescens Biotype A Biotype B Biotype C Biotype D Biotype E Biotype F, P. Melophthora, P. multivor P. phaseolicola, P. putida, P. stutzeri, P. syringae, P. thomasii, P. viridiflava, Xanthotnonas begonia, X. campestris, X. hyacinthi, X. phaseoli.

Different Streses on Phylloplane Bacteria and the Way to Overcome

Leaf surface is a complex structure of microenvironment. The continuous interaction between epiphytotic microorganism are mostly affected by the phylloplane characteristic. Among these the protection from the sunlight, moisture availability are the main factors. The water film on the phylloplane helps in the spreading of the bacteria across the leaf surface in the search for abundant nutrient. Moreover, different plant metabolites like sugars, polyols cannot be freely available for the nutrition of phylloplane bacteria if leaf surfaces are protected by lipidic or waxy cuticle. Trees that are adopted in adverse condition like desert or salinity can secrete compounds which can generate alkaline and saline stresses on phylloplane microbes. To overcome all these problems Phylloplane bacteria evolved some biochemical exchange pathways among them and the host plant. For

an example, Phylloplane bacteria can developed a mechanisms of exo-polysaccharide synthesis in order to improve adhesion or protection from dessication. They are able to synthesize and secrete phytohormonal compounds such as indole -3-acetic acid, which facilitates nutrient exudation from plant tissue as a result of plant cell wall relaxtion. (Vorholt,2012)

Role of phylloplane bacteria: -*Pseudomonas fluorescens* strain A506 and *Pantoea agglomerans* strain inhibits the colonization of *Erwinia Amylovora* which leads to the reduction of the disease. These antagonists move rapidly from the inoculated to non-inoculated flowers, thereby facilitating bio control mechanism in flowers. Phylloplane bacteria can increase the wettability of leaves by producing compounds like tolaasin, a toxin produced by *Pseudomonas tolaasi*, with surfactant properties which may facilitate the movement of bacteria on the phylloplane. *Methylobacterium* (*Alphaproteobacterium*) or pink pigmented facultative methylotrophic bacteria have been reported to stimulate seed germination and plant growth. Along with these they also repored to produce many growth hormones viz, cytokinin (Ex:- Zeatin and trans zeatin) and auxin (indole-3-acetic acid). More over these bacteria could turn the methanol, a waste product of rice into simpler compounds and make it available for plants.

On the other hand, the phylloplane bacteria have immense role in Induced Systemic Resistance (ISR) by the changing in phenolic content like Phenyl alanine ammonia lyase, chitinase, B-1,3-glucanase and peroxidase. For an example, *Pseudomonas fluroscence* have been reported to activate ISR in several crops by activating defence related genes like in case of tobacco this bacterium activates ISR by accumulating b-1,3-glucanase and chitinase which hydrolyze the fungal cell wall component b-1,3-glucans and chitin respectively. (Ham et al;1991). *Bacillus subtilis* and *B. mojavensis* shows strong antifungal activity against *F. moniliformae*. *B. mojavensis* A-BC-7 is a natural colonizer which was isolated from oilive phytoplane shows antagonistic effect against *Pseudomonas savastanoi pv. savastanoi* causing olive knot disease.(Ghanney et al.2016).

Future Aspects

Study of phylloplane bacteria along with other phyllosphere inhibiting microorganism can open up a new era towards developing new strategy of more effective and eco-friendly means of plant protection. The development of resistance against many agrichemicals by the disease-causing micro-organisms creating a serious concern for researchers. In this scenario the combined effect of ISR and antagonistic activity of phylloplane bacteria against the harmful pathogen can be a good alternative for the research and as well as practical uses for the benefit of the farmers.

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70. Diseases of Jasmine and their Management

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Jasmine belonging to the family Oleaceae is a climbing, trailing and erect flowering shrub. It is best loved for its fragrance and is excellent landscape plants. Some important diseases occurring on jasmine and their management described below:

1. **Damping-off**: Damping off is caused by *Pythium* sp. and *Rhizoctonia solani*. *Pythium* primarily attacks the jasmine's roots, while *Rhizoctonia* can infect all parts of the plant. The disease is more in wet and humid conditions. Infected roots soften and darken, and new shoots on the plant may grow in distorted. Plants exhibit slow growth and slowly die. The pathogen survives in the soil. Poor soil drainage, limited air circulation, heavy rainfall or overhead irrigation will predispose the plants to infection. The disease can be managed by improving the drainage system, pruning to remove the infected portions and improving air circulation. Sanitizing the garden tools before use and drenching the soil around the plant with 1% Bordeaux mixture or Carbendazim 0.1%.
2. **Fusarial Wilt**: The disease is caused by *Fusarium solani* (Mart) Sacc. The initial symptom is seen as yellowing of lower leaves which gradually spread upwards and finally resulting in death of the plant. The pathogen survives as chlamydospores which overwinter

in in infected or dead tissues. It can be spread by air, equipment and water. Application of benomy 1(0.1 %) + copper oxychloride (0.3%) and carbendazim (0.2 %) + copper oxychloride (0.3 %) as drenching twice at 15 days interval is found to be effective in checking the incidence and spread of the disease. Soil application of talc based commercial formulation of *P. fluorescens* @ 20g/pot, *B. subtilis* and T. *viride* @ 25g/pot effectively reduces the wilt disease incidence in the pot culture experiment.

3. **Sclerotial wilt, collar rot and root rot:** The disease is caused by *Sclerotium rolfsii* Sacco The disease can be present at all stages of the plant and the early symptoms is yellowing of the lower leaves which slowly spreads upwards and finally results in the death of the plant. Young leaves turn yellow and twigs dry from tip downwards. The disease can occur in patches. The infected plant base shows network of fan-shaped white mycelial strands of the fungus which later on produce mustard like brown sclerotia on the infected tissue and stem surface. The disease can be managed by mulching around the plant, sanitizing the tools used for pruning and destroying the infected cuttings. Soil drenching with Trifloxystrobin + Tebuconazole @ 0.75 g / lit or Difenoconazole @ 0.5 ml / lit.
4. **Rust:** The disease is caused by *Uromyces hobsoni* Vize. The pathogen infects all parts of the plant, including the stem, underside of the leaves, and even the flower buds. First symptoms appear as orange coloured aerial cups on both sides of the leaf, but predominantly on the lower surface. Numerous blisters are produced in advanced stage of infection causing yellowing and crinkling of the leaves. The stems and branches are also infected, causing splitting of barks and subsequent death of the branches. As the disease progresses, rust will disfigure newly emerging leaves and flowers. Yellowish orange coloured pustules appear on the lower side of the leaves and also on young twigs and flowers buds. The infected parts become distorted. The disease can be managed by removal of the affected plant and plant parts, pruning to improve air circulation, dusting Sulphur @ 20-25 kg/ hectare. Spraying with Bordeaux mixture or Copper oxychloride (0.3%) or Mancozeb (0.2%) or Zineb (0.2%) is also recommended for the control of the disease.
5. Powdery mildew: The most common disease, powdery mildew is characterized by circular, powdery- white or gray spots that coat over leaf surfaces, spreading to stems quickly. The pathogen often attacks new growth in spring, deforming buds, flowers, leaves andshoots. The disease is caused by *Pseudoidium braunii* (Hosag.) Braun & Cook. Synonym of this fungus is *Oidium braunii*. The disease is managed by pruning the infected foliage to provide better aeration, follow proper water and nutrient management. Spraying with Wettablesuplur 0.2 % or Chlorothlonil 0.1% or Azoxystrobin @ 1ml / lit is also effective.
6. **Leaf blight:** The disease is widespread in its occurrence. *Cercospora jasminicola* Muller &Chupp infects *Jasminum officinale* and *Alternaria jasmini* attacks *J. auriculatum* Blight symptoms are produced by following two different pathogens:

a) *Cercospora jasminicola*: The symptoms appear as circular to irregular, reddish- brown spots with a darker border on both surfaces of leaf and other aerial parts of the plant. Severe infection leads to premature defoliation which has an adverse effect on flowering. The pathogen also attacks the stem and branches.
b) *Alternaria jasmine*: Symptoms appear as reddish-brown circular spots (2-8 mm in dia.) on the upper surface of leaves which spread rapidly during rainy season. In severe disease conditions, vegetative bud and young branches dry up.

The spread of the disease is high during rainy season with slight high temperature and humidity regimes. Collection and burning the infected plant debris and spraying carbendazim (0.1%) or benomyl (0.1%) or mancozeb (0.25%), or copper oxychloride (0.3%) is recommended.

1. **Leaf spot:** Leaf spot is caused by *Septoria aichisonia* Sydow. The disease starts as irregular to circular distinct spots are produced which are light yellow with reddish brown margins on upper surface and light –grey on the lower surface. The disease can be managed by spraying the crop either with zineb (0.25%) or mancozeb (0.25%) and repeat at 10 to 14 days interval depending on the severity of the disease.
2. **Anthracnose:** Anthracnose is caused by *Elsinoe jasmine* which produces **c**ircular to angular, raised spots with slight depressions on the lower surface of the leaves which are pinkish buff in colour and 1-5mm in diameter. Similar spots appear on tender shoots also. Later these spots coalesce to form large patches. Anthracnose is also caused by *Colletotrichum jasminicola* which produces large, circular, distinct and brownish to grayish spots outlined with brown to yellowish halo appear on the upper surface of the leaf. The infected tissues turn grayish in due course, become papery and fall off. Spots are studded with numerous acervuli. The pathogen overwinters in infected plant debris. High humidity and moderate temperatures are favourable for the initiation and spread of the disease. The disease is managed by destroying the infected plant debris and spraying the crop either with zineb (0.25%) or copper oxychloride (0.3%) at 10-14 days interval.
3. **Mosaic:** The diseased plants show stunted growth and yellowish green appearance with small leaves. Yellowish green to chlorotic flecks of 1-2 mm in diameter appear irregularly on the leaf. The streaks later form ring like structure which are more conspicuous on the older leaves. The virus responsible for this disease is Jasmine

Mosaic Virus. The virus is graft transmitted on *Jasminium simplicifolium*, *J. sambac* and *J. pubescens*. Destruction of the infected material and use of healthy stock is recommended. *J. auriculatum* is found relatively tolerant to the mosaic virus.

PLANT DISEASE MANAGEMENT

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71. Diseases of Flax and its Management

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Flaxseed is emerging as an important functional food ingredient because of its rich contents of α-linolenic acid (ALA, omega-3 fatty acid), lignans, and fiber. Flax is adversely affected by different diseases of Fusarium wilt and Rust has been considered major limiting factors in flax production in India.

1. Fusarium Wilt

Causal organism: *Fusarium oxysporum* f.sp. lini.

Symptoms

- In early infections seedlings may killed shortly after emergence, while delayed infections cause yellowing and wilting of leaves, followed by browning and death of plants
- The tops of wilted plants often turn downward and form a "shepherd's crook".
- Roots of dead plants turn ashy grey and show brownish vascular discoloration near collar region when stem is split open longitudinally

Disease Cycle

Primary inoculum: Soil borne chlamydospores and dormant mycelia on seeds

Secondary inoculum: Wind-blown and water run-off soil may spread the fungus from one field to another.

Management

- Use of resistant varieties like JRF-2 (released by ICAR- CRIJAF, Barracpore)
- Crop rotation of at least three years with Sorghum
- Seed treatment Trichoderma harzianum @ 4-6g or Carbendazim + Mancozeb @ 2g/Kg seed
- soil application of T. viride @4g/kg with 40 kg/ha well rotten FYM

2. Rust

Causal organism: *Melampsora lini*

Symptoms

Bright orange and powdery pustules appear on leaves, stems and also on bolls.

As the season progresses, the orange pustules turn black and produce over wintering telia and teliospores.

Disease Cycle

Primary inoculum: Teliospores on flax debris

Secondary inoculum: Windborne uredospores

Management

Growing resistant varieties like Jeevan (DPL-21), Him Alsi-I (KL-187)

Spraying Carbendazim or thiophenate methyl @ 1ml /lit

3. Phyllody

In India the disease was first reported by Biswas et al. (2014) Central Research Institute for Jute and Allied Fibres (CRIJAF) research farm, Barrackpore

Causal organism: Phytoplasma

Symptoms

- Floral virescence, phyllody, and stem fasciation (flattened stem).
- Floral malformation replaces normal flowers with green small hair like leaf structures.

Transmission

Transmitted by the leafhopper *Orosius albicinctus*, Akhtar et al. (2013)

4. Powdery Mildew

Causal organism: *Oidium lini*

Symptoms

- White powdery mass of mycelia that start as small spots and rapidly spread to cover the entire leaf surface
- Heavily infected leaves dry up wither and die.

Disease Cycle

Primary inoculum: Dormant mycelia on crop debris

Secondary inoculum: Windborne oidiospores

Management

- Field sanitation

- Use of resistant varieties like Jeevan (DPL-21), Him Alsi-I (KL-187)
- Spray of Hexaconazole or Propiconazole @ 1ml/lit twice at 15 days interval

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NEMATOLOGY

18441

72. The Necessity of Omics in The Field of Nematology and their Role in Nematode's Management

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INTRODUCTION: The phytonematodes are responsible for the huge crop yield losses worldwide. Even in many cases, these losses are unpredictable and uncountable. Because the characteristic visible symptoms are lacking in case of nematode infestation. The losses are attributed to both in the quantitative and qualitative term, for an example, reduced fruit size or malformation in grounded edible arts due to infestation will lead to an overall reduction in final yield. Even though the number and species of nematodes infecting host are numerous but they can be categorized into two genera based on their threat potential on crops, namely major genera which includes root-knot nematodes, cyst nematodes, foliar nematodes, citrus nematodes, burrowing nematodes etc. and minor genera which include mostly ectoparasites.

What do these Nematodes do?

Majority of nematodes infesting on the host, modify their cells and alter their physiology which helps in their survival by developing a successful interaction. The genes, guiding the interactions need to identify and a successful understanding of the mechanism of these interactions is the only way to develop a new type of management strategies. Throughout the world, the scientific communities are involved in creating the omics databases of various nematodes, which will help in understating and predicting the biology of another unknown species by sequence analysis. Today huge databases of genomic sequences and their functions of the model nematode *Caenorhabditis elegans* is available on the internet, namely Wormatlas and Wormbook. These data help in predicting similar genes in their functions in another nematode

Genomics in the Field of Nematology

The whole genomes sequencing of an organism helps in identifying the total gene pool of that species and in later stages, the work functions of those genes can also be predicted by bioinformatics analysis. In recent the next generation sequencing technologies are making the whole genome sequencing economic and feasible. The sequencing platform like Illumina, 454 sequencings, SOLiD, and Nanopore, all have certain advantages and limitations over one another and highly used today by the researchers. In the late 1990s, the whole genome sequencing of free-living model nematode *Caenorhabditis elegans* boosted the research for future nematode genomics. Today the sequences of economically important sedentary endoparasitic nematode *Meloidogyne incoginita*, *Meloidogyne hapla* and migratory endoparasite pine wilt nematode and *Bursaphelenchus xylophilus* is available. Many other sequencing projects of other important plant-parasitic nematodes in under progress in various part of the world.

The Necessities of the Whole Genome Sequences

These available whole genome sequences help in documentation of novel proteins involved in parasitism, reproduction, feeding behaviour, and various other aspects of biology. Upon identification of these functional genes and protein, some of them can be chosen as effective targets for drawing management perspectives.

Role of Transcriptomics in the Field of Nematology

The overall RNA profile on an organism is called as

transcriptome and the study of these transcriptome helps indirectly identifying the expressed genes as all the genes of an organism are not functional. The transcriptome data of some important nematodes are available on the internet like Wormbase or Nembase, which can be utilized to understand the transcriptomes of closely related other important nematodes.

Role of Proteomics in the Field of Nematology

The overall interaction mechanism between nematode and its host depends upon the protein-protein interaction at the target site and the secretion of specific proteins is affected by the environmental factors. Numerous effecter proteins for the sedentary and migratory endoparasitic nematodes have been documented and the proteome data is generated.

Summary with Significance of Omics in the Field of Nematology

The only way to manage nematodes in the field is to prevent them to get established above certain threshold limits. The correct and timely identification of problem causing nematodes is the first step to apply any management practices. Omics provides way for correct and fast identification of the exact nematodes based on the availability of sequence databases. Further omics helps in identifying the resistant genes in the host against nematodes, effector targets of nematode or genes utmost needed for the survival of nematodes. Thus, these genes can be target by gene silencing methods and help in devising alternative management tactics. Knocking down the genes involved in pathogenesis by nematodes helps in preventing losses to plant. The necessity of omics in the field of nematology cannot be underestimated and there is an immediate need to develop nematode's genomics databases.

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73. The Status of Plant Parasitic Nematodes and their Hosts in Rajasthan

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INTRODUCTION: The diversified climatic conditions in Rajasthan makes it unique in adopting different cropping patterns. The geographical area of the state can be categorized into the arid, semi-arid, humid and sub-humid zone. These zones support the growth of the wide range of agricultural and horticultural crops. The farming communities in the state grow wheat, rice, cotton, mustard, maize, pearl-millet, spices, fruits and many other economically important crops. The crops are grown by the farmers naturally suffers losses due to several abiotic and biotic factors. The biotic factors including various pest and pathogens are the key constraints in profitable crop production. The plant-parasitic nematodes fauna becoming thwarting biotic stress on the crops grown in the field or in the protected cultivation. These nematodes remain undiagnosed at the field by the farmers and cause huge quantitative and qualitative losses.

The Historical Status of Nematodes Problems in Rajasthan

The acceleration of any scientific research gain momentum once the existing problems challenge the scientific communities to come up with the solution. In the same way, the diagnosis and identification of the cyst nematode *Heterodera avenae* associated with the Molya disease of wheat and barley in the late 1950s by Vasudeva boosted the nematological research not only in the Rajasthan but also motivated the scientist at the national level to carry out the research work in the field of nematology. Later on, from the land of Rajasthan other nematodes like maize cyst nematode and pigeon-pea cyst nematodes were identified.

Division Wise Nematode's Presence in The State: The geographical regions are categorized in the seven division, which comprises a different type of plant-parasitic nematodes fauna.

Division	District under that division	Nematode fauna under the district	Host
Jodhpur	Barmer, Jaisalmer, Jalore, Jodhpur, Pali, Sirohi	*Heterodera avenae* *Meloidogyne* spp. *Hoplolaimus* spp.	Wheat, barley, bajra
Bikaner	Bikaner, Churu, Sri Ganganagar Hanumangarh	*Heterodera avenae,* *Meloidogyne* spp. *Pratylenchus* spp.	Wheat, barley, bajra, bengal gram, vegetables, rice, moth

Division	District under that division	Nematode fauna under the district	Host
Bharatpur	Bharatpur, Dholpur, Karauli Sawai Madhopur	*Tylenchulus semipenetrans* *Pratylenchus* spp. *Heterodera cajani* *Heterodera zeae* *Rotylenchulus reniformis*	Wheat, barley, bajra, bengal gram, vegetables, rice, moth
Udaipur	Udaipur, Banswara, Chittorgarh Pratapgarh, Dungarpur Rajsamand	*Heterodera avenae* *Meloidogyne* spp. *Pratylenchus* spp. *Heterodera cajani* *Heterodera zeae*	Wheat, cowpea, bajra, bengal gram, green gram, black gram, soybean, vegetables, fruit crops
Kota	Baran, Bundi, Jhalawar, Kota	*Meloidogyne* spp. *Rotylenchulus reniformis* *Tylenchulus semipenetrans*	Wheat, barley, bajra, bengal gram, green gram, black gram, soybean vegetables, rice, moth
Ajmer	Ajmer, Bhilwara, Nagaur, Tonk	Meloidogyne incognita Meloidogyne javanica	Wheat, barley, bajra, bengal gram, vegetables, rice
Jaipur	Jaipur, Alwar, Jhunjhunu Sikar, Dausa	*Heterodera avenae,* *Meloidogyne* spp. *Pratylenchus* spp	Wheat, barley, bajra, bengal gram, vegetables, rice

Plant Parasitic Nematodes of Economic Consideration

Even though the different types of nematodes infest the valuable crops, but few of them are much of scientific consideration as they cause unimaginable losses once they established themselves above the economic threshold level. In Rajasthan, the major group of thwarting nematodes are the root-knot nematode, cyst nematodes of wheat, maize and pigeon-pea, citrus nematode and reniform nematodes etc.

