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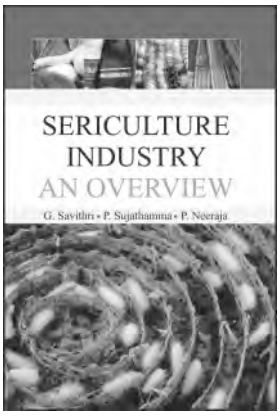

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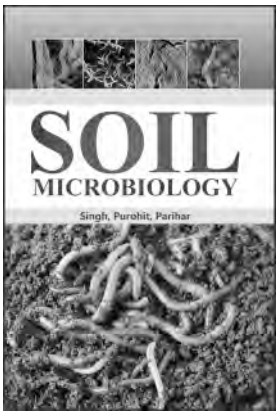

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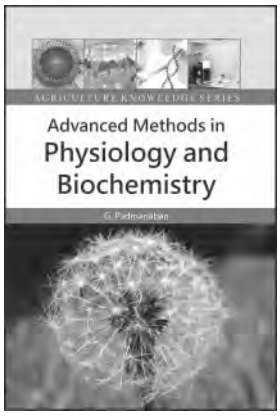

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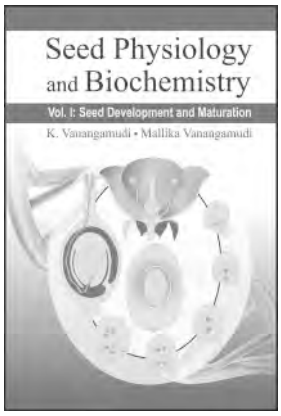

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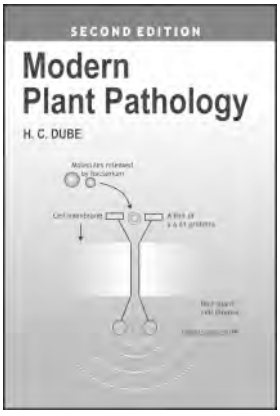

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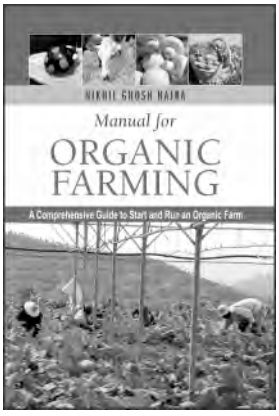

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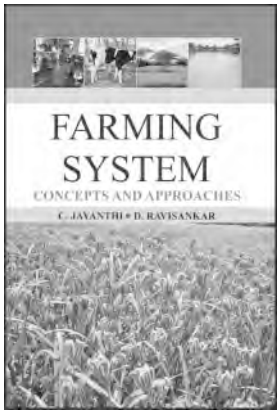

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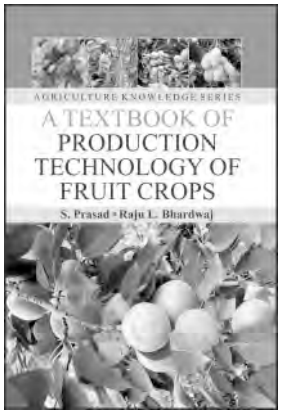

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