Management Guidelines and Advisory for the Farmers

The research regarding nematodes problem and diagnosis is currently done at two major locations in Rajasthan, at RCA Udaipur and RARI Jaipur. There are numerous management options are available for the management of these nematodes. The farmer should contact the scientific staff at these research station regarding the issues they face related to nematodes problem in their fields.

SUMMARY: Nematodes problems should not be neglected as once they established then managing them is a cumbersome task. Preventative measures, sanitation practices and advisory guidelines should be strictly followed to overcome nematodes related issues in cropping patterns to prevent yield losses.

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74. Citrus Nematode: A Major Threat to Citrus Production

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Tylenchulus semipenetrans is encountered throughout the world wherever citrus, grape vine and Rutaceae host, these second stage juveniles cause infection of the fine feeder roots and accompanied by secondary invaders like Fusarium and Macrophomina. These nematodes are considered as major plant-parasitic nematode because they can cause 30- 50% losses reported on citrus trees. Popularly use nematicide for their control and rootstocks in recent years is becoming a good alternative.

INTRODUCTION: Citrus is one of the major fruit crops grown in India. The sweet lime, citrus limetta, Citrus limettioides are more common in the North Western parts. These fruits are rich source of Vit. C. There are varied number of pests attacked which are widely distributed. Their attack and that of Nematodes are some of the factors contributing to the problem of citrus decline observed in various parts of India and South Asia.

The Citrus Nematode- *Tylenchulus semipenetrans* (Cobb, 1913)

In India it was first reported by Siddiqui (1961) from Aligarh (UP). This species is encountered throughout the world wherever citrus is grown. In

India also it has been recorded from almost all the states.

Hosts

All species of citrus and 11 other species of Rutaceae are hosts of *T. semipenetrans.* Besides, some populations attack olive, grapes, loquat etc.

Biology and Life Cycle

T. semipenetrans is sedentary semi-endoparasite. Second stage juveniles cause infection of fine feeder roots. The anterior portion of the body is embedded in the cortical tissues. The juveniles moult to young females which move their heads deeper inside the cortex. The posterior portion of the body becomes swollen. The mature females secrete a gelatinous matrix through excretory pore in which eggs are laid. Usually a single female lays 40-60 eggs. Several females are often found clustred at the same site depositing eggs in a common egg mass. Eggs hatch in about 12-14 days at 24° and come out into the soil. The life cycle takes about 6-8 weeks. The second stage juveniles destined to become males attain adulthood in soil without feeding.

In north Indian conditions, the nematodes attain peak populations during April and October. Maximum numbers are found 30-50 cm from the tree trunk in the top 30 cm soil. Coarse textured soils are not favourable for nematode reproduction.

Damage Symptoms

The nematode is responsible for slow decline or citrus decline disease of citrus. Symptoms of decline are similar to the caused by poor nutrition. The above ground symptoms are generally not distinguishable during the early years of plantation. Within 5-6 years, nematode reach to the level of pathogenic effect and damage to roots exhibits an adverse effect on the above ground parts of plant, Affected trees show reduced terminal growth, chlorosis and shedding of leaves, dieback of branches and considerable reduction in size and number of fruits. Young trees grow slowly and production delayed. Dieback symptoms first occur on upper position of tree which later extend to the lower portion. The nematode infested fibrous roots show irregular thickening and badly infected roots exhibits extensive necrosis which give them a rust brown colour. In heavily infested roots soil particles usually adhere with rootlets and finally the cortex separates readily from the vascular stele.

In the presence of *T. semipenetrans*, citrus plants become more infected by *Fusarium oxysporum* and *F. solani* and the combined activity of the nematode fungus is thought to be factor for poor growth of citrus.

Tylenchulus semipenetrans Cobb nematode and symptoms produced by them.

Management

- Nurseries should never be established on or near old citrus orchard
- The bare root treatment at 45°C for 25 min can disinfect citrus seedling from citrus nematode.
- Removal of old feeder roots before the growth flush followed by application of FYM.
- Interculture of onion, garlic or marigold reduces the nematode population and also provide additional income.
- Hybrid citrus rootstock developed by crossing Rangpur lime were reported highly resistant to the pest.
- Application of Carbofuron @ 4 and 6 kg a.i./ha, Benfurocarb @ 4 and 6 kg. a.i./ha and combination of neem cake @1kg/plant is effective.

Conclusions: *Tylenchulus semipenetrans* is encountered all region of world on citrus, grape vine and Rutaceae host, considered as major plant-parasitic nematode causing 30- 50% losses reported

on citrus trees. Mostly use of chemicals and bio-nematicide for their control and resistant rootstocks in recent years is becoming a good alternative to increase yield.

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18554

75. Biological Control of Plant Parasitic Nematodes

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INTRODUCTION: Plant parasitic nematodes are responsible for causing yield loss worth billions of US dollars in annual and perennial crops. Many of them are polyphagus and feed on crops belonging to diverse botanical families. Among all plant parasitic nematodes, root knot and cyst nematodes have a sophisticated interaction with the host making them most important crop pests. Because of the increasing concern about hazardous effects of chemical nematicides and withdrawal of many nematicides from markets due to their harmful effects on environment and human health, biological control offers an effective alternative to chemical nematicides. Plant parasitic nematodes interact with a number of soil microbes including bacteria, fungi, actinomycetes, etc. Some of them are antagonistic towards nematodes and have potential to suppress nematode multiplication in soil. Some of the important bio control agents effective against plant parasitic nematodes are listed in table.1.

TABLE.1: Bio-agents effective against plant parasitic nematodes

Genera	Mode of action	Nematode targeted
Bacteria		
Pasteuria penetrans P. thornei, P. nishizawae	Spores multiply inside the nematode forming endospores	*Meloidogyne* spp., *Pratylenchus* spp. *Heterodera, Globodera* spp.
Brevibacillus laterosporus	Digest the host tissue for multiplication	Heterodera glycines, Bursaphelenchus xylophilus,
Pseudomonas fluorescens	Production of secondary metabolites	Heterodera spp.
Rhizobium etli Paenobacillus macerans, Bacillus amyloliquefaciens and B. firmus	Induced systemic resistance	*Globodera pallida*, *Meloidogyne incognita* and other plant parasitic nematodes
Fungi		
Dactylella dianchiensis, Arthrobotrys oligospora Arthrobotrys botryospora, Arthrobotrys brochopaga,	Adhesive network Adhesive hyphae Constricting rings and Non-Constricting rings	Vermiform stages of plant parasitic nematodes
Drechmeria coniospora	Production of parasitic spores	Vermiform stages of plant parasitic nematodes
Pochonia spp. Paecilomyces spp.	Infect eggs of parasitic nematodes	Cyst and root-knot nematodes
Trichoderma virens	Inhibited egg hatch and mobility of hatched juveniles	*M. incognita*
Glomus mosseae	Competetion	Root knot nematodes
Algae, Ascophyllum nodosum	Production of toxic secondary metabolites	*M. incognita* and *M. javanica*
Predatory nematodes, Mononchus spp.	Ingestion of whole nematode or piercing and sucking od nematode body contents	Vermiform stages of plant parasitic nematodes
Protozoan, Theratomyxa webari	Encysting and engulfing of nematode	*Heterodera schactii* and *Globodera rostochiensis*

It is a well-known fact that these bioagents have greater potential in the management of plant parasitic nematodes. There are many biopesticide formulations available in market in the form of

wettable powders, aqueous suspensions, dust etc and some of the important formulations are listed in table 2. It is necessary to understand interaction among biocontrol agents, targeted nematode species, soil biota, plant and environmental factors for successful application and establishment of a bioagent.

TABLE. 2: Bio-nematicide formulations available in India

Product name	Formulation	Bioagent	Nematode targeted	Company
Nemator	Wettable powder	*Paecilomyces lilacinus*	Root knot nematodes and cyst nematodes	Biotech International Limited, Delhi
Nematocure	Wettable Powder	*Bacillus firmus*	Plant parasitic nematodes	Biotech International Limited, Delhi
Bouncer	Talc	*Pseudomonas fluorescens*	Plant parasitic nematodes	Curative Microbes Pvt. Ltd, junagadh, Gujarat
Bionemagon TM	Wettable Powder	*Bacillus firmus*	Plant parasitic nematodes	Agri Life, Hyderabad, Telangana
Niyanthran	Liquid suspension	*Paecilomyces lilacinus*	Soil borne plant parasitic nematodes	Multiplex pvt. ltd, begaluru
Nematofree	Wettable powder	*Paecilomyces lilacinus*	Endoparasitic nematode pests	International Panacea Limited, India
Nematoz-free	Wettable powder	*Paecilomyces lilacinus*	Root knot nematodes and Cyst nematodes	Utkarsh agrochem pvt. ltd, surat, gujarat
Green nemafree	Liquid suspension	*Pochonia chlamydospria*	Nematode pests of horticultural crops	Greenlife biotech laboratories, Coimbatore, tamilnadu
Mysis	Wettable powder	*Paecilomyces lilacinus*	Nematode pests of horticultural crops	Varsha bioscience and technology, telangana
Nemastin	Wettable powder	*Paecilomyces lilacinus*	Nematode pests of horticultural crops	KAN Biosys Private Limited, Pune, Maharashtra
Nemakill		*Paecilomyces lilacinus and Arthrobotrys spp*	Plant parasitic nematodes on different crops	KAN Biosys Private Limited, Pune, Maharashtra
Trichoderma Harzianum	Wettable powder	*Trichoderma harzianum*	Plant parasitic nematodes on different crops	Uttam Chemical Industries, Rajasthan
Ecosom-TH	Dust	*Trichoderma harzianum*	Plant parasitic nematodes on horticultural crops	Agri Life SOM Phytopharma (India) Limited, Hyderabad

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76. Secondary Metabolites: A Defense Mechanisms of Plants Against Insect Pests

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Plant-ecosystems square measure related to range of prospective enemies like microorganism, viruses, fungi, nematodes, mites, insects, mammals, and alternative anthophilous animals. By their

nature, plants cannot avoid these herbivores and pathogens just by moving away; they have to protect themselves in alternative ways that. Plants turn out the amount of natural product or secondary metabolites with a outstanding perform within the protection against its enemies on the idea of their toxic nature and repellence to herbivores and microbes and a few of that additionally concerned in defense against abiotic stress and additionally vital for the communication of the plants with alternative organisms and square measure insignificant for growth and biological processes. There square measure 3 major teams of secondary metabolites viz., terpenes, phenolics, N and S containing compounds. Recent in vitro experiments victimization plants whose secondary metabolites expression has been altered by trendy molecular strategies got to make sure their defensive roles. Although the scenario is still unclear, it is believed that almost all of the additional then thousands of known secondary metabolites square measure to be concerned in plant chemical defense systems, which square measure shaped throughout the millions of years throughout that plants have co-existed with their attackers. Although high concentrations of secondary metabolites may lead to a more resistant plant, the production of secondary metabolites is assumed to be expensive and reduces plant growth and replica. The price of defense has also been invoked to elucidate why plants have evolved induced defense, where concentrations typically increase solely in stress things. Throughout the previous years, it has been discovered that many compounds that plants build have vital ecological and chemical defensive roles, opening afresh space of scientific endeavor, usually referred to as ecological organic chemistry.

What is Secondary Metabolite?

Plants turn out an oversized and numerous arrays of organic compounds that seem to possess no direct functions in growth and development. They need no significance roles within the physiological method like chemical action, respiration, matter transport, translocation, nutrient assimilation and differentiation. These compounds square measure called secondary metabolites or secondary product or natural product. They have a really restricted distribution than primary metabolites within the whole kingdom i.e. they're usually found solely in one plant species or a taxonomically connected cluster of species. High concentrations of secondary metabolites may lead toa additional resistant plant. Plant secondary metabolites may be divided into following teams,

1) Terpenes

Terpenes represent the most important category of secondary metabolites and square measure united by their common synthesis origin from acetyl-coA or glycolytic intermediates. a massive majority of the various terpenes structures made by plants as secondary metabolites that square measure likely to be involved in defense as toxins and feeding deterrents to a sizable amount of plant feeding insects and mammals. Below, many examples can draw from the 5major subclasses:

a) **Monoterpenes (C10)-** Pyrethroids (monoterpenes esters) occur within the leaves and flowers of Chrysanthemum species show sturdy neurolysin to insects like beetles, wasps, moths, bees, etc. and a well-like dingredient in business pesticides owing to low persistence within the surroundings and low-class toxicity.

b) **Sesquiterpenes (C15)-** Costunolides square measure anti herbivore agents of family composite characterized by a 5 6-membered lactone ring (a cyclic ester) and have sturdy feeding repellence to several anthophilous.

c) **Diterpenes (C20)-** Abietic acid could be a diterpene found in pines and herb trees. it's gift in or in conjunction with organic compounds in resin canals of the trunk. once these canals square measure perforated by feeding insects, the outflow of organic compound might physically block feeding and function a chemical deterrent to continuing predation.

d) **Triterpenes (C30)-** Phytoecdysones (triterpenes) have some defensive role against insects by disrupting ecdysis and alternative biological process and physiological processes with fatal consequences.

e) **Polyterpenes $(C5)_n$** - Rubber found in long vessels referred to as laticifers, give protection as a mechanism for wound healing and as a defense against herbivores.

ii) Phenoplast Compounds: Plants turn out an oversized style of secondary products that contain a phenol cluster, ahydroxyl useful cluster on AN aromatic ring called Phenol, a with chemicals heterogeneous group additionally. They might be a very important half of the plant's arms against pests and diseases as well as root parasitic nematodes.

a) **Coumarin-** They derived from the shikimic acid, common in microorganism, fungi and plants however absent in animals. Also, they're an extremely active cluster of molecules with a good vary of anti-microbial activity against each fungi and microorganism. it's believed that these cyclic compounds behave as natural pesticidal defense compounds for plants.

b) **Furano-coumarins-** Psoralin, a basic linear furacoumarin, well-known for its use within the treatment of plant life defense and located terribly seldom in SO2 treated plants.
3. Ligin- it's a extremely branched compound of phenyl-propanoid teams, shaped from 3 totally different alcohols viz., coniferyl, coumaryl and sinapyl that change to free radicals (ROS) by a omnipresent plant enzyme-peroxidase, reacts at the same time and willy-nilly to create polymer. Its physical toughness deters feeding by anthophilous animals and its chemical sturdiness makes it comparatively inedible to herbivores and insects' pathogens.

c) **Flavonoids**- One in every of the most important categories of plant phenoplast, perform terribly totally differentfunctions in plant system as well as pigmentation and defense.

d) **Isoflavonoids-** Isoflavonoids square measure derived from a flavonone intermediate, naringenin, ubiquitously gift in plants and plays a essential role in plant biological process and defense response.

e) **Tanins-** Tannins square measure general toxins that considerably cut back the expansion and survivorship of the many herbivores and additionally act as feeding repellents to a good diversity of animals the defensive properties of tannins square measure typically attributed to their ability to bind proteins. Protocatechllic and chlorogenic acids most likely have a special perform in illness resistance of bound plants.

iii) Sulphur and gas containing secondary metabolites

Sulphur containing secondary metabolites includes GSH, GSL, phytoalexins, thionins, defensins and allinin that are coupled directly or indirectly with the defense of plants against microbic pathogens, and a number of them thought to be concerned within the SIR. While, gas containing secondary metabolides includes alkaloids, cyanogenicglucosides, and non-protein amino acids. Most of them square measure biosynthesized from common amino acids. All square measure of goodish interest owing to their role within the anti-brute defense and toxicity to humans.

Conclusion: Plants have evolved multiple defense mechanisms against insect pests and varied kinds of environmental stress. In a very range of previous analysis articles and review papers, show that plant made many secondary metabolites that have defensive mechanisms against pests. Therefore, extra analysis in space of natural pesticides development is required in current situation. Within the future, it'll most likely be attainable factor rate to get to come up with} gene cassettes for complete pathways, that might then be used for production of valuable defensive secondary metabolites in bioreactors or for metabolic engineering of crop plants. This can improve their resistance against herbivores and microbes pathogen further as varied environmental stresses.

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77. Role of Digestive Enzymes in Insect Pest Management

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INTRODUCTION: The common method of insect control is usage of synthetic insecticides, which lead to various problems to human, animals and as well as environment. So, the pest management tends to focus on alternative methods among which disruption of insect digestive physiology is prominent. There are many specific inhibitors, especially against the digestive enzymes viz., amylases and proteases, which suppress their activity resulting in an overall disturbance in digestion. Many of these inhibitors are in use for incorporating resistance in transgenic plants. In fact, creating resistant varieties using a biotechnological approach has led to the development of insect-resistant transgenic plants through the transfer of resistance genes to suppress insect growth. It is mandatory to study the associated digestive enzymes and their processes in order to develop genetically modified resistant host plants. The digestive enzymes of insects could be a target to overcome their feeding ability so their developmental secretion and site of activity in the insect gut needs some specific attention.

Digestive Enzymes of Insects

Insects obtain their nutritional requirements by digestion and utilizing of ingested food from the environment. This process is perfectly controlled by digestive enzymes that depend on their site of activity in the insect gut. The major digestive enzymes in the midgut of insects consist of α-amylases and proteases that are similar in their hydrolytic nature.

1. à**-amylases:** These are widespread hydrolytic enzymes found in microorganisms, animals and plants. They catalyze the initial hydrolyses of α-1,4-linked sugar polymers, such as starch and glycogen, into shorter oligosaccharides, an important step towards transforming sugar polymers into single units that can be assimilated by the organism. The inhibitors, which inhibit this activity of amylase, are known as α-amylase inhibitors. For instance, pea weevil *Bruchus pisorum* is sensitive to the bean inhibitor αAI-1, yielding a high larval mortality (93%) in the pests. Coffee plants were also transformed with

αAI-1 and became resistant to the coffee berry borer *Hypothenemus hampei*.

2. **Proteinases:** Depending on the midgut pH, insect proteinases are of following types:

Types	Properties	Examples
Serine proteinases (active at alkaline pH)	Large family of proteolytic enzymes and cleave endopeptide bonds	Trypsin, Chymotrypsin and Elastase
Cysteine proteinases (active at alkaline pH)	Cleave endopeptide bonds; papain family is most prominent	Papain, Glycyl peptidases and Cathepsins B and H
Aspartic proteinases (active at acidic pH)	Cleave peptide bonds that have hydrophobic residues and beta-methylene group	Pepsin, Cathepsins D and E, Renin
Metallo proteinases (involves a metal)	Zinc, manganese and cobalt coordinated to the protein via ligands.	Meltrin

Proteinase inhibitors (PIs): They inactivate protease activity of insect pests and are highly proven inhibitory activity. The following are the various proteinase inhibitors:

I. **Serine proteinase inhibitors:** The major role of serine PIs is to block the activity of endogenous proteinases from the digestive tracts of insects. Particularly in lepidopteran insect order many of the enzymes are inhibited by proteinase inhibitors. Serine proteinases and metalloexopeptidase are most active in alkaline pH range. They are also having antinutritional effects against several lepidopteran insect pests. Ex: Trypsin inhibitors at 10% of the diet were toxic to larvae of the *Callosobruchus maculatus* and *Manduca sexta*.

II. **Cysteine proteinase inhibitors:** Several cysteine proteinases are isolated from different insect larvae. They are inhibited by both synthetic and naturally occurring cysteine proteinase inhibitors. Especially, several coleopteran order insects contain cysteine proteinase in their midguts. Ex: P- chloromercuribenzene sulphonic acid (PCMBS) a potent sulfhydryl reagent effective against the beetles.

III. **Aspartic and metalloproteinase inhibitors:** Aspartic proteinases (cathepsin D-like proteinases) were found in species of six families of the order hemiptera, along with cysteine proteinases. Metalloproteinase inhibitors are evolved in several plants. As metallocarboxypeptidase inhibitors found in potato and tomato plants, cathepsin D inhibitors are present only in potatoes. Ex: Pepstatin, a specific inhibitor of aspartyl proteinases strongly inhibited the proteolysis of the midgut enzymes of Colorado potato beetle.

Developing Insect-Resistant Transgenic Plants Expressing Enzyme Inhibitors

The choice of suitable PIs on development of transgenic crops represents a success or failure of any pest control strategy relying on protease inhibition. Firstly, the choice of suitable PIs should be based on a detailed understanding of the target biological system. Resistant biotypes of insects may evolve after prolonged exposure to selection pressure that is mediated by an insecticidal protein or plant resistance gene. Secondly, the targeted expression of PIs in response to pest attack could be controlled by using inducible promoters, such as those of PI-II85 and TobRB7 that are activated at the site of invasion by pests, pathogens and nematodes, respectively. The promoter should be active to mediate a substantial defence, especially localized to the site of pest invasion. Suitable promoters such as those regulated in response to pest invasion can be identified by using promoter trapping techniques.

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78. Semiochemical Parsimony in Different Insects

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INTRODUCTION: Semiochemical (Greek: *Semeion*, a signal) are signalling chemicals produced by an organism to send a message. They are divided into two categories based on whether the use of chemical is between members of the same species (pheromones) or different species (Allelochemicals). Number of pheromones have been identified with a single function (*e.g.*, alarm and sex pheromones); in contrast few among them possess multiple functions. The use of same chemical for two or

more functions in different contexts is referred to as semiochemical parsimony or pheromone parsimony. These multifunctional pheromones are proved to be well developed in eusocial insects *e.g.*, honeybees. Originally, pheromones are used as defensive compounds. Further, evolutionary development used these chemicals in communication. Consequently, insects may exploit these secretions for disparate diverse roles that can include defence and sexual attraction. Recently this parsimony was also observed in ladybird beetle, a potential predator in agricultural pest management. A few parsimony activities observed in termites, honey bees, ants and ladybird beetles are discussed below.

Semiochemical Parsimony in Termites

The chemical parsimony of termites is also functional *i.e.*, the same compound is secreted by different glands, different species and for different functions. Termites likely employ the antimicrobial volatiles to protect eggs and queens and secondarily as communication agents informing queen fertility. They are also involved in colony organization including foraging, defence, brood care and caste regulation. The chemical (3Z, 6Z, 8E) - dodecatrien-1-ol has been identified in different species of termites which is multifunctional and acts as both as trial and sex pheromone.

Semiochemical Parsimony in Honey Bees

In general, multifunctional pheromones were prominent in queens of eusocial species. In honey bee, queen substance is involved in many functions like maintaining the social structure of the colony, regulating worker tasks and maintaining own reproductive dominance etc. Especially, queen substance (9-oxo-2-decenoic acid) of the honey bee, *Apis mellifera* possesses unrelated primer and release functions for the workers and act as sex attractant for drones.

Semiochemical Parsimony in Ants

In ants cuticular hydrocarbons (CHCs) have at least two pheromonal functions. They act as recognition cues that facilitate colony insularity protecting it from parasites. The second function of CHCs is in signalling fertility. In ants, this dual function seems contradictory since nestmate recognition necessitates a uniform colony odour, whereas fertility signal requires peculiarity since the fertile individual needs to be singled out among the colony members, rather than confirm the colony odour. A possible resolution is that species that use CHCs for nestmate recognition do not use them as fertility signals and vice versa.

Semiochemical Parsimony in Ladybird Beetles

Aphidophagous ladybird beetles use chemicals with parsimonious versatility like social insects. In ladybird beetle, various chemicals are involved parsimonious activities. The chemical 3-alkyl-2-methoxypyrazines are major defensive compounds against predators and associated with bright colourations of the beetle. The cuticular hydrocarbons act as arrestants in aggregations, protect insect against desiccation and mediate several kinds of behaviour like mate recognition, conspecific recognition. Coccinellid larva deposit oviposition deterring semiochemicals (ODS) from the tip of their abdomen. These ODS are found on the elytra of the adults and on the surface of conspecific eggs. This chemical on elytra is used in mate recognition and on the surface of the eggs it acts like a chemical defence against intraguild predation. A similar chemical is also secreted from the under surface of ladybird tarsi aiding adhesion onto smooth surfaces.

Conclusion: A wide variety of arthropods have adapted their own semiochemicals to promote multiple functions in diverse contexts. The semiochemical parsimony has been identified in many arthropods and it plays a key role in evolutionary biology of the arthropod. The alarm pheromones of many arthropods are also used as defensive allomones, activity inhibitors, aggregative attractants, trail pheromones and antimicrobial agents. In addition, some of these compounds possess highly distinctive roles, such as functioning as lethal attractants for prey or in the aquatic substrate as cuticular wetting agents. Certainly, the availability of a variety of pheromones and allomones has permitted arthropods to evolve to effective semiochemical parsimony with which to exploit the biological environment.

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79. Pesticide Resistance Management: An Essential Part of IPM

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INTRODUCTION: Pesticide resistance is the development of an ability to tolerate a dose of a pesticide, which would prove lethal to the majority of the individuals in a normal population of the same species. It is caused by a genetic change in response to selection pressure. With the continuous use of

pesticide, the heterozygous resistant genotype has a selective advantage over the susceptible. Thus, the heterozygous resistant genotypes, with high fitness, get selected to survive, reproduce and evolve making completely different version. The process of selection can be rapid or develop slowly over a number of years, depending on the pest, its genetics of resistance to the pesticide and the exposure to a particular pesticide.

Resistance management presently aims at reducing the resistant individual's fitness when insecticide is applied or reduce the total amount of selection pressure applied. The amalgamation of the various disciplines is essential to understand the many aspects of the evolutionary process and to implement successful resistance management.

Three Basic Resistance Mechanisms Seen in Arthropods

1. Decreased rate of cuticular penetration probably only delays the onset of symptoms,
2. Increased rate of metabolic detoxification achieved by several enzymes like mono-oxygenases, hydrolases, glutathione-Stransferases and DDTases etc.
3. Target site insensitivity achieved against pyrethroid and organophosphorus pesticide by reduction of the amount of toxin reaching the vulnerable target.

Definition

The resistance management is the use of methods that extend the number of generations that a given pest population can be controlled economically by a pesticide (Rick Roush).

Georghiou has Proposed three Categories of Management Strategy based on Insecticide use

1. **Moderation**: Application of pesticide at a rate that brings less than 100% mortality of susceptible ones, thus the susceptible genes gets preserved. This can also be achieved by incomplete coverage or by leaving untreated area. Hence the onset of resistance is delayed.
2. **Saturation**: The resistance mechanism is overwhelmed with high doses that are sufficient enough to kill both the susceptible and heterozygous resistant genotypes. This can also be achieved by use of synergists.
3. **Multiple attack**: In this case the resistance is managed by mixing or sequencing pesticides with different mode of action so as to reduce the selection pressure of one which leads to develop resistance.

Later Roush proposed ten management strategies which either reduce the fitness of resistant individuals or reduce total selection pressure

1. Increase insecticide dose so as to kill heterozygotes or resistant homozygotes
2. Use chemical compounds that confer lower levels of resistance
3. Treat the pest at its most vulnerable life stage
4. Use synergists to suppress the mechanisms of detoxification
5. Mix pesticides with different modes of action and metabolism
6. Decrease concentration of pesticide use to ensure some of the susceptible individuals exposed to the pesticide survive
7. Reduce the pesticide application number
8. Use pesticides with less residual activity and avoid slow release formulations
9. Use spot treatments
10. Rotate pesticides so that not all the generations are exposed to the same chemical

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80. Mass Production and Field Application HNPV

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INTRODUCTION: *1Helicoverpa armigera* Hubner, chickpea pod borer is a serious pest of legumes, cotton and vegetables in the Indian subcontinent. Widespread appearance of resistance to chemical insecticides has stimulated efforts to develop alternative control methods including the use of insect viruses against this pest. A new idea for integrated pest management of *Helicoverpa armigera* is use of naturally occurring disease causing, the Helicoverpa nuclear polyhedrosis virus (HNPV).

Mass Production

The process of making NPV is simple. Larvae are first collected from the field by shaking pigeon pea plants. In the production center, they are fed on soaked chickpea seeds mixed with virus (40 Larval Equivalents (LE) for every kg of seed). The infected larvae are reared until they die of the virus. The carcasses that display clear virus symptoms are then picked and macerated in a blender with clean water. The mixture is then filtered through a muslin cloth. The filtrate is centrifuged for about 15 minutes at

5000 rpm. The supernatant liquid is discarded and the residue is assessed for quality (amount of virus particles presents in a given volume)

Measuring the Quality of Virus

Measure the quality of virus by Haemocytometer.

Either dark field or phase contrast microscope is needed to count the polyhedral inclusion bodies (PIB) using a Haemocytometer.

The dose of virus is expressed as larval equivalent (LE) and one LE is 6 x10^9 POB.

One LE can be had from three fully grown up and virus infected larvae.

Commercial Products

Elcar, Gemstar and Spodo-X.

Application

Spraying the NPV late in the day after peak sunshine to improving the effectiveness of the NPV.

Adding UV absorbents use of 1 ml of robin blue nil to a litre of spray solution has been reported as improving the effectiveness of the NPV.

For gram, pigeon pea and cotton HNPV should be used at250-300LE, 500LE and 250LE/ha.

Mode of Action

Ingestion of occlusion bodies (POBs) by insect larvae

↓

In the highly alkaline pH of the insect midgut the occlusion body protein dissolve and further degraded by the host alkaline proteases.

↓

As result of dissolve and degradation of polyhedral occlusion bodies the virions are released and subsequently attached to the peritrophic membrane lining of the midgut. virion invade the coloumnar cells of the midgut and integrate DNA in to the nucleus of midgut cell.

↓

The DNA of the virus multiply rapidly and diventually fill the body of the host with virus particles.

↓

Cessation of feeding and followed by of the larvae from virus infection occurs within 3 to 8 days.

Symptoms

The insects that are infected stop feeding and the larvae turns in to pinkish white on the ventral side because of accumulation of polyhedral bodies.

In advanced stage of the larvae if the infection continues, larvae become flaccid, skin becomes fragile and finally ruptures.

The diseased larvae in the field crawl to tip of the plant and from that position it hangs upside down. This symptom is called as tree top disease.

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81. Chemo-Ecology of Insect-Plant Interaction

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INTRODUCTION: Communication of an organism with surrounding environment is an important aspect which is necessary for its interaction with other components of ecosystem which gives it the stability in the ecosystem. Having the capacity to produce their own food by photosynthesis, plants play a very important role in our ecosystem. One of the way through which plants interact with its surrounding is through release of volatiles *i.e.* volatile organic compounds (VOCs), most of which are stored in glandular trichomes or resin ducts (Gershenzon *et al*., 2000; McGavery and Croteau, 1995) that are released from different organs such as flowers, fruits and leaves (Tholl *et al*., 2006). VOC's are often complex mixtures, comprising several hundred compounds and more than 1000 volatiles have so far been identified. VOC's are low-molecular and largely lipophilic molecules with high vapour pressure mostly belonging to the classes of terpenes and non-terpene aliphatics (including nitrogen- and sulfur-containing compounds), phenylpropanoids and benzenoids which serve various ecological roles.

Insect-Plant Interaction

In the context of insect-plant interactions, plant volatiles play a very crucial role by helping herbivore insects to locate host plants besides enabling parasitoids and predators to locate their host insects. While floral volatiles serve as attractants for species-specific pollinators (Pichersky and Gershenzon, 2002). Two hypotheses have been proposed regarding location of hosts by specialist and generalist phytophagous insects (Visser, 1986): first hypothesis is based on 'token stimuli' theory of Gottfried Fraenkel which says that highly specific volatiles of particular species are used for host recognition (species-specific odour recognition) whereas second hypothesis says that plant odour specificity is achieved through ratio specific odour recognition. The volatile compounds released from herbivore damaged plants can be sub-divided into two major groups – constitutive and inducible or herbivore induced plant volatiles.

Constitutive compounds are present constantly in plants and are released immediately in response to mechanical damage or at the beginning of herbivore feeding. They include green leaf volatiles (GLV's) such as *cis*-3-hexenol, hexanal and *cis*-3-hexanal. In contrast, herbivore induced plant volatiles (HIPV's) are emitted as a delayed response to herbivore feeding damage. They include *cis*-3-hexenyl acetate, *cis*-3-hexenyl butyrate, indole and various terpenoids such as α-farnesene, β-farnesene, β-ocimene and linalool. Since the early work of Dicke and co-workers and Turlings and co-workers in the early 1990's, several studies have documented volatile blends released from herbivore damaged plants differ qualitatively and quantitatively depending on the plant species and variety. These volatiles blends have been documented to provide cues to parasitoids which enable them to locate their host insect pests.

During the past decade, a new dimension has been introduced to our understanding of the role of chemical cues mediating tritrophic interactions. De Moraes *et al*. (1998) described the ability of a parasitoid to distinguish tobacco plants damaged by *Heliothis virescens* and those from tobacco plants damaged by *Helicoverpa zea* or undamaged plants. In yet another study volatile produced by tobacco plants at night upon damage by *H. virescens* are found to be different and female moths exploit these night time volatiles to avoid oviposition on previously damaged plants. However, like many adaptations, plants operate with a high level of economy. A useful distinction is the type of plant defense – be it constitutive or induced. Although both are effective, direct defenses are generally not lethal and indirect defenses may act late or reduce pest damage minimally. In the recent past, several studies have challenged these questions by describing systems in which plants actually respond to oviposition by an herbivore by killing the eggs directly or by attracting natural enemies that eat them before they hatch. The first study demonstrated that egg deposition induces a change in plant volatile emission locally at the site of egg deposition was a study of elm (*Ulmus minor*) laden with eggs of the elm leaf beetle, *Xanthogaleruca luteola*. Odor from elm leaves laden with eggs was shown to attract the specialist parasitoid, *Oomyzus galerucivorous*.

Techniques to Study Insect-Plant Interaction

In order to analyze the response of insect to plant volatiles and also other compounds certain electrophysiological techniques have been developed. As the plant volatiles are mixture of diverse compounds these compounds are separated and exposed to insect antenna simultaneously through GC-EAD (gas chromatography - electroantennographic detection) which is thought to be best method for analysing pant volatiles. In another technique called electroantennography (EAG) the compounds after being purified or synthesized in a separate process are exposed to the antenna. Tip recording for recording impulses from gustatory neurons, electroantennogram for recording impulses from sensilla on the antennae, single-sensilla recordings

for recording impulses from individual sensilla to volatile stimuli – using a sharpened tungsten electrode etc. Once the neurological response is established the selective chemicals are tested through olfactometer to study attraction or repulsion for the same by insect pests.

Applications of Insect-Plant Interaction

Studying an approach with emphasis on insect-plant interactions will not only help to understand ecological and evolutionary relations but also to develop novel crop protection strategies, either by engineering or selecting crop plants for endogenous resistance to insect pests or by treating crops with semiochemicals to make them less attractive, developing novel lures to attract males and females of pests and as a mean of monitoring and forecasting populations. With increasing evidences on problems related to indiscriminate use of synthetic pesticides, attempts to search for alternative methods of crop protection has been a global effort. In this regard, studies on chemical ecology will be a viable alternative.

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82. Insecticide Resistance in Green House White Fly (*Trialeurodes vaporariorum* Westwood)

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Trialeurodes vaporariorum is one important pest of field and greenhouse crops of horticultural and ornamental plants. Crop losses caused by adult and nymph direct feeding may be substantial, and plant quality and vigor may also be indirectly affected by the development of epiphytic fungi on the honeydew excreted by the whitefly nymphs. The transmission of plant Clostero-viruses is often the most devastating indirect effect mediated by the greenhouse whitefly.

In Integrated Pest Management (IPM) programs, greenhouse whitefly populations are currently regulated by combining chemical with biological control (Gorman *et al.* 2002). Biological control in greenhouses is mainly based on the release of parasitoid insects, such as *Encarsia formosa* Gahan and *Eretmocerus eremicus* Rose & Zolnerowich, as well as predatory mites (*e.g. Amblyseius swirskii* Athias-Henriot and *Amblydromalus limonicus* Garman & McGregor) and insects, such as the mirid *Macrolophus pygmaeus* Rambur.

Insecticide Resistance can Result from two Main Types of Mechanism

1. Reduced binding of the insecticide to its target through target site mutations (*e.g.* acetylcholinesterase for organophosphates/ carbamates, the voltage-gated sodium channel for pyrethroids and the nicotinic acetylcholine receptor for neonicotinoid insecticides) (Pittendrigh *et al.*, 2008) and
2. Increased detoxification or sequestration of insecticides (Ranson *et al.*, 2002; Pittendrigh *et al.*, 2008) by enzymes such as carboxyl-cholinesterases (CCEs) (Oakeshott *et al.*, 2005), glutathione-S-transferases (GSTs) (Ranson & Hemingway, 2005) and cytochrome P450 monooxygenases (Feyereisen, 2005). Also, there are cases of resistance caused by reduced toxin penetration, increased toxin excretion or even behavioural resistance (avoidance of insecticide). A pest can develop more than one mechanism of resistance (multiple resistance) to one or more different compounds. Cross resistance, occurs when the genetic mutation that made the pest resistant to one pesticide also makes it resistant to other pesticides, more commonly affecting compounds with similar modes of action (Pittendrigh *et al.*, 2008).

Insecticide Resistance and Cross-Resistance In *Trialeurodes vaporariorum*

Trialeurodes vaporariorum has developed resistance to several insecticide groups. The first documented occurrence of resistance involved pyrethroid and organophosphate insecticides during the 70s and 80s. By the mid-80s, this resistance had become widespread in the UK (Wardlow *et al.*, 1976; Wardlow, 1985; Wardlow, 1987). Furthermore, resistance to the insect growth regulators buprofezin and teflubenzuron has been documented in Northern Europe and the Mediterranean region (De Cock *et al.*, 1995; Gorman *et al.*, 1998; Gorman *et al.*, 2002). Organophosphate resistance in whiteflies arises most likely through changes in target site (AChE) sensitivity and/or insecticide detoxification by CCEs or P450s (Cahill *et al.*, 1995; Gorman *et al.,* 1998; Javed *et al.*, 2003; Alon *et al.*, 2008).

Management

Cultural Control

- Healthy plants
- Judicious application of suitable insecticides
- effectiveness of UV absorbent plastic films at reducing T. vaporariorum infestations on protected crops (Mutwiwa et al., 2005).

Biological Control

- E. formosa parasitizes T. vaporariorum, each female being capable of laying 50-200 eggs during its lifespan of 10-14 days.
- The predatory beetle Delphastus pusillus
- Lacewings (species of Chrysoperla) are also used as general predators of glasshouse pests and will consume whiteflies.
- The fungal pathogen Verticillium lecanii attacks whiteflies and thrips and can be a useful control agent in situations where the crop is grown in high humidities (Masuda and Kikuchi, 1993).
- Microbial insecticides based on the entomopathogenic fungus Paecilomyces fumosoroseus have also been used for the control of T. vaporariorum (Bolckmans et al., 1995; Sterk et al., 1996).

Chemical Control

- Use insecticides selectively, and alternate classes of insecticides.
- Thorough coverage.
- Target susceptible stages.
- Soaps and oil sprays.
- Rotations and multiple applications

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83. Field Level Identification of *Spodoptera* Species

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The noctuid genus Spodoptera contains many pests throughout the world (Kranz et al. 1977, Hill 1975). Four species are known to cause serious damage in India. *Spodoptera litura* Fabricius, *Spodoptera mauritia* Boisduval, *Spodoptera exigua* (Hubner) and the recent introduction *Spodoptera frugiperda (*J. E. Smith), A reliable morphological identification is best carried out at adult stages. But species level identification can be done based on the morphology of immature stages (in particular larvae) present study is based on importance of morphological characteristics in species level identification of *Spodoptera*.

Eggs of all *Spodoptera* species are laid in groups, ranging from 20 to 350 eggs per batch (Peterson, 1964). They are usually laid in one layer, but sometimes in two (partial) layers. Typically, *Spodoptera* egg batches are covered with hairs from the female's abdomen, coloured creamy white to light camel with tufts of darker hairs in some species. In case of *S. litura* Eggs are spherical in shape and

yellowish creamy in colour covered with yellowish brown hairs, few hours prior to hatching, colour of the egg mass changed from yellow to dark black. In *S. marutia* eggs are greenish with spherical shape, laid in mass covered with greyish hairs Few hours before hatching, eggs changed their colour from green to dark black. In *S. exigua*. eggs are circular greenish to white in color, and covered with a layer of whitish scales. In *S. frugiperda* eggs are green coloured, dome shaped laid in mass covered with greyish hairs. Few hours before hatching, eggs changed their colour from green to dark black

First stage larvae (egg-larvae) of *Spodoptera* species are 1–2.5 mm long, whitish with a black head and dark pinacula They cannot be distinguished morphologically from other *Spodoptera* species. Morphological identification is possible with Late larval instars. In case of *S. litura* larvae are dark blackish brown with three lines or bands one central, orange colour and two lateral bands which are yellow in colour are present on the body. black intermittent spots are present dorsally along each lateral yellow band from anterior to posterior part of the body. Mature larvae of *S. mauritia* are 3.8-4 cm long and are green, grey, or brown in colour with dark dull dorsal and sub dorsal longitudinal stripes. Two rows of C-shaped black spots are visible along the backs, In *S. exigua* late instar larvae are green dorsally with pink or yellow colour on ventral side. A white lateral stripe and a series of dark spots or dashes are often present dorsally and dorsolaterally. Sometimes larvae are very dark in color, even black. The spiracles are white with a narrow black border. The body is practically devoid of hairs and spines. Late instar larva of *S. frugiperda* are brownish, with lateral white lines. Head is reddish brown; brownish larval body bears white sub dorsal and lateral lines. Elevated spots occur dorsally on the body; they are usually dark in colour, and bear spines. Presence of four spots on the eighth and ninth abdominal segment in the form of a square is the characteristic feature of the larva. The face of the mature larva was also marked with a white inverted "Y" shaped suture.

Adults of *S. litura* are brown with a complex pattern of creamy coloured crisscrossing markings on the forewings. hind wings were silvery white in colour. In *S. mauritia* forewings of female moth are greyish brown with wavy lines having a dark spot in the middle. Tuft of hairs are absent on forelegs of female adult whereas male moth has immense tuft of hairs on forelegs. Forewings of the male moth are bright greyish and hind wings are brownish white with black margins. In *S. exigua* forewings are mottled gray and brown, and normally with an irregular banding pattern and a light-colored bean-shaped spot is present. The hind wings are a more uniform gray or white colour, and trimmed with a dark line at the margin in S. frugipeda Forewing of adult male moth was shaded with gray and brown colour, with triangular white spots at the tip and near the centre of the wing. The forewings of females were less distinctly marked, ranging from a uniform greyish brown to a fine mottling of gray and brown. The hind wing is iridescent silver-white with a narrow dark border in both sexes.

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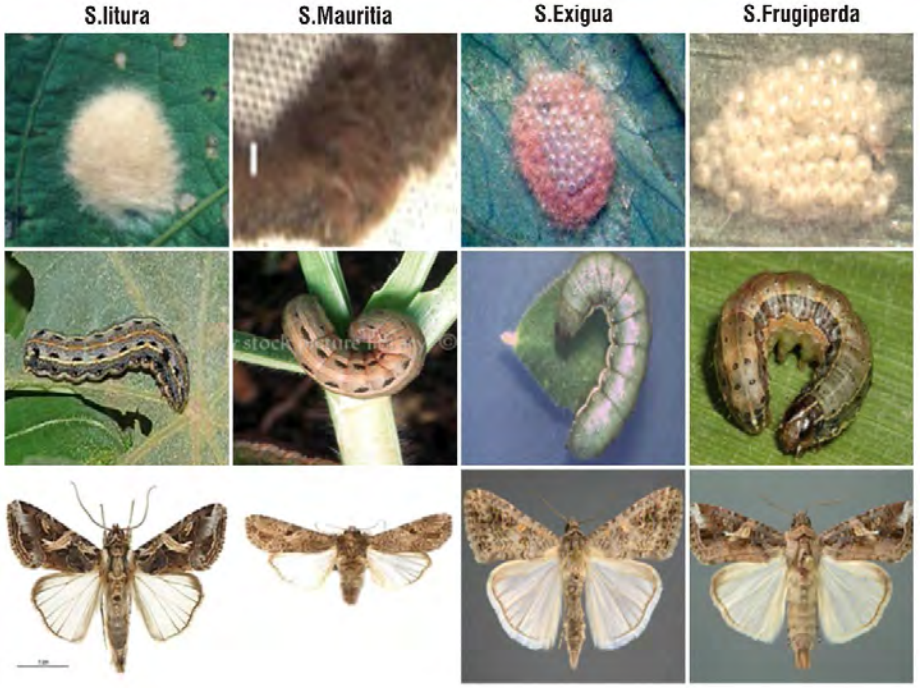
Different Speecies of *Spodoptera*



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84. DNA Barcoding of Insects: Current Development and Future Perspective

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Species identification is the fundamental part in describing biodiversity. Among the animals, insects are the most dominant group whose taxonomy is primarily based on the morphological characters. India has gifted with varied agro climatic conditions and considered one among the mega biodiversity countries which favors the hotspot for numerous species of insects and supports nearly 7% of the world insect fauna. Several insect species especially in Andaman and Nicobar Islands, Western Ghats and Himalayan regions of country are hitherto unexplored. Due to change in climatic condition and taxonomy crisis these areas also have a high level of endemism. At the same time increased trade and rapid transportation facilities between the countries invites many invasive pests into the country which causes havoc and alarming biosecurity concern. The prompt identification of alien invasive insect species is very much important for biosecurity of any country because of their economic importance. Also, insect pests are of major concern for farmers across the world and accurate identification of the pest is an important issue.

With the existence of millions of species and significant variations in their life-stage, the correct identification becomes a challenge task for taxonomy. But the recent advancement in science, the new method called DNA barcoding, a tool of DNA-based taxonomy is used to identify known and unknown species on the basis of the pattern of nucleotide arrangement in a fragment of DNA from target species. **DNA barcoding provides the fastest way for taxonomists to sort specimens and helps in species identification.** In 2003, Paul Hebert (Jinbo *et al*., 2011) proposed this technique using a primer set to amplify a 648-base pair (bp) region of the mitochondrial cytochrome-*c* oxidase subunit 1 (*COI*) gene to ensure rapid and accurate identification of a wide range of biological specimens. In animals, a 5' fragment of the COI gene has been considered as the standard barcoding region based on several experiments carried out with this region on many taxons (Hebert *et al*, 2003). These region of COI gene has been considered to be very informative in terms of evolutionary and speciation perspective.

DNA based detection by using mitochondrial COI gene helps in resolving the identification problem. DNA barcoding techniques are a uniform and practical method for identification of insect species and can be used for the identification of all developmental stages of insects, their food webs and biotypes and there indeed are not possible with morphology-based taxonomy (Jalali *et al*., 2015). Molecular techniques have been developed in recent years to discriminate closely related species and provide powerful tools to identify insect species and investigate their evolutionary history and phylogenetic relationships. DNA polymorphisms in mitochondrial and nuclear genes have been used for insect molecular systematics and diagnostics.

The number of insect species described in India is approximately about 59,000; however, the number of barcodes generated from India is slightly 4.6% of known species, while the corresponding global scenario is about 16% of described species (Jalali *et al*., 2015), therefore a lot of emphasis is required to catch up with the World scenario. Currently, more than one million records are available in the BOLD system, which is the official depository of DNA barcode data. Molecular diagnostic tools provide valuable support for the rapid and accurate identification of morphologically indistinct alien species (Armstrong and Ball, 2005). DNA barcoding are considered as a 'tremendous tool' to accelerate species discovery and initiate new species descriptions. It has emerged and established itself as an important tool for species identification and phylogenetic studies.

Pic source: Mark Stoeckle (2006)

DNA-based approach for species identification has advantages because they are technically simple, more accurate, and applicable to large-scale screening and provides efficient platforms to identify insect species (Srinivasan *et al*., 2013). In order to speed up taxonomic research, DNA barcoding is now been

considered as an alternative tool for insect biodiversity identification in India and the World. DNA barcoding is inseparably linked with the traditional taxonomy which complements the taxonomic studies. The integration of taxonomic information and barcode data will faster species discovery and description process and further it will also strengthen the biodiversity database of the country

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INTEGRATED INSECT PEST MANAGEMENT

18389

85. Integrated Management of Banana Diseases

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INTRODUCTION: Banana is one of the most important fruit crops cultivated in tropical countries. The whole plant or fruits, leaves, stem, and other plant parts play major role in the daily activity or use by the local population where they have multiple uses. Its original home is believed to be India, but it is now a widespread, highly commercial crop in many countries, including Ecuador, Honduras, Panama, Columbia, Jamaica, Mexico, India, Sri Lanka and several other Far-Eastern countries. In India, banana occupies an area of about 4.2 lakh hectares, mostly in the Southern States.

Moreover, there are fifty diseases of banana in this country and elsewhere, a few of which are devastating. The chief ones are Sigatoka Leaf Spot Diseases of Banana, Panama wilt, Bunchy top, Moko or Bacterial Wilt Disease of Banana and Xanthomonas Wilt of Banana

Components of Integrated Disease Management (IDM)

Broadly IDM involves four components namely:

i) **Host Resistance:** Resistance is the character of a plant which suppress pathogen and disease development. The use of resistant genotypes is a highly effective approach to suppress disease to tolerable levels. Resistance alone is sometimes sufficient to suppress disease to tolerable levels.

ii) **Biological Control:** In this method the pathogen actively is reduced through the use of other living organisms *e.g.*, hyper-parasites, resulting in a reduction of disease incidence and severity.

iii) **Cultural Control:** This involves extensive manipulation of the crop environment to make it less favorable to harmful organism *e.g.*, by disrupting their life cycles, remove their food sources, or encouraging their natural enemies. Other practices such practices as intercropping, crop rotation, field sanitation, manipulation of sowing dates *etc.* Some of these techniques provide only small benefits when integrated with other techniques, they significantly improve disease management.

iv) **Chemical Control:** In IDM programme chemical control implies the judicious and need based use of pesticides (fungicides, insecticides and herbicides). Chemical control is essential in areas where diseases appear in the early stage of plant growth and environmental conditions are likely to spread them fast.

Sigatoka Leaf Spot Diseases of Banana

Ebimieowei and Wabiye (2011) evaluated the various methods applied so far to control black sigatoka disease in plantains and bananas. Disease can be controlled in various ways *viz.*, culturally, chemically, quarantine, and breeding for disease resistance. A proper management of organic matter using different crop residues as mulch builds up the soil fertility level, and substantially reduced the effect of the disease. The use of forecasting methods could be part of an integrated disease management strategy

Disease Management

1. Planting banana in well drained soils.

2. Pruning suckers periodically to avoid overcrowding in the field.
3. Removal of diseased or infected leaves.
4. Provide good drainage and enough air circulation.
5. Apply potassium fertilizer. Spraying mancozeb or chlorothalonil @ 0.2 % suspended in mineral (paraffin) oil.

Fusarium Wilt or Panama Wilt of Banana Disease Management

Management of fusarium wilt is extremely difficult as the fungus survives in the soil for many years and there are no fungicides or limited cultural controls that can be usefully applied against it. Should not use suckers for planting from plants that show symptoms of fusarium wilt, even though they may appear to be healthy, as the fungus may be in the roots. Use healthy planting material, preferably from disease-free certified plants. If these are not available, growers should be encouraged to take suckers only from areas that have not shown symptoms of the disease, preferably from growers' own farms which have been monitored for disease.

Remove the plant with its root mass and suckers, and burn everything on the spot. Do not chop the plant into pieces. Consider removing a ring of plants around the diseased one, this is done in case the disease has already spread to adjacent plants through root-to-root contact. If possible, fence infected areas so that people do not spread the disease in soil on footwear, and clean the tools used to remove plants with sodium hypochlorite bleach. As a future caution, dig drains to divert surface run-off (and irrigation) water if it flows through infested areas. Furthermore, do not go repeated cultivation with the same or another fusarium wilt susceptible variety, and monitor the remaining plants every two weeks.

1. Moko or Bacterial Wilt Disease of Banana

Disease Management

1. Destruction of infected plants and debris.
2. Exposure of soil to sunlight during dry hot weather.
3. Control of nematode populations (Fumigation of infected site with Methyl bromide or Chloropicrin.
4. Crop rotation with non-solanaceous crops (like rice, corn, bean, cabbage and sugarcane that are resistant to the disease).
5. Regular sterilization of farm implements.
6. Biocontrol with *Pseudomonas fluorescens*.

2. Xanthomonas Wilt of Banana

Disease Management

While the host plant may be a pre-requisite for driving the disease epidemic, some cultural agronomic practices can also be extremely important. Cultural control practices including the timely removal of male buds (de-budding), complete destruction of infected mats, use of disinfected farm tools, and use of healthy planting material have been recommended, based on their effectiveness in controlling other banana bacterial wilts. These practices have resulted in effective way of reducing the inoculum in infested fields (Tushemereirwe et al., 2004; Blomme et al., 2005)

3. Bunchy Top/ Curly Top/ Cabbage Top/ Strangle Disease

Disease Management

1. Rouge out virus affected plants before spraying.
2. Use disease free, healthy, suckers or rhizomes or planting materials for commercial production.
3. Follow clean cultural practices and maintain sanitation in the orchard.
4. Raising barrier crops like sunhemp in 3-4 rows on the field boundaries to check aphids from entering the fields from neighbouring infected fields.
5. In case of post-planting infestation, spray 0.06 % dimethoate or 0.05% methyl-oxydemeton on seedling.

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PEST MANAGEMENT

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86. Anti-Termite Activity of Medicinal and Aromatic Plants

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Termites are hemi-metabolous, Eusocial insects that fall under the Isoptera and nearly 300 species have been recognized as pests. Termites are important successful groups of insects on different ecosystem. Termite's colonies size normally from few hundreds to millions of individuals. Termites are normally two groups, *viz.*, higher termites (Termitidae, Serritermitidae, Rhinotermitidae and Termopsidae) and lower termites (Mastotermitidae, Kalotermitidae and Hodotermitidae). Among these families Termitidae are found largest in the worldwide. It consists mound-building termites and sub-terranean termites. It is one of the important pests on various ecosystems and causing considerable yield loses. Termites are generally damaging to various agricultural crops, forestry, pastures and buildings. Same time it will act as a beneficial organism in the conversion of dead plants to other plant products. Generally, these pests causing a damage in several ways and reduce the crop yield drastically. Apart from these wooden structures and other cellulosic materials damaged heavily and it causes considerable damage to wooden industries annually. Use of some synthetic insecticides to management of these pests successful some extent but same time it will create the problem of negative effects, same time there is increasing in naturally occurring plant products and essential oil to management of this pest. Besides of these some of the medicinal plants have developed defense mechanisms against these termites through their own secondary metabolic pathways and these certain metabolites that causes toxic to different termites as repellents or deterrents. In traditionally usage of synthetic pesticides for management of this insect but same time having some problems like pesticide resistance and environmental contamination problems to ecosystem. But recent reports of some plant defense systems and medicinal property of some plants against the termite's species has new sign to replacing the synthetic pesticides against the termites' control and prevents the adverse effects of synthetic pesticides on environment and pest resistance problems.

Anti-Termite Activity of Some Medicinal and Aromatic Plants

Many medicinal and aromatic plants having an anti-termitic activities and resistant to termite's species like lemmon grass, Eucalyptus *globules, Eucalyptus citrodora*, vetiver grass, *Taiwania cryptomerioides and Dodonaea viscosa*. *Ocimum basilicum* L., *Cymbopogon winterianus, Cinammomum camphora*, *Rosmarinus officinalis* and *Coleus ambionicus* are less studied plants but having good amount of insecticidal properties against to different termite species. Different concentration of *Cassia fistula*, *Myrtus communis*, *Sapium sebiferam* and *Thevetia peruviana* species have protection against different termites' species. Same like *Adhatoda vasica, Cynodon dactylon, Pongamia pinnata, Rauvolfia serpentine, Cleistanthus collinus, Tamarindus indica and Eichhornia crassipes* have reported against termite species. The effect of aqueous extracts from *Melia azedarach* and *Trichilia pallida* plants also give good amount of control against termite species.

Different plant oil extraction of neem oil, karanj oil and jatropha oil was tested against the *Odontotermes obesus,* same time mortality of termite's species was recorded in these plant species. The effect of essential oil like *Ocimum canum*, and *Cymbopogon schoenanthus* were evaluated against *Amitermes evuncifer* between the two plants-formulations *C. schoenantus* has got good results on *Amitermes evuncifer* than those from *O. canum*. Toxicity and repellency of *Azadirachta indica, Eucalyptus camaldulensis* and *Zingiber officinale* extracts applied against termite's species under laboratory and field condition, mortality was observed quite effectively. Plant extracts of *E. camaldulensis, A. indica* and *Z. officinale* have 100% mortality of termite species have recorded. The insecticidal activity of two plant extracts, *Withania somnifera* and *Solanum incanum* was against the two species, *Amitermes messinae* and *Microtermes najdensis*, Crude extract of *Solonum. incanum* leaves was more toxic effective than the *W. somnifera*. Aerial parts essential oils of *Ocimum basilicum, O. canum* and *Cymbopogon schoenanthusanti* having an anti-termite activity as in In-vitro condition and invitro anti-termite activity

of the aerial parts of *Ocimum canum* volatile oil and its major components of insecticidal activities on the termite species *Macrotermes subhyalinus* has reported 100 % mortality.

Conclusion: Termites are important phytophagous pest under various ecosystems and caused very serious damages to our crops. Termite workers are responsible to cause damage to crops as well as our households. Here, our major concerns is use of medicinal plants like lemongrass, neem, eucalyptus, ashwagandha *etc* against termites under field as well as in vitro conditions for management of termite infestation and It is necessary to study all the aspects related to its life cycle and management aspects through using medicinal plants for avoid this major economic losses of termite species.

SERICULTURE

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87. The Secret of Sericulture

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INTRODUCTION: Sericulture or silk production is the breeding and management of silk worms for the commercial production of silk. Sericulture is an important industry in Japan, China, India, Italy, France and Spain.

Brief History

The silk production from the moth, *Bombyx mori* is the only living species of insect in family Bombycidae and has been domesticated. The silk production from *B. mori* was discovered in 2700 BC according to the Chinese records. The empress Si-lung-Chi was asked by emperor Huang-ti to find the cause of damaged mulberry leaves on trees in their garden. The empress found worms which are white in colour eating the leaves. She noticed that they were also shiny cocoons around themselves. A cocoon dropped in her cup of tea and silky threads separated from the cocoon. Silk industry began in China and the source of silk was kept a secret for more than 2000 years. After some time, China lost their monopoly in silk production so that sericulture reached Japan through Korea and then to other countries. Sericulture has been growing in India as an agro-based industry playing a vital role in the improvement of rural economy.

Source of Silk – The Silkworm

The silkworm is a larva or a caterpillar of the silk moth *Bombyx mori* and its life cycle take 50 days from egg to adult. The different stages are as follows:

(i) Adult

The adult silk moth is a creamy white moth which has a flat body and a wing is about 5 cms expandable. It takes no food and seldom attempts to fly. It lives for only 2 to 3 days. After mating, the female moth lays 300-500 eggs on the mulberry leaves.

(ii) Eggs

The eggs are round and yellowish-white, and they become grey as hatching time.

(iii) Larvae

The newly hatched larva is about 3 mm long and it is black in colour. The larvae grow in size and moult for four times. The caterpillar consumes lot of mulberry leaves in each growing stage. The full grown larva is about 7 cm long in its last stage. It has a spine-like horn at the tail end and hump behind the head. The mature larva stops feeding, climbs on a twig and spins a cocoon, when it has grown fully.

(iv) Pupa

The full-grown larva pupates inside the cocoon. It transforms into a winged adult in 10 days. The adult moth makes an opening in the cocoon and escapes through it.

The Cocoon

The cocoon is formed from a secretion of two large silk glands (actually the salivary glands), which extend along the inside of the body and open through a common duct on the lower lip of the mouthparts. The larva moves the head about 65 times per minute from side to side very rapidly throwing out the secretion of the silk glands in the form of a thread. It is a clear viscous fluid, that exposure to the air gets hardened into the fine silk fibre. The filament forming a cocoon is continuous and ranges in length from 700-1100 metres. The cocoons from which moths have emerged are called pierced cocoons. They are low valued because continuous thread cannot be obtained. Pieces are removed by instruments and spun into a thread.

Rearing of Silkworms

The silk moths which are healthy are selected that are allowed to mate for 4 hours. In a dark plastic bed, the female moth is kept. It lays about 400 eggs in 24 hours, the female is taken out, crushed and examined for any disease, only disease- free eggs that are certified can be reared for industrial purpose and

hatched in an incubator. The hatched larvae are kept in trays inside a rearing house at a temperature of about 20°C-25°C and they are first fed on chopped mulberry leaves. The fresh leaves are provided after 4 – 5 days. They are transferred to fresh leaves on clean trays as the larvae grow, when fully grown they spin cocoons.

Reeling Silk

The cocoons are boiled in hot water and the silk fibre is unwound from the cocoons and called reeling. The silk has two proteins. The inner core is called fibroin and an outer cover is called sericin. The cocoons are gathered about 8 days after spinning for reeling. The cocoons are treated by steam or dry heat to kill the insect inside. This is essential to prevent the destruction of the continuous fibre by the emergence of the moth. The cocoons are soaked in hot water (95° -97°C) for 10-15 minutes for softening the gum that binds the silk threads together and it is called cooking. The cooked cocoons are kept in hot water and then the loose ends of the thread are caught by hand. Threads from several cocoons are wound together on wheels ("charkhas") to form the reels of raw silk. Only about one-half of the silk of each cocoon is reelable, the remaining is used as a silk waste and formed into spun silk. Raw silk is obtained which is then processed through several treatments to give it the final shape.

Main Properties of Silk

1. Lustrous,
2. Soft and strong,
3. It can be dyed into several colours.

Silk moth *Bombyx mori* is fully domesticated at present. It is no longer exists in a wild state and it cannot survive without the human care.

Silk Producing States of India

Major Indian States producing mulberry silk are: Karnataka, West Bengal, Jammu and Kashmir

Non-Mulberry "silks"

1. Tasar silk is produced by certain species of another moth *Antherea royeli*. Their larvae are reared on Arjun trees, chiefly in Bihar, Madhya Pradesh and West Bengal.
2. Muga silk is obtained from *Antherea assama* and its larvae are reared on "Som" trees in Brahmaputra Valley.
3. Eri silk is produced by the moth *Philosamia ricini* whose larva feeded on castor leaves and produced in Assam.

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BEEKEEPING

18481

88. Causes, Symptoms and Management of Microbial Diseases in Honey Bee

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INTRODUCTION: All living organisms are subject to infestation or attack by their natural enemies, and honey bees of the genus Apis are no exception. Through their long history of evolution and natural selection, they have achieved a high level of eusociality, many thousands of individual bees living together in a tightly knit social organization. Since, individual bees have more than frequent contact among themselves, and since trophyllaxis (the sharing and orally passing of food among members of the nest) is one of the most important and frequent aspects of the bees' social behavior, which allows hormones and pheromones to be widely distributed throughout the colony and due to these same characteristics of its highly eusocial behavior, whenever a pathogenic organism is present in the colony it gets spread quickly, as well as fiercely into the whole of the colony with great ease. Therefore, honey bees are susceptible to different pathogen and these pathogens cause serious damage to industrial aspect of the apiculture. Diseases may be spread in a honey bee colony due to, improper hygienic conditions in apiary, migration

and sale of colonies, congenial climatic conditions, equipment and/or bees.

In India there are a number of diseases which affect the honeybees and the economy, relying on it's commercially valuable products. Some of the major diseases, their causes, symptoms and management practices are as follows:

1. **American foulbrood disease (AFB):** It is regarded as the most destructive honey bee disease in temperate and sub-tropical regions.
   a) **Cause:** *Bacillus* larvae, a microscopic spore-forming bacteria.
   b) **Effect:** American foulbrood (AFB) is the most widespread and the most destructive of the brood diseases. At first, the strength of an infected colony is not noticeably decreased and only a few dead larvae or pupae may be present.
   c) **Symptoms:** First the capping of the diseased cell becomes moist and darkens in color. Then as the larva shrinks, the capping is drawn into the mouth of the cell so the convex capping becomes concave. Worker bees may puncture this sunken capping and may eventually remove it altogether. At death, the diseased larva changes from a normal pearly white color to a creamy brown, then gradually darkens. These larval remains can be drawn out into a brown thread or rope.
   d) C**ontrol:** Sanitation and elimination of disease reservoirs is a necessity for adequate control of American foulbrood. No drug should be fed when there is danger of contaminating the honey crop. Ethylene oxide (ETO) combined with a drug treatment has also been found to effectively control AFB.
2. **European foulbrood disease (EFD):** European foulbrood (EFB) is most common in the spring when brood rearing is at its height.
   a) **Cause:** *Streptococcus pluton*, a microscopic lancet shaped bacteria.
   b) **Effect:** Sometimes the disease appears suddenly and spreads rapidly within infected colonies; at other times it spreads slowly and does little damage. As a rule, it subsides by mid-summer, but occasionally it continues to be active during summer and fall or may reappear in the fall.
   c) **Symptoms:** Larvae diseased by European foulbrood move restlessly within their cells and, therefore, when they die, are usually twisted in the cells. The larva collapses as though it had been melted, turns yellowish brown, and eventually dries to form a loosely attached brown scale. The consistency of recently dead larvae varies but it is not ropy.
   d) **Control:** Re-queening of badly infected colonies usually will help clear up the disease. Feeding of the drug oxytetracycline (Terramycin) as a dust may be necessary in severe cases.
3. **Sacbrood disease:** Sacbrood is a widely distributed disease, but it usually does not cause serious losses to bee colonies.
   a) **Cause:** Sacbrood virus.
   b) **Effect:** Sacbrood may appear at any time during the brood rearing season, but it is most common during the first half of the season. Usually it subsides after the main honey flow starts.
   c) **Symptoms:** Scattered among the healthy brood are cells containing dead brood. Their cappings are dark and may be punctured or partly removed by the adult bees. About the time the cell is sealed, the larva dies. When it does, the head end turns up like the end of a canoe and remains in that position; also, the pearly white color begins to darken, and the skin then becomes tough and the contents watery.
   d) **Control:** In severe cases moving the colony or re-queening may help. Colonies usually recover from sacbrood without beekeeper's aid.
4. **Nosema disease:** It is a widespread disease of honey bee in India and causes extensive damage to **adult** bees.
   a) **Cause:** *Nosema apis*, a small, single celled protozoan.
   b) **Effects:** There is reduced brood production in a colony affected with the disease. Colonies infected with Nosema have heavier winter losses and there is a decrease in foraging and colonies store less honey.
   c) **Symptoms:** No symptoms are specifically indicative of Nosema. Inability of bees to fly when they leave thew hive, excreta on combs or entrance boards, and a pile of dead bees on the ground in front of the hive may be manifestations of Nosema infection, but they may also be caused by other abnormal conditions.
   d) **Control:** The drug fumagillin (Fumidil-B) is approved for Nosema control. It should be fed only in sugar syrup with feeding. The recommended feedings are 100 mg. fumagillin (about 1 teaspoon) to 1 gallon of sugar syrup (mix 2 parts sugar to 1-part water).
   e) To eliminate disease spores from bee equipment, treatment in a heated chamber (120$8^{0}$F for 24 hours) has been found to be completely effective. Ethylene Oxide (ETO) fumigation also eliminates Nosema spores when combined with the heat treatment as will acetic acid and heat.

BIOCONTROL

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89. Assassin Bugs: A Potential Biological Control Agent

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Bio-control agents plays an important role in suppression of harmful crop pests without disturbing the ecosystem functioning. The utilization of bio agents in agriculture is restricted to few specific taxonomic groups of insects like Coccinellidae, Chrysopidae, Evanidae, Braconidae, Trichogrammatidae, Scelionidae, Chalcididae and Bethylidae for the management of specific insect pests. They fit well in crops which harbour few major insect pests. But in the majority of agro ecosystem like cotton, tobacco and vegetables, complex pest is known to occurs, in such cases specific bioagents are quite difficult to deploy, as application of insecticides is mandatory to manage other secondary pest, which will intern disturbs the efficiency of natural enemies. So, there is a requirement to screen the generalist bioagent which fits well in complex ecosystem, but they have not been properly addressed till date, such group of generalist bioagents comes from the heteropteran families like Reduviidae, Anthocoridae, Nabidae, Gecoridae and Asopinae subfamily of Pentatomidae. But, these groups of insects are underutilized because of their limited work on taxonomy and life history attributes.

Among the heteropterans, members of Reduviidae are found to be the most promising ones with greater diversity and abundance in natural and agro ecosystem. This is a second most mega diverse family in Heteroptera after Miridae and one of the largest predatory clade in animal kingdom with 7000 described species (Weirauch *et al.,* 2014). Members of these group possess all the desirable characteristic features of predators similar to Coccinellidae and Chrysopidae. In addition to this, they also have added advantages for biocontrol which includes venomous saliva for paralyzing the prey, modified advanced type of fore legs for prey capture and behaviour of attacking the preys which are larger than their body size. Besides, being a generalist predators, reduviids has survival advantage over host specific parasitoids or predator by being able to switch their dynamics to secondary prey during the absence of main host.

Assassin bugs, as they are often called, are either specialized (stenophagy) on certain groups of prey organisms or relatively unspecialized (euryphagy). Several laboratory studies, caged experiments, fields and natural habitats study witnesses the potentiality of reduviids as biological control agents. Many authors from India and elsewhere, by realizing their importance, studied the predatory behaviour, prey record, biology, host and stage preference, functional and numerical response, insecticidal impact and augmentation of various species of reduviid, they found that 165 reduviid predators belonging to 53 genera are feasible and potential for bio-control programme. But problems associated with measuring the biological control provided by the generalist heteropteran predator is mainly responsible for limited research in this area even though they possess good biocontrol features.

Characteristics Features of Assassin Bugs for Biological Control

Members of reduviids exhibit all desirable characteristics features of predators like limited host range, positive functional and numerical response, good host searching efficiency, multiply faster with good fecundity, short life cycle, female biased sex ratio, high pest suppression efficiency, amenable for mass culturing in laboratory, high adaptability to fluctuating and new climatic condition and mainly they are free from other natural enemies. In addition to that, reduviids being evolved as predators from their phytophagous ancestors, during the course of evolution they are also evolved with additional features which facilitates the biocontrol includes,

1. *Morphological adoptions i.e. advanced raptorial forelegs:* Forelegs of reduviids shows apparently a unique modification in relation to prey type and strategies involved in prey capture. For example, chelated in Phymatinae for motionless catching, sticky trap in Harpactorinae (*i.e.* apex of the fore legs is coated with resin) for entrapping soft bodied insects, legs with spine in Stenopodainae for gripping and legs with plesiomorphic fossula spongiosa (tibial pad) in Reduviinae, Ectrichodinae and Salyavationae for effective grabbing and grasping the wide array of prey.
2. *Innovative prey capturing strategies:* Reduviidae are diversified in prey choice and developed wide repertoire of innovative prey capture strategies. For example, some Emesinae, (thread-legged bugs), cut through webs to reach their psocids and spiders through aggressive mimicry. Members of the hartpactorinae coat their fore legs with plant resins for prey capture and the Holoptilinae, (feather legged bugs),

attract ants to imbibe their paralyzing secretions of their trichomes before killing their prey.

3. *Venomous saliva:* Saliva of reduviids is relatively homologous to the calcium channel blockers g-conotoxins which are analogous to snake, spiders and marine cone snail venom. So immediately after piercing, prey gets paralysed and dies after sometime even though they escape. By this way they are known to kill more prey than actual consumption.
4. *Behaviour:* As the bugs are armed with strong forelegs and poisonous saliva, they are habituated to attack the preys which are larger than their body size. Thus, screening of this neglected heteropteran predators for use in augmentative biological control is currently an important issue to figure out and also an important step in identifying and utilizing novel predators to solve the insect pest problem, as the present day crop protection agenda is in strong need of cost effective and environmentally friendly management strategies to reduce the disturbance in ecosystem which is polluted with injudicious use of agrochemicals.

Reduviids in Integrated Pest Management

Prey record of the reduviids are large and diverse (Ambrose, 1999). A few species are being successfully explored in integrated pest management system includes *Pristhesancus plagipennis* (Walker) against cotton bollworm (Grundy and Maelzer, 2000) and *Creontiades* spp. (Miridae) (Grundy, 2007), *Zelus* and *Sinea* as a generalist predators against bugs, caterpillars and boll weevils (Cogni *et al.*, 2002), *Endochus albomaculatus* Stål, *Epidaus bicolor* Distant, *Euagoras plagiatus* Burmeister, *Irantha armipes* Stål, *Panthous bimaculatus* Distant and *Sphedanolestes signatus* Distant against tea mosquito bugs, *Helopeltis antonii* Signoret in Cashew (Srikumar *et al.*, 2014).

Future Prospects

Despite of their positivity towards biological control, the reduviids are not commercially available for augmentative release. The basic prerequisite for a biocontrol agent is the availability of sound and low-cost rearing technique and mass multiplication protocol which is lacking. In addition to that, to bring any novel predator into biocontrol programme, step by step systematic, consistent and sequential evaluation starting from analysing the diversity of indigenous bugs and screening for prioritisation of potential species by their life history attributes, followed by standardisation of mass production technology and finally evaluation in the confined and field condition is very much necessary, which is need of the hour. Besides this backdrop, problems associated with measuring the biological control provided by the generalist heteropteran predator is also partially responsible for limited research in this area. By addressing these lacunae, reduviids can be deployed in augmentative biocontrol in integrated pest management.

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90. Krishi Vigyan Kendra (KVK): Fostering Agricultural Development

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Agriculture is of major importance in Indian economy as more than half of the population of the nation depends on it for livelihood. Poverty and unemployment are the major issues of concern for the rural society. There is a large section of farming community, who are still unaware of various technological advancements in agricultural domain. The agricultural production, can be increased if the modern technologies related to crop production are being transferred from research institutes to the, farmers' fields. Realizing this crucial gap, the Indian Council of Agricultural Research established Krishi Vigyan, Kendra (KVK) as an innovative institution which would help in accelerating the agricultural production and also in improving the socio-economic conditions of the farming community to bring in financial and livelihood security for rural households. At present total 705 numbers of Krishi Vigyan Kendras are being existed in different districts of India.

History of KVK Evolution

Education Commission (1964-66) first recommended to establish specialized institutions to provide vocational education in agriculture and allied fields. This was thoroughly discussed by the Ministry of Education, Ministry of Agriculture, Planning Commission, Indian Council of Agricultural Research (lCAR) and other allied institutions during 1966-72. Finally based on the committee report headed by Dr. Mohan Singh Mehta after analyzing the overall feasibility and situation, ICAR approved the establishment of first KVK, on a pilot basis in 1974 at Pondicherry under the supervision of Tamil Nadu Agricultural University.

Krishi Vigyan Kendra (KVK)/ Farm Science Centre

Vision

Science and technology-led growth leading to enhanced productivity, profitability and sustainability of agriculture.

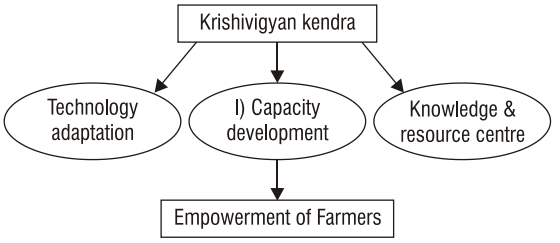
Mission

Farmer-centric growth in agriculture and allied sectors through application of appropriate technologies in specific agro-ecosystem perspective.

Mandate

Technology Assessment and Demonstration for its Application and Capacity Development.

Basic KVK Model



Various Activities of KVKs

1. Data Generation

Database generation on various district profile such as socio-economic profile of the farmers, weather-related data, land utilization pattern, land holding of farmers, crop production related information, agriculture and allied enterprises, marketing facilities etc. Baseline data collection through participatory approach for accessing the effectiveness of various livelihood interventions of KVKs.

2. Need assessment and Prioritization

Identify and prioritize various problems of agriculture and allied sectors in existing farming conditions on district level along with specific need identification of the farming community. Analyse various causes of the existing problem and prepare appropriate strategies to overcome them. Every KVK scientist needs to address at least one most relevant issue related to farming.

3. Development of Instructional Farm

Establishment of technology demonstration units, Integrated Farming system units, model orchards etc. Production of bio-fertilizers, saplings, seeds, seedlings, fingerlings, livestock etc.

4. Budgeting

Annual budget preparation for carrying out various proposed activities of KVK throughout the year and timely submission of the plan budget to ICAR.

5. Farm Advisory Services

- KVK provides solutions for various farming related problems. It also provides recommendations

regarding crop production, plant protection, nutrient management, livestock rearing etc. KVK suggests various livelihood generation activities, entrepreneurship opportunities to empower the rural youths. KVKs also Provide farm advisories using ICT and other media means on varied subjects of interest of farmers.

6. Implementation of various Training Programmes

KVK basically organizes various training programmes to increase the knowledge, improve the skills and to change in attitude of the target groups. According to the trainee category KVK basically impart training to three different groups *i.e.* farmer and farm women, rural youths and extension personals.

7. Frontline Demonstration

Under close supervision of the scientists, Frontline Demonstrations are being conducted in the farmers field to demonstrate any new technology for the first time before being fed into the main extension system. FLD helps in generating various information related to factors contributing to higher yield of any particular crop and analyses production related constraints under various farming situations.

8. On-Farm Testing

In this method two or more improved technologies are being tested against the existing available technologies with the farmer in the same field condition. In this process both the farmers and the scientists participate actively. Based on the suggestions collected from the farmers after OFT, the improved technologies can be modified to get best results.

9. KVKs work as knowledge and resource centre of agricultural technologies for supporting initiatives of public, private and voluntary sector in improving the agricultural economy of the district.

Conclusion: KVKs are the centre of grass root level extension delivery system. Through various training programmes KVK imparts latest information to farmers along with the change in their knowledge, attitude and skill. Multidisciplinary scientists are required to fulfil the requirements of the KVK. Government should take initiative to establish more number of KVKs in rural areas, which will ultimately help the farmers to get solution for their farming-related problems and eventually agricultural production of our country will boost up.

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91. Digital Green's ICT Initiatives in Agricultural Extension

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India is primarily an agricultural country. Over 60% of the population relies on agriculture for its livelihood. Though a generational vocation, farming has been unable to maintain its traditional heritage because of social, economic, and environmental change. The livelihoods of small and marginal farmers are in jeopardy in fragmented agricultural systems such as the one in India.

Background of the Digital Green

Indian agriculture currently faces the twin challenges of meeting the rising food demand of an increasing population in a sustainable manner and making resources and technology for enhancing the production and productivity of the agricultural sector. The very nature of Indian agriculture has been on a change - increasing resource (land and water, mainly) degradation, changes in demand and consumption pattern, changing farming systems with a focus on horticultural crops etc, declining public investments in agriculture, liberalization of agricultural trade and such like. Farmers require a different type of support (training, problem-solving consultancy, marketing advice etc) to deal with these changes in agricultural practices.

Concept of the Digital Green

DG is a system to disseminate targeted agricultural information to small and marginal farmers in India through digital video. The system, called Digital Green, sustains relevancy in a community by developing a framework for participatory learning. The system includes a digital video database, which is produced by farmers and experts. The content within this repository is of various types, and sequencing enables farmers to progressively become better farmers. Content is produced and distributed over a hub and spokes-based architecture in which farmers are motivated and trained by the recorded experiences of local peers and extension staff. In contrast to traditional extension systems, we follow two important principles: (1) cost realism, essential if we are to scale the system up to a significant number of villages and farmers; and (2) building systems that solve end-to-end agricultural issues with interactivity that develops relationships between people and

content.

Work flow of Digital Green System or Standard Operating Procedure of DG

Standard operating procedures (SOPs) - a step-by-step guide to implementing the Digital Green approach. These may be adapted to the different contexts, geographies, domains and partner organizations. Digital Green and partner staffs involved in the implementation of the Digital Green approach follow these SOPs to ensure a consistent level of quality in all its operations to achieve desired outcomes. There may be need for some variation or customization in different locations, but this should be done in consultation with Digital Green's authorized representatives. These SOPs are applicable to all personnel involved in the planning, coordination, execution, reporting, and evaluation of field operations of the Digital Green approach.

Research and Technology Partners

- D-Rev is working to build an affordable device that will enable farmers' ready access to suitable and value-adding agricultural practices.
- Microsoft's team incubated the Digital Green project as a pilot initiative that evolved from a research exploration into a spinoff, non-profit organization.
- University of California, Berkeley works with us to conduct a randomized controlled trial evaluation of the Digital Green system as its operations are extended to scale.
- GREEN Foundation focuses on the conservation of indigenous seed varieties and promotes sustainable agricultural practices based in Karnataka.
- Digital Study Hall uses innovative approaches to improve education for the poor children in slum and rural schools in India.
- Awaaz. De is a voice-based question and answer service, information portal, forum, asynchronous call center and narrow-cast radio platform.

Digital Green believes that information and communication technology by itself cannot bring about change in peoples' attitudes or behaviors unless it is blended with existing participatory mode. The DG approach blends technology with social organizations in which village-level mediators use locally produced videos to motivate and train community members in adopting new and improved practices and technologies.

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92. Challenges for Agricultural Extension Practice

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Agricultural extension as a professional practice is changing, or will have to change, considerably. The challenges to agricultural extension in the early 21st century derive, on the one hand, from the challenges that farmers and agriculture face in view of their ever-changing social and natural environment, and, on the other hand, from the changes that emerge within extension organizations themselves in connection with, for example, new funding arrangements, developments in extension theory, and the emergence of new computer-based communication technologies. Extension activities are being pulled in many directions, and are being called on to respond more effectively to the needs of farmers to produce and to forge links with markets. Extension services, while concentrating on production agriculture, especially via privatized and private extension-type service companies, are simultaneously broadening out to include new purposes and a new clientele. While extension's role is straightforward in contract farming and other commercial ventures, such is not necessarily the case with public sector extension. Its structure, organization and operating system may differ from country to country, even from region to region. Nonetheless, whether in the private or public sector, a major concern for extension is to operate in the context of agricultural innovation systems (AIS) so that new knowledge is applied and used.

As the problems and challenges faced by agricultural sectors change over time, extension professional will have to adapt their ideas about the role and meaning of 'agricultural extension'. Below are some of the challenges that agricultural extension is facing, and point to the need to reinvent agricultural extension as a professional practice.

- Food production, food security and intensification- Improving food security is a challenge which is not simply about producing more food, as many of the causes of food insecurity relate to insufficient access to available food, insufficient economic development outside agriculture, bad governance, detrimental trade relations, debt crisis, inadequate functioning of agricultural institutions, etc.
- Poverty alleviation, income generation and

future prospects- There are some 1000 million economically active people worldwide whose livelihood depends at least in part on subsistence and/or commercial farming.

- Sustainability, ecosystems and natural resource management- Soil degradation, erosion, water pollution, excessive use of chemicals, waste of water, etc are just a few of the concerns raised by environmentalists, ecologists, nature conservationists and the public at large about the detrimental effects of agriculture on the natural environment. This had led to a call for agriculture to become less exploitative and more 'sustainable', which means that agriculture will have to be carried out to make the best use of available natural resources and inputs, and regenerate conditions for future production.
- Globalization and market liberalization- Due to huge changes in communication and transport technologies, the exchange of goods, people and ideas has become much easier and more widespread than before. Even the most remote rural areas often have numerous direct or indirect connections with the wider world economy.
- Multi-functional agriculture- In connection with the societal debates on environmental issues and sustainability, it has been realized that agriculture has, or can have, many more functions than producing food and non-food plant or animal products.
- Agrarian reform- Due to policy induced changes in the agrarian structure across various industrialized countries, farm sizes have steadily increased while the numbers of farms has dropped significantly.
- Food safety and chain management- Increasingly, urban consumers of food products are concerned about the safety of the food they consume. The shops and markets in our globalising economy can be full of vegetables, processed food and meat that were produced in far-away places.
- Knowledge intensity, knowledge society and commoditization of knowledge- Free exchange of knowledge and information between (and even within) fundamental research, applied research, extension and farmers becomes less and less self-evident. For agricultural sectors across the world it is a challenge to keep in touch with, contribute to, and/or catch up with the rapid developments in knowledge, science and technology.

Reinventing Extension

When challenges change, the organizations which are supposed to support farmers in dealing with them will have to change as well. Besides, there are internal challenges that extension organizations will have to meet if they wish to play a role in the future. Below are some of the issues/points where practical changes may be required:

- Dealing with collective issues
- Co-designing rather than disseminating innovations
- Matching the technical and social dimensions of an innovation
- Catering for diverse farming and livelihood strategies
- Managing complexity, conflict and unpredictability
- Becoming learning organizations
- Being brokers in an era of participation
- Coping with dwindling resources
- Changing professional identities

The challenges outlined above have many implications. Among others, we have to adapt our view of what extension is and also our ideas of *why* it is important. In the early days of extension, the latter question was usually answered with reference to the need to increase food production and to encourage economic development. To this end, extension was mainly seen as a function that *fostered knowledge and technology transfer* between farmers and researchers, or among farmers themselves. But now, extension should focus on enabling innovation rather than focusing purely on technology and knowledge transfer.

ENGINEERING AND TECHNOLOGY

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93. Risks Allied with A Cold Storage Facility

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There are a number of hazardous factors that a cold storage facility may face. Some of these factors and an example of each include:

1. Financial
2. Operational
3. Market
4. Construction cost
5. Environmental
6. Managing the risks that a cold storage facility faces is a major part of management and

operating the business. While it is impossible to identify every risk, it is important that management have substitute plans or concepts for dealing with major risk factors. There are a number of formal approaches that can be used for risk analysis.

Approaches include

- Sensitivity analysis – This method assesses the effect of varying levels of different revenues and costs using the financial models used to develop the pro forma financial statements
- Break-even analysis – At what point do revenues equal costs? How many units or various services are necessary to meet this point? Answers to these questions can help management identify key parameters for successful operations.
- Probability theory – Software programs can provide very complicated and powerful risk analysis tools but often there are insufficient data to effectively employ this approach.
- Portfolio analysis – Based on the concept of spreading the risk of financial investments between stocks and bonds, this type of analysis concept attempts to mitigate the risks associated with a cold storage facility. It does so by identifying other actions such as broadening the services offered, integrating the facility with a processing facility, or other investment options that could offset the risks associated with cold storage.

Maintenance food cold remains one of the best ways of reducing the risk of food poisoning and extending the life of the food. It is vital that in a food business that all high-risk foods and perishable foods are held at temperatures at or below 5°C. Ensure all high-risk foods are placed in cold storage areas and check the inside of the refrigerator or cool room using a thermometer. Refrigeration units should operate between 1°C and 4°C and it is important that the following steps are taken to ensure that these temperatures are maintained:

- Cool hot food before refrigerating i.e. place in shallow containers so that it cools more quickly.
- Keep opening and closing of fridge doors to a minimum.
- Keep seals on refrigerator and cool room doors in good condition.
- Store unprocessed and cooked/ready to eat foods one by one to eliminate the risk of cross contamination.
- Store cooked and ready to eat foods above raw foods.
- Foods stored in cool rooms should be placed on shelving at least 30cm above the floor.
- Clearly label and date stored foods.
- Ensure stored foods are rotated on a first in, first out basis.
- Regularly check perishable products and discard any that are spoiled, contaminated or out -of-date.
- Regularly clean the refrigeration units including cool rooms and fridges.
- Do not store cans/tins in the refrigerator once they have been opened. Place contents in food grade containers.
- Do not over crowd refrigerators and cool rooms with product.
- Do not stack product in front of motors or fans.
- Do not let ice buildup in the fridge. Defrost regularly.

Remember: All opened food packages should be stored on clean and sterile surfaces in the cold storage area. They must be protected against contamination by covering with plastic wrap or foil, or by placing the contents in food grade containers with fitted lids. All items should be properly labeled and dated.

Thermometers

A thermometer must be used to determine the temperature of refrigerated storage units. The temperatures are recorded twice daily on the record sheet from the Food Safety Program.

If Problems Occur

The following may assist with cold storage problems:

If the temperature of the refrigeration unit is above 5°C, check surface temperature of potentially dangerous foods. Throw away high risk food that has been between 5°C and 60°C for more than four hours. Adjust the temperature control and check temperature again within one hour.

- Call a refrigeration mechanic if the refrigeration unit or cool room can't keep food at 5°C or colder.
- Reduce product levels will help to achieve better temperature control.
- Ensure staff has the necessary skills and knowledge to handle and store products correctly.
- Have a refrigeration mechanic check and service the refrigerators and/or cool rooms regularly.

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18478

94. Hydro-Compaction of Sand Fills

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INTRODUCTION: Soil compaction is where soil particles are pressed all the more intently by decrease of volume voids, coming about because of the flitting use of burdens, for example, moving, packing or vibration. This procedure includes the ejection of air from the voids without the dampness content being changed altogether. It likewise includes the decrease of volume prompting increment of thickness and shear quality of the dirt. Powerful compaction is typically accomplished by compacting constituent particles of in-situ soil or acquired fill to a denser arrangement that can achieve most extreme at ideal dampness content. Very much compacted materials show designing properties that are considerably better than similar materials in a free state. The nature of compacted fill is constrained by interrelated factors, for example, soil type, thickness of compacted layer and the compaction exertion. Soil type including; grain size, degree and earth or fine substance, assume a significant job in soil conduct under compaction. Coarse-grained soils exist in between granular contact and their compaction includes molecule modification. The manner by which these particles are organized inside the dirt mass, and the dispersion of molecule measure all through, will eventually decide the level of compaction and thus the thickness, strength and the bearing limit of the dirt. Along these lines the greatest compaction can be accomplished by the best pressing of well-reviewed soil where the fine grains fill the spaces between the huge grains. Anyway, overflow of fines can be unfavorable by counteracting between granular contact between course particles. Moisture content is a noteworthy controlling component for soil compaction uniquely the fine-grained soils. Expanding the water substance of soil under compaction successfully builds the usefulness of the dirt and empowers higher thickness to be accomplished. Be that as it may, further increment of the level of water content past a specific basic esteem will result in fall of thickness because of device air and overabundance water in soil pores. This basic estimation of water content, known as the ideal dampness substance can be dictated by the Delegate or standard compaction test. An ideal layer thickness of 200 to 300 mm is ordinarily determined in street and sterile line works, anyway the thickness of compacted layer fluctuates with grain size and compaction exertion. For the most part coarse-grained soils smaller more promptly than fine grained ones and henceforth the better the particles the less great thickness of layer to be compacted. The required level of compaction (relative compaction) is ordinarily determined in respect to the kind of fill being basic or non-auxiliary where the relative compaction is indicated to be 95% and 90% individually. The relative compaction is controlled by looking at estimations of estimated field and research center dry densities. Field dry thickness is apportioned via conveying one of the standard methodologies as ASTM D-1556 (sand cone test).

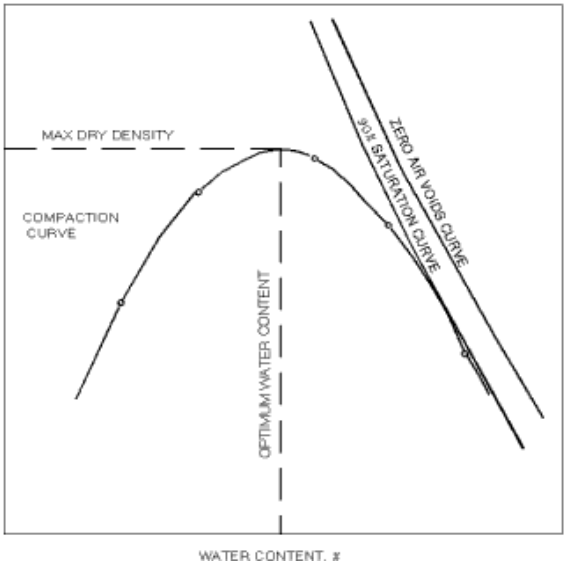

FIGURE 1: Typical curve for the change of dry density

One of the precautionary measures against this test is the blunder that can be brought about by drooping of the sides of the exhumed thickness opening if there should arise an occurrence of wet granular soils and this can prompt over-estimation of the thickness. As of late an increasingly effective procedure has been created utilizing radioactive instruments to decide both thickness and dampness content. Refilled materials are generally compacted by mechanical methods utilizing hand worked vibratory compactors if there should be an occurrence of little limited territories and machine-driven vibratory compactors, for example, smooth and oar foot rollers, for huge open regions. Hydro-compaction is likewise utilized by flooding or flying the granular fill material with water in which super immersion produce level of compaction. This technique for compaction has been utilized for establishments with little loads. Anyway, its utilization is much of the time kept down

by numerous deficiencies, for example, dangers for contiguous existing structures, moderate procedure, oversetting of the dirts and conceivable reason for water table ascent, and lacking compaction to the top layers. There are confinements and certain conditions for the accomplishment of this technique, for example, consistency of sand, fines substance and free depleting notwithstanding the time factor.

Conclusions: Estimated dampness substance and thickness estimations of hydro-compacted sand were arbitrary both along the side and vertically, and no example was identified in the spread of results. Hence, hydro¬-compaction is viewed as lacking to give uniform compaction to high relative densities of more noteworthy than 95%, that is required for auxiliary fills. Hydro-compaction is commonly moderate procedure. Site preliminaries on thick layers have shown that it has no preferred position over the ordinary mechanical compaction as far as accelerating the procedure of refilling. Actually, mechanical compaction of flimsy layers with appropriate administration and enough hardware utilized by talented works can be quicker or more all, traditional compaction guarantees that compaction can be seen and unquestionably endorsed subsequent to testing.

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FOOD TECHNOLOGY

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95. Nanofiber Production through Electrospinning and its use in Food Processing

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Nanofibers are thin threadlike nonwoven structures, categorized as 1-D (one dimensional) nanomaterials having diametrical dimensions in the range of nanometers with the length extending over several meters. Synthetic, natural or biopolymers can be used for production of nanofibers. Among the various techniques employed for their production (drawing, template synthesis, phase separation, self-assembly and electrospinning) electrospinning is considered one of the most easy, versatile and cost-effective methods. The advantageous features in terms of mechanical, electrical and thermal properties exhibited by polymeric nanofibers enable their novel and functional applications in textiles, tissue engineering (scaffold production), pharmaceuticals, food processing etc.

Electrospinning is an electrohydrodynamic process which involves the utilization of electrically charged jet of polymer solution or melt resulting in the production of nanofibers at varying dimensional scales (micron, submicron and nanoscale). The principle of electrospinning involves the distortion of hemispherical surface of a droplet into a conical shape followed by jet formation, all due to the action of electrostatic force. A typical electrospinning apparatus consists of four main components shown in **Figure 1**. These include a high voltage source (1-30 kV) operated in both DC (generally) and AC mode, a blunt-ended stainless steel needle or capillary (latest is needleless electrospinning), a grounded collector of flat plate or rotating drum shape and a syringe pump. In electrospinning, the polymer solution (solvent and polymer or mixture of polymers) or melt in the capillary (needle) is induced with free charges by the applied high voltage potential.

When the polymer solution or melt comes from capillary, due to two electrostatic forces viz. coulombic force of external field and electrostatic repulsion of like charges, the hemispherical surface of the droplet is distorted to a conical shape known as Taylor cone. When the electrostatic force increases the surface tension of polymer solution or melt, a charged polymer jet is ejected from the taylor cone tip. Subsequently, jet elongation and rapid solvent evaporation takes place with the formation of thin fibre deposited on the grounded collector as non-

woven and randomly oriented mat. The solution concentration influences the final product formed. At high solution concentration, the taylor cone jet is stabilized with elongation by whipping instability mechanism, while at low solution concentration, jet is destabilized by varicose instability result in droplet formation (called Electrospraying, a sister electrohydrodynamic technology of electrospinning). By variation of solution, electrospinning and environmental factors the morphology of the nanofibers to can be altered to achieve desired characteristics. Also, the characterization of nanofibers for evaluation of different parameter can be done by devices like confocal laser scanning microscopy (CLSM), Scanning electron microscope (SEM), Transmission electron microscope (TEM), Atomic Force Microscopy (AFM) etc. Some variants of electrospinning including coaxial electrospinning and emulsion electrospinning lead to additional functionalities in the nanofibers. Moreover, the polymers used for electrospun nanofibers lie within a wide domain from synthetic to natural biopolymers.

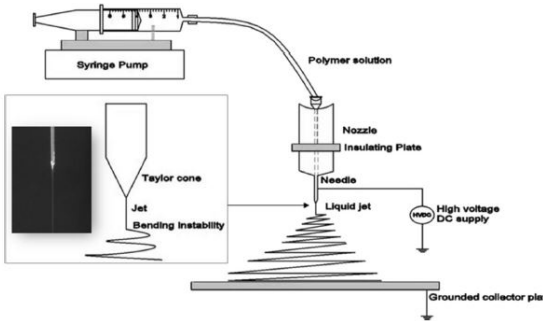

FIGURE.1: A typical laboratory scale electrospinning setup.

Owing to the structural like porosity, high surface to volume ration, tailored morphology, intertwined fibrous structure and functional advantages like sustained and controlled release, non-thermally processed products, reduced denaturation, efficient encapsulation, enhanced stability of bioactive etc. electrospun nanofibers have profound applications in various disciplines. However, in food domain, both the research and commercial applicability is still in its development phase. The main fields of application in food domain include micro and nanoencapsulation of food bioactive compounds and enzymes, fabrication of functional materials for active food packaging, use of electrospun fibres and filtration membranes in food and beverage processing. Encapsulation involves trapping of an active ingredient into the wall material. It helps to improve the bioavailability, stability and controlled release properties of the biomolecule. Encapsulation by electrospinning has the advantage of being a one-step process and suitable for encapsulation of heat labile compounds. Moreover, electrospinning for encapsulation uses a wide range of biocompatible, biodegradable, food grade, conducting polymeric substances as wall materials for encapsulation of bioactive. Also, some non-polymeric systems, especially cyclodextrin (CD) have been utilized through electrospinning for encapsulation of bioactive. Various bioactive like antioxidants, antibacterial, flavours and aromas, probiotics have been successfully encapsulated by electrospinning with enhanced encapsulation efficiency, greater thermal, light and storage stability, and enhanced protection from chemical degradation. Immobilization of enzymes can also be achieved through the process of electrospinning by two methods. The enzymes can either be encapsulated in the electrospun nanofiber or can be physically adsorbed or attached covalently to the surface of nanofiber. In both the methods, due to increased surface area and porosity, and reduction of size of carrier materials improve the efficiency of immobilized enzymes. The electrospun immobilized enzyme nanofiber can be utilized in biosensor development and bioactive food packaging for food safety and quality operations. Various enzymes like glucose oxidase, cellulose, beta-galactosidase, chymotrypsin, lipases etc have been immobilized by the electrospinning process in different polymers. Electrospinning also has extensive potential application in development of biopolymer-based active packaging materials. This is attributed to the nano-dimension of fibres, along with other features including like large area to volume ratio, higher sensitivity to external changes and ability to have stable encapsulation of heat sensitive active compound. The extent of application of electrospinning for food packaging is most widespread. The nanofibers can be used with use of various combinations of synthetic and natural biodegradable and non-biodegradable polymers achieving desired physical, thermal, mechanical and functional properties besides having reducing the load of plastic problem. Moreover, the polymeric electrospun nanofibers can be used as reinforcing materials for making nanocomposites or nanolaminates for food packaging with improved strength and barrier properties. Recently, active packaging development using algal biopeptides in the nanofibers made through electrospinning have been successfully experimented. Thus, the process of electrospinning being simple, flexible and versatile offers wide range of economically viable and potentially scalable applications in food processing.

18471

96. Role of Biosensor in Food Industry

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What is Biosensor?

Biosensor is an analytical device for the detection of an analyte that combines a biological component with a physicochemical detector component. Quality control becomes necessary part in the food industry keeping in a view to quantify the nutritional quality and other important analysis like food toxicity Allergenicity, determining phenolase activity, sucrose concentration in fruit juices and soft drinks like coke, presence of organic acids like tartaric acid, isocitrate concentrations in fruit juices, and determining adulteration with urea in milk. etc. In present day conditions food adulteration becomes major issue due to which many people has to suffer due to adulterated food which may be hazardous sometimes exceed toxicity leads to death so Due to this Biosensors can be the efficient, fast and accurate method to ensure food safety.

Parts of Biosensor

1. The *sensitive biological element* a biologically derived material or biomimic like nucleic acid DNA/RNA, Enzymes, Cell receptors etc. by through biological engineering these sensitive elements can be created.
2. The *transducer* or the *detector element*
3. Signal processors which is required to process and display the signals in a user-friendly way. This is the most expensive and sensitive part of the sensor device.

Types of Biosensors and their Principles of Detection

There are various kinds of biosensors most of which work on the principle of one of the following:

1. Electrochemical Biosensors

These kinds of biosensors are works on the principle of monitoring electro active species which are either formed or utilized by the action of the biological components like enzymes and cells.

2. Potentiometric Biosensors

These are based on monitoring the potential of a system at a working electrode, against reference electrode, under conditions of essentially zero current flow.

3. Amperometric Biosensors

In contrast to potentiometric devices, in Aerometric Biosensors is based on constant potential applied between a working and a reference electrode. The potential which is applied results in oxidative reductive reactions, leads to a net current to flow. The magnitude of this current is proportional to the concentration of electro active species present in test solution. The biological component in this type of biosensor involves use enzymes like oxidase and dehydrogenase as the bio recognition element.

4. Calorimetric Biosensors

Most of the biochemical reactions are exergonic (Liberates Energy) and endergonic (Absorbs Energy). The calorimetric biosensors are designed to detect heat produced or absorbed during a biological reaction.

5. Optical Biosensors

These measures light illumination or to light emissions like chemiluminescence, fluorescence, light absorbance, phosphoresence, photothermal techniques, surface plasmon resonance (SPR), light polarization and rotation, and total internal reflectance. These sensors can be used to detect the presence of allergens, in particular peanuts, during food production

6. Immunosensors

Immunosensors involves specific interaction of antibodies with antigens. *E.g.* ELIZA, RIA, these kinds of Biosensors are providing the rapid and accurate quantitative measurements of target analytes.

Applications of Biosensors

- Glucose monitoring in diabetes patients ☐historical market driver. Most of the glucose biosensors developed are based on immobilized glucose oxidase. In many cases, glucose oxidase has been associated with mediators so as to bring down the high working potential required for hydrogen peroxide breakdown. The α-D glucose sensor developed was also based on glucose oxidase, at the working potential of -350 mV vs. Ag/AgCl, hydrogen peroxide was catalytically oxidized at a rhodinised carbon electrode (White et al, 1994). A novel and simple method which do not involve enzyme or monomer modifications, for the coimmobilization of ferrocene and GOx in a poly(pyrrole) matrix for use as glucose biosensor was developed (Foulds and Lowe, 1988).
- Other medical health related targets like cheking level of insulin or other growth factors enzymes,

metabolites, etc.
- Environmental applications e.g. the detection of pesticides and river water contaminants like some heavy metal's toxic chemicals etc.
- Remote sensing of airborne bacteria e.g. in counter-bioterrorist activities. There are some bacteria which are pathogenic and can be transfer though air.
- Detection of pathogens in case of plants animal and human diseases.
- Determining levels of toxic substances before and after bioremediation. like bioremediation of industrial dye where it becomes important to check toxicity level before and after of bioremediation as after the deconstruction of some recalcitrant dyes their breakdown product may have toxicity.
- Detection and determining of organophosphate as application of pesticides which becomes routine practice in case of agriculture it becomes important to check the levels of organophosphate or say pesticide residues.
- Routine analytical measurement of folic acid, biotin, vitamin B12 and pantothenic acid as an alternative to microbiological assay
- As per increasing demand of Milk, Milk products and meat, use of growth promoters and drugs becomes routine practice so as to achieve high biomass and milk. So, it is necessary to Determine drug residues in food, such as antibiotics and growth promoters, particularly meat and honey.
- Drug discovery and evaluation of biological activity of new compounds.
- Protein engineering in biosensors
- Detection of toxic metabolites such as mycotoxins
- Fruit Maturity, Ripening and Quality Relationships Fruit maturity at harvest is the most important factor that determines shelf life and final fruit quality
- Biochemical Composition of Fruits The quality of soft fruit, in terms of taste, nutrition and consumers acceptance, is fundamentally based on the biochemical composition of the fruit

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FOODS AND NUTRITION

18463

97. Food Fortification: Fighting Micronutrient Deficiencies

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INTRODUCTION: Globally approximately 2 billion people suffer from chronic micronutrient deficiencies viz., vitamin and mineral deficiencies with the most common forms being caused by a lack of iron, folate, iodine, vitamin A, and zinc (Global Nutrition Report 2016). Micronutrient deficiencies prevalent in population, diets lacking in micronutrients pose a constant threat on public health problems. It is stated that India annually loses USD 12 billion in GDP to vitamin and mineral deficiency (UNICEF 2004, World Bank 2009). The diet of more than half of the population lacks micronutrient leading to consumption of less than 50 per cent of their daily needs (National Nutrition Monitoring Bureau 2012). These deficiencies need to be corrected for sustainable development, prosperity and wellbeing of the country as whole. Fortification of foods is one such effective solution which comes to rescue and easily reaches masses. Under the National Nutrition Policy of India 1993, food fortification of essential food with appropriate nutrients is identified as short-term direct nutrition intervention.

Food fortification is a broad term which includes adding essential trace elements and vitamins. It has been defined as the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups (FAO/WHO 1994). Other terminologies associated with food fortification used interchangeably or used synonymously are restoration and enrichment. Restoration is addition of essential nutrients to a food which are lost during the course of Good Manufacturing Process (GMP), or during normal storage and handling procedures, and Enrichment is increasing the level of nutrients present to make the food a 'richer' source (*Codex Alimentarius* 1987).

Types of food fortification: Food fortification

can be **mandatory** for serious public health needs or risks and **voluntary** for lower order public health needs or risks. **Mass fortification** (widely consumed by the general population) **targeted fortification** (fortifying foods designed for specific population sub groups, *e.g.* complementary foods for young children) and **market-driven fortification** (allowing manufacturers to fortify foods voluntarily) are also types of fortification.

General and Technical Criteria for Selecting Vehicle for Fortification

- Should be consumed by high population
- Should not be related to socio economic status
- Potential for excessive intake should be low
- Should not change consumers acceptability
- Should be centrally processed
- Segregation of fortificant and vehicle should be minimal
- Minimal regional variation
- It should have good masking quality
- Simple low-cost technology
- Good shelf life
- High bioavailability

Various foods are identified as suitable vehicle for fortification in India such as salt, oil, milk, wheat and rice. Fortifying salt with iodine is one such success story for India.

Benefits of Food Fortification

- Widely consumed staples can be fortified, thus is excellent way to reach and improve health of large section of population at once.
- Staples and widely consumed foods can be fortified thus changes in eating pattern or food habits are not required.
- Characteristics of food is not altered.
- Within the regulations and prescribed standards food fortification is safe method for improving nutrition among people as the likelihood of overdose of nutrients is unlikely.
- It is a socio-culturally acceptable way to deliver nutrients to people.

Conclusion: Prevalence of micronutrient deficiency across the population puts wellbeing of the whole country at risk slowing down development. In such situation dealing with these deficiencies is essential. Food fortification is an effective solution for dealing with vitamin and mineral deficiencies in all groups of population especially the at-risk population. It is a cost-effective strategy and has a great potential to fight the hidden malnutrition.

HEALTH

18476

98. Health Benefits of Storing Drinking Water in Copper Vessels

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INTRODUCTION: In most developing countries like India microbially-unsafe water is still a major concern. Although many water-purification methods exist but these are expensive and beyond the reach of many people, especially in rural areas. It has been estimated that around 37.7 million Indians are affected by waterborne diseases annually, 1.5 million children are estimated to die of diarrhea alone and 73 million working days are lost due to waterborne disease each year. In many scientific studies it has been reported that copper can inactivate harmful water borne microorganisms, including *L. pneumophila*, the principal agent of Legionnaire's disease, methicillin-resistant *Staphylococcus aureus*, *E. coli* (a food and waterborne bacterium that causes severe illness and death) and *Listeria monocytogenes*. A study conducted by Patil, 2018 reported that the amount of *E. coli* in the copper vessels dropped dramatically over time, and fell to undetectable levels in 18-24 hours. The result of this indicates potential to the practical use of copper vessels in rural areas of India and elsewhere.

Beyond this there are some other benefits of drinking water stored in copper vessels which have been mentioned below.

1. Copper is an essential micro nutrient for proper functioning of our body, which cannot synthesize in human body, needs to consume from dietary sources. Drinking water stored in copper vessels can provide enough amount of copper to our body.
2. Copper also helps to keep digestive system healthy and it is a great for ulcers, indigestion and infections.
3. Copper also has antioxidant property which fights with free radicals help to prevent aging and cancer.
4. Copper also prevents anaemia by helping in the absorption and utilization of iron present in

body.

5. When water is stored in a copper vessel; the copper gently leaches into water and lends it all its positive properties. The greatest thing about this water is that it never becomes stale and can be stored for long periods of time.

Conclusion: In ancient India storing drinking water in copper vessels was practiced which have been replaced by some other metals and plastic containers in modern India. Now there is need to provide knowledge about benefits of copper vessels and easy access. Though copper has many health benefits it should not exceed 1 to 3 mg/day according to WHO recommendation. Excess consumption of copper can cause toxicity in our body.

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FISHERIES

18380

99. Fisheries: An Imminent Approach for Nutritional Security

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INTRODUCTION: The world's most devastating problems which are inextricably linked to poverty are hunger and malnutrition. The population which largely suffers food and nutrition insecurity resides in Asia and Sub-Saharan Africa. In low-income countries, malnutrition accounts for 45% of mortality in children under age five. In addition to direct consumption, fisheries contribute to food and nutrition security through income generation, providing a source of employment for women who participate in fishing and postharvest activities and increasing the household's ability to purchase food. It is widely recognized that if supported and developed in a regulated manner, fisheries have the capacity to address the confronts and contribute towards eradication of hunger, food insecurity and malnutrition. Animal protein supply can be acquired from other terrestrial animal sources also, but as they expensive so poor cannot make such choices and remain critically dependent on cheapest source as fish.

Fish as Critical Food Source

Fish represents a rich source of protein, essential fatty acids and micronutrients. The contribution of fish to nutrition and household food security depends upon access, availability and personal preferences. Fish comprises of a total 18% to 20% protein content as well as essential amino acids including those that contain sulphur such as lysine, methionine and cysteine. The human body cannot naturally synthesize essential amino acids and must be accompanied exogenously and the fish diet is the best way of supplying the amino acids, which plays a greater role in maintenance, growth, development and repairing of worn out tissues of the human body.

The lipid composition of fish is unique in having long-chain, poly-unsaturated fatty acids (PUFAs) with many potential beneficial effects for child development and human health. Marine fishes (like salmon, trout, sardines, tuna and mackerel) are the richest sources of PUFAs. Fatty fish are also much higher in omega-3 fatty acids. These fatty acids are crucial for body and brain to function optimally, and are strongly linked to reduced risk of many diseases. High level of PUFAs in fish, especially the long-chain omega-3 fatty acids DHA and EPA, are essential for cardiovascular and brain health. The intake of fish or fish oil has been associated with of lower risk of death and sudden death from coronary heart disease, ischemic stroke, atrial fibrillation, and congestive heart failure. The presence of PUFAs in the diet of pregnant women gives rise to proper development in unborn babies as well as reduced risk of premature delivery. The fats assist in proper absorption of fat-soluble vitamins namely A, D, E and K and contribute to energy supply.

Another most important contribution of fish is in the form of vitamins including vitamin A, B (of which B_{12} is associated with seafood) D and micronutrients comprising calcium, phosphorus, iodine, zinc, iron, and selenium. The actual nutritional content of fish varies substantially by species and species group. Presence of micronutrients in fish can lead to a variety of health benefits like lowered cardiovascular disease risk, progressive maternal health and pregnancy outcomes and improved immune system function. It also alleviates health issues associated with micronutrient deficiencies like rickets, anemia, childhood blindness, and stunting. Availability of natural low-cost dietary sources of vitamin D is highly scarce, so the contribution of fish is particularly

important for curing Vitamin D deficiency (which includes rickets in children, bone health disorders in adults, and increased risk of common cancers, autoimmune diseases, high blood pressure, and cardiovascular diseases). Supplementation of Vitamin A is helpful in strengthening immune system and anemia whereas, Vitamin B is important in combination with iron and folate to prevent a number of cognitive and neurologic problems. Vitamin A from fish is more readily available to the human body than from plant foods.

Conclusion: In recent years, with dramatic rise and increased volatility in food prices, there is a risk that the diets of the poor will become devoid of nutrients and even less diverse. So, the importance of nutrient-rich fish, especially from the wild and from aquaculture can play a vital role in improving human nutrition. The significance of fish protein in the growth and development of children should be highlighted among both fishing and non-fishing communities to boost the consumption of fish specially among pregnant and under five age group children to increase the chances of improved nutrition status and high birth weight. Therefore, it must be provision to enhance sustainability and productivity of aquaculture in small- and large-scale systems and make fish an integral element in inter-sectoral national food security and nutritional policies and programmes.

ENVIRONMENTAL SCIENCE

18551

100. Climate Smart Agriculture: A New Trend for Sustainable Agriculture

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Agriculture needs significant transformation in order to meet the global challenges of achieving food security and mitigating climate change. After considering the livelihood and consumption pattern of the growing population, FAO estimates that to meet the global food demand, 70 percent increase in total agricultural production is required. Most of the researches have shown that climate change is responsible for reducing agricultural productivity, production stability and incomes thus leading the nation towards food insecurity. In 2030 Agenda it is stated to be the need of the hour to make our agriculture and food systems more sustainable by shifting our approaches to more sustainable in the context of consumption and production Climate Smart Agriculture is one of the viable options to achieve the goal of sustainable agriculture.

Evolution of Climate Smart Agriculture (CSA)

FAO has developed the concept of Climate Smart Agriculture (CSA). It was first presented through the paper "Climate Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation" at the Hague Conference on Agriculture, Food Security and Climate Change held in 2010. CSA has strong focus on food security, considering the present demands and the future needs, including adaptation to climate change. Thus, developing climate-smart agriculture is thus crucial to achieving future food security and climate change goals.

Why we need Climate Smart Agriculture?

Climate change is emerging as a major threat on agriculture, food security, and livelihood of millions of people in many places of the world **(IPCC, 2014)**. Both globally and locally, climate change is adversely impacting agricultural production. Thus, agriculture has to become "climate smart" to overcome the challenges posed by climate change. It is wrong to say that CSA is a set of practices that can be universally applied, but rather it is an approach that involves different element to be implemented specifically at local level. CSA involves activities both on-farm and beyond the farm, and incorporates technologies, policies, institutions, and investment. Due to weaker adaptive capacity, low-income countries are going to suffer more drastically to climate risks in the area of cropping, livestock, and fisheries. Climate Smart Agriculture technologies will address a number of context-specific multi-dimensional threats of agricultural systems.

What is Climate Smart Agriculture?

CSA is an approach which provides the means to help stakeholders from local to national and international levels in identifying location specific agricultural strategies suitable to secure sustainable food security under climate change scenario. To transform and reorient agricultural systems, Climate Smart Agriculture (CSA) needs to be promoted which will ultimately support development goals and ensure food security in this climate change scenario **(FAO,**

2010). According to FAO, CSA sustainably increases productivity, enhances resilience (adaptation), reduces or removes GHGs (mitigation). It enhances achievement of national food security and thus supports development goals. Being integrative in approach Climate-smart agriculture (CSA) addresses the interwoven challenges of food security and climate change. CSA has three objectives:

Increased productivity: More food is produced to improve food and nutrition security and boost the income of farmers deriving their livelihood from on agriculture and allied sectors.

Enhanced resilience: Reduce vulnerability to drought, pests, disease and other odd situations and improve adaptive capacity to the face of long-term stresses like shortened seasons and erratic weather patterns.

Reduced emissions of harmful GHGs gases: Deforestation should be discouraged and ways are to be identified to suck carbon out of the atmosphere. Ex- Low CH_4 emission rice varieties.

Advantages of CSA

1. **CSA ensures food and nutritional security:** CSA helps to improve food security for the poor and marginalized groups while also reducing food waste globally.
2. **CSA helps in poverty alleviation**: Agriculture is the main activity of majority of third world countries. Agriculture is helpful to propel people out of poverty. Agricultural growth is the most effective way and equitable strategy for reducing poverty and increasing food security.
3. **CSA addresses the challenges of climate change in agriculture:** Agriculture sector is most vulnerable to climate change. Agriculture is highly dependent on temperature, rain and other factors. There is two-way street between agriculture and climate change *i.e.* agriculture is not only affected by climate change but has a significant effect of climate change on it in return. If agricultural emissions are not reduced with time then agriculture will account for 70% of the total GHG emissions. For addressing this challenge, mitigation is one of the three pillars of Climate Smart Agriculture.

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18462

101. Mercury Toxicity: Indian Perspective

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INTRODUCTION: Mercury is one of the heavy metals mainly exists as elemental form, inorganic form as salts of mercury and the organic form. Of all the three forms of mercury the organo metallic form of mercury poses threat to the living organisms. The methyl mercury is the organometallic form which was transformed from the elemental form by methylating bacteria as the methyl groups are added to the mercury and make them fat soluble which tends to the bioaccumulation and biomagnifications of mercury in various trophic levels. The transformation occurs mainly in the aquatic ecosystems such as lakes, ponds and estuaries where the flow of the water gets stagnated. The mercury deposits in the sediments gets methylated and converted into organic form as methyl mercury. The mercury was used for numerous purposes starting from industrial sector to service sector. Some of the uses releases the mercury in the environment and remains in the vapour and suspended as particulate matter and gets deposited by rain in aquatic ecosystem tends them easy to methylate and biomagnify. The mercury released during mining of coal, oil, cement production (PM-Hg), disposal of waste batteries, chlor-alkali industries, steel industry, thermal power plants, clinical thermometers, Blood pressure monitoring, dental amalgams, electrical switches, fluorescent, mercury vapour lamps, fungicides such as (PMA), Mercuro chrome and in the paper processing in mills.

Mercury Emission Sources

The natural sources of the mercury emission include the volcanic eruption, vents and hot springs. The global release of mercury was estimated as 2269 tonnes $year^{-1}$ while Asia contributes 52% of the total emissions as India releases for about 291 tonnes of mercury each year.

Impact on Human Health

The mercury being a potent neurotoxin has mainly few kinds of exposure such as by inhalation of dust or vapour of mercury by means of the nose directly affects the brain and ingestion by means of consumption of mercury bioaccumulated foods. There are about 258 symptoms of mercury toxicity which are numbness, effect to Central Nervous System, loss of hearing, misleading in legs and hands, tremors, ringing in ears, awkward movements, tiredness and it can transmit to foetus of the mother and leads to malformed children and causes serious disorders.

The chronic exposure to mercury causes Mad hatters disease which has irritability, tremors, excitability, pathological shyness, fatigue, loss of memory, vivid dreams etc.

Impact on Various Trophic Levels

The mercury poisoning was first observed in the minamata bay in japan due to the release of industries in the minamata bay by which the mercury bioaccumulated in the shell fish and it gets biomagnified in humans and showed serious symptoms in the adults, children's and in the foetus of the mother. The mercury was absorbed in the blood by means of ingestion of the mercury contaminated foods.

Mercury Poisoning – Indian Perspective

In india there are various source of the mercury poisoning. Some of the episodes are the mercury was found in the fish (91.2 ppm), radish (1.67 ppm) in the Varanasi as the maximum permissible limit by CPCB was 0.001 mg L^{-1}. The gaseous form of mercury precipitated in the region of the chamber in Mumbai and the mercury levels exceeded as high as 82 mcg as wet deposition. The dry deposition of the mercury taken place in the Raipur due to the release by the steel plant which was between 60 – 835 g km^{-1} $month^{-1}$. Another episode taken place in Kodaikkanal by the thermometer manufacturing industry Hindustan unilevers as the Industry dumped the waste thermometers containing mercury in the soil as the mercury polluted the soil and water in kodaikkanal.

Mercury in Paper Mills and Quarrying

The paper mills were another source of mercury as the paper mill dust contains 20 µg g^{-1} of mercury as the particulate mercury levels recorded in the paper mills between 0.79-0.99 ng $cu.m^{-1}$. the cement factory due to the quarrying and processing of limestone leads to release of mercury which ranges upto 3 kg day^{-1}.

Coal Combustion and Mercury

The thermal power plants use coal firing for the thermal conversion as the coal contains few amounts of mercury leads to release into atmosphere and tends to bio transform and bioaccumulates. The episode in the singrauli thermal power plant the mercury assessment was made to the local people of 1200 persons and the mercury in the hair and blood has been assessed. The hair samples contain 1.0 µg g^{-1} for about 48% of the population while blood samples contain 5 ng mL^{-1} for about 76% of the population. In children it was observed are respiratory problems, diarrhea, abdominal pain and worm infestation.

Dental Amalgams

The main source of the direct exposure was dental amalgams as the amalgams could release mercury for upto 70 years. The dental amalgams could generate 15 µg of Hg day^{-1} as 8 amalgams could generate 120 µg day^{-1} while the maximum allowable limit of EPA was 0.1 µg kg^{-1} of body weight.

The mercury which bioaccumulate in the human body by meany of its high affinity to the sulfhydryl groups (-SH) and it can bind with it. The time taken for the removal of mercury from human body was 18 years. So, avoid amalgams, shell fish and ensure your food is free from mercury.

18467

102. Emerging Issue of the Present: Microbead Pollution

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INTRODUCTION: Microbeads are the small plastic particles of size less than one millimeter in dimension. These are the manufactured particles composed of polyethylene, polypropylene and polystyrene. They have found their use in variety of our daily products like exfoliating personal care products, toothpaste etc. The microbeads are small beads like structures which wash off down the drain and leads to water pollution. The particles reach the water bodies and are dispersed. The particles attract the biotic species like fishes and enter their bodies. These plastic particles cause serious harm to their metabolic activities and also affects their reproduction. The major concern about the microbeads is that it does not disintegrate into smaller pieces and continue to pass from one trophic level to another. Thus, the production and use of the microbeads should be regulated to protect the environment.

Microbeads

The microbeads are the small plastic particles with size less than one millimeter. The microbeads are usually made with petrochemical plastics like polyethylene, polypropylene and polystyrene. These were invented in 1976 as polystyrene beads for use in medicines. These are the emerging source of water

pollution and pose serious environmental threat.

Availability

The microbeads are added by the manufacturers to the daily use products like soaps, facial scrubs, facewash, toothpaste and medical drugs. The particles are spherical or rectangle in shape and usually uniform in size. They help to improve the texture and enhance the spreadability of the cosmetic products. The coloured microbeads increase the aesthetic appeal of the products and hence leads to increased sales.

Effect on Environment

The microbeads present in the cosmetic products are washed down and are unable to be captured by the water treatment plants and reaches larger water bodies leading to plastic water pollution. The coloured microbeads attract the biotic species like zooplanktons and fishes. The zooplanktons mistake them for their food and ingest them. Several researches show the harmful effects of ingesting these harmful particles. Some of the changes involve behavioral changes, unable to detect predators, low egg production, disturbance in metabolic activities, reproduction. The microbeads add to further disadvantage by absorbing the harmful chemicals like pesticides, polychlorinated biphenyls, polyethylene terephthalate, polymethyl methacrylate and other polycyclic hydrocarbons.

These microbeads have polluted different water bodies like lake Michigan, Lake Erie, Lake Huron, etc. A study conducted in State University of New York found that the presence of microbeads in the Great lakes range from 1500 to 1.1 million per square mile.

Steps to Prevent Microbead Pollution

After the discovery of microbeads in the ocean waters the initiative to stop microplastic pollution was taken by different foundations working to protect the ocean waters. The foundation like North Sea Foundation and Plastic Soup Foundation launched an application (beat the microbead) to generate awareness among the people about microbead pollution. This led to ban of microbeads in cosmetic products in U.S.A., U.K., Canada, France, New Zealand, South Korea. The first local ban was imposed in Erie country, New York in 2015. National Green Tribunal (NGT), Bureau of Indian Standards classified microbead products as 'not fit for use' in May 2017. India has also decided to impose ban on microbeads in rinse off cosmetic products by 2020.

The alternatives for the microbeads have been suggested by the different foundations to protect the environment. The products like raw honey, natural clays, baking soda, organic oatmeal, organic sugar, natural sea salt and ground fruit kernels.

UNEP report on "Plastic in Cosmetics" and TAUW report on "Test to assess and prevent the emission of primary synthetic microparticles" listed some microplastic ingredients in cosmetics which cause harm to the environment. Some of the ingredients mentioned were Poly (2-hydroxyethyl methacrylate), Poly (2-hydroxypropyl methacrylate), Polyacrylate, Polyacrylonitrile, Polyacrylonitrile butadiene styrene, Polyactide, Polyalkyd resins, Polyalkyl stereate/vinyl acetate copolymers, Polybuthylene/Ethylene/Styrene copolymer, Polybutyl acrylate, Polyisobutylene, Polyisoprene, Polylactic acid, etc.

Conclusion: Microbead pollution is the emerging culprit for the environmental damage. The issue need to be solved through awareness generation. The laws and regulations regulating the use of microbeads in cosmetics should be internationally recognized and strictly followed. This pollution is raising an international concern and require the part of consumers to prevent the pollution.

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ECONOMICS

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103. Gramin Agricultural Markets (GrAMs): Bridge Between Farmgate and Consumers

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A very old saying "India resides in its villages" is very true in its sense as the majority of the population of our country resides in a rural background. According to the 2011 census, 68.84% of India's population resides in rural areas with 833.1 million people scattered in 236,004 villages with an average landholding size of about 1.1 hectares. Thus, in a nation like India agricultural marketing plays an important role in economic development stimulating the production and consumption process. The Indian agricultural population is dominated by small and marginal farmers with 89.2 % of the agrarian population falling in this class. According to NSSO 2016, 28% of the rural population is below the poverty line which emerges the demand for fair and remunerative prices to the producers and benefit of consumers and transforming the farming from, production-centric to profit-centric. As defined by IRDA, a rural market is, "A villages with a population of less than 54,000, with 85% of the male population engaged in agricultural actions". The four majorly different channels of marketing system prevalent with respect to Indian agriculture include village sale, market sale, mandi sale and cooperative sale. Thus, the purchasing power of the people in rural areas is mainly dependent on the profitable agricultural surplus and rural-urban trade. The major lacunas of Indian agricultural marketing system include lack of proper storage facility, poor transportation arrangements, lack of market intelligence, too many middlemen or intermediaries, defective weights and grades, illiteracy and lack of unity among the farmers, lack of financial resources, and lack of organized marketing system. In order to confront the above issues, Government of India started an online trading platform named National Agriculture Marketing or e-NAM in 2016 to link the established APMCs (Agricultural Produce Market Committee). 498 mandis have been integrated with e-NAM with a total of 23,41,901 farmers using it since 14th February 2016 to 5th March 2018. Major states where this integration was a success were Uttar Pradesh, Gujarat, Madhya Pradesh and Haryana. There are about 2477 principal regulated markets based on geography (the APMCs) and 4843 sub-market yards regulated by the respective APMCs in India. The transition of Indian agriculture from commoditization to commercialisation raises the need to strengthen the regulated market system for better and easy market access and efficient information flow in order to bring out the desirable market orientation of the production system. Hence, an alternative market architecture is needed to overcome the issues of non-farmer friendly existing market structure. GrAMs or Gramin Agricultural Markets emerged as an alternative to serve as first mile facilitators to organize the marketing chain that will initiate and service transactions at terminal destinations, and with other primary and secondary markets. They are defined as "Retail agricultural markets in close proximity of the farm gate that promote and service a more efficient transaction of the farmers' produce across the agricultural sub-sectors, by enabling both direct sale, between the producer and consumer, and aggregation of small produce-lots for subsequent transaction, both of which can occur either physically or online". (Committee on Doubling Farmers' Income). The Union Budget 2018-19 announced to develop and upgrade existing 22,000 rural haats into Gramin Agricultural Markets (GrAMs). The GrAMs will be supported by creating an Agri-Market Infrastructure Fund (AMIF) in order to strengthen the infrastructure required for the commission and operation upgradation of 585 e-NAM on-board markets. Physical infrastructure to be strengthened using MGNREGA and other government schemes such as PMGSY (Phase III) to fortify road linkages from farm gates to GrAMs. GrAMs will facilitate two principal activities which include direct sale and aggregation of lots, thus, combating the issues of inadequate marketable surplus, long distance to nearest APMC markets, and lack of transportation facilities. Direct sale enables the farmers to sell their produce physically or online directly to consumers without going through the market regulations. The disintermediation of such a transaction will result in the transfer of maximum value to the farmer for his produce. Aggregation of lots means that the small lots of the farmer-producers can be aggregated through an institutional mechanism (like FPO, VPO etc.) to gain enhanced bargaining power and subsequent sale either at the GrAMs via an online trade platform like e-NAM or by availing primary preparatory or pre-conditioning services, such as assaying, cooling, packaging, and transporting from the GrAMs to APMC/RMC or any other primary or secondary or terminal wholesale

agricultural market. In India, there are 22941 rural haats owned by local bodies including councils (11811 haats), marketing board/APMCs (1274 haats) and under private sector (9856 haats). These haats are periodic markets which assemble at regular interval of 7 days, 15 days and at times seasonally and are located at a distance of 5-6 km distance from the farm gates overcoming the transportation problem. The infrastructure of GrAMs is majorly divided into two major categories- the off-market structure and on-market structure. The off-market structure primarily includes efficient connectivity through roads for the transportation of farm produce from farm gates to GrAMs, and from there to wholesale markets like APMCs or other consumption centres. The on-market infrastructure includes two sub-categories basic and supports infrastructure and market transaction infrastructure. The basic and support infrastructure will define a place as a market and create the primary environment to undertake various trade activities. The market transaction infrastructure generally includes electronic/normal weighing scales; pre-conditioning- cleaning, sorting, grading, washing, waxing etc. unit of minimum capacity; appropriate storage and transport facilities; IT infrastructure to integrate with e-NAM and for market information including electronic ticker board/ market information system etc. At last, we can conclude that in a leading agricultural commodity producing nation, an effective marketing system is of utmost necessity for the better linkage between the producer or farmer and the consumer. GrAMs, thus have great potential to prove as an alternate structure to bridge the gap between farm gates and consumers by increasing the producers share in consumers' rupee and overcome the shortcomings observed in the APMC marketing system.

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104. Out-Migration from Bihar: Reasons and its Impact

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Migration is an essential part of process of development. It explains a vigorous link between both area of origin and destination. Migration functions within the framework of social, cultural, economic and institutional conditions at both sending and receiving ends. Migration is often streamlined as a consequence of asymmetry of development between area of origin and destination. Bihar migrants are facing increasing opposition from political class but the continuing policy of urban planning, which is tossed towards the richer section of urban inhabitants and is also increasing difficulties to survival of poor migrants.

The current phenomenon of labour migration from the state Bihar can be bounded back to colonial period. This region started to experience labour out-migration of the initials. The pattern of regional inequality and underdevelopment raised in colonial period is largely attributed by this phenomenon of labour migration. The migration stream was dominated by lower caste and landless labourers, who were staying at basic subsistence level and ready to respond to the fair high wage gap between their native place and east. They found employment in the mills, factories, docks and coal mines, or on the roads and railways, or in harvesting the crops of other districts of West-Bengal. This migration was mostly seasonal and improved communication through railways made it possible for them to migrate easily and come back to their native place for agriculture and other activities. For the subsistence of agricultural labourers and marginal farmers, circular migration is important. When the peasants and labourers were not able to get enough from cultivation, this migration played an important complementary role to satisfy their needs.

Reasons of Out-Migration

The census has classified the reasons of migration in six broad categories. These categories are:

- Work or Employment
- Business
- Education
- Marriage
- Moved with households
- Moved after birth

According to NSSO, the reason of out-migration was categorized into 18 categories. employment related reasons are also classified into 6 categories, which are in search of employment, in search of better employment, to take up employment or better employment, business, transfer of service or contract and vicinity to place of work.

Impact of Out-Migration

The average household expenditure of all migrant households is Rs 35,719 and remittances contribute around 42% of it. The contribution of remittances is equally important for all the section of households. In the poorest quintile, around 20% of entire households receive remittances which contribute more than half (around 56%) of total household expenditure. (Source: NSSO 64th round, 2007-08)

The important use of remittances in migrant households, who received remittances are around 69.3 per cent of household, mentioned the use of remittances for the food. Around 10 per cent of household used remittances for other consumption purposes. Around 6.5 per cent used it for health care and 6 per cent used it for other needs. (Source: NSSO 64th round, 2007-08)

Poorest households use remittances more on their need of food (78 %), compared to 53 % use among richest households. The health care expenditure met by remittances is higher among rich compared to the poor households. However, the facts remains among the migrant households regardless of economic status, remittances are important source of food expenditure in Bihar. Thus, the importance of remittances in mitigating food insecurity in Bihar is supreme and this must be recognized by policymakers. (Source: NSSO 64th round, 2007-08)

Conclusion: Out-Migration from Bihar is a well-established phenomenon started back in the nineteenth century and it seems shot up in the recent decades. The flow and direction of migration has also been transformed in course of time and most of the migration is taking place in the north-western and western parts of India. The states like Delhi, Maharashtra, Punjab, Haryana and Gujarat account half of the inter-censual migrants. The main reason for this heavy out-flows is related to employment. People are migrating not only for the sake of employment but also to secure a better earning. It also seems that the out-migration for employment is taking place not only in poor and socially backward households but the members of affluent households are also migrating either in the same proportion or even higher. Around one-fifth households have received remittances sent by the migrants of the households. These remittances comprise almost half of the household expenditure, irrespective of economic status of the households, it is mostly spent on food and other items of consumer expenditure, health care and education of the family members.

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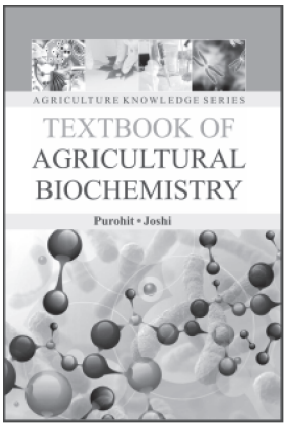

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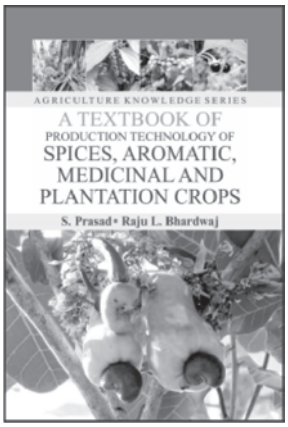

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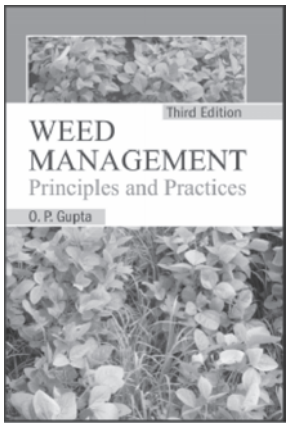

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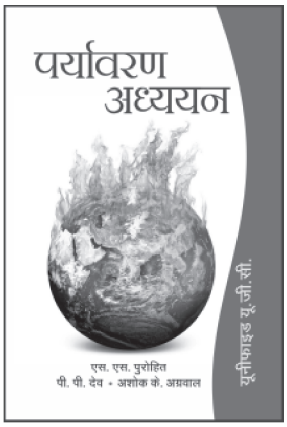

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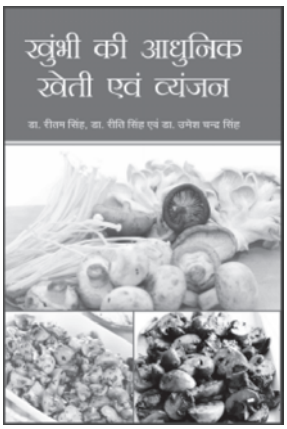

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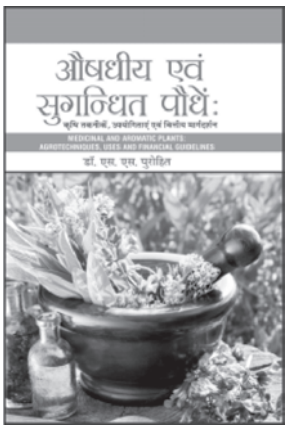

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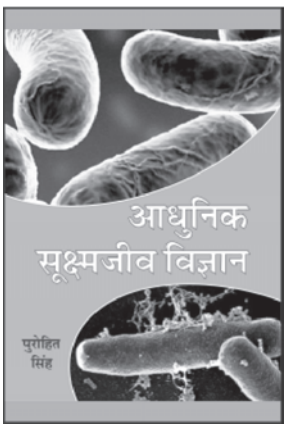

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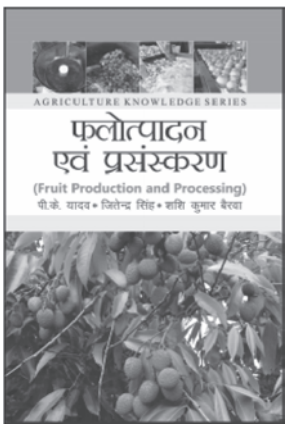

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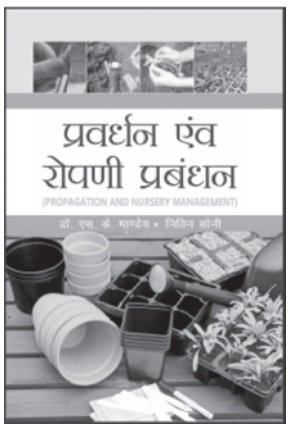

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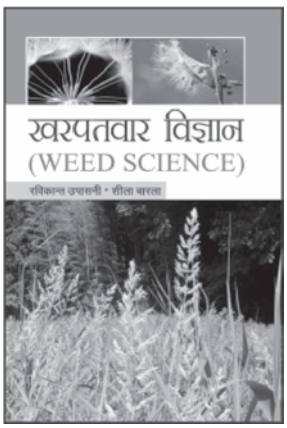

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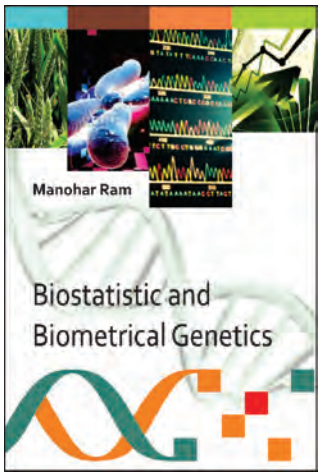

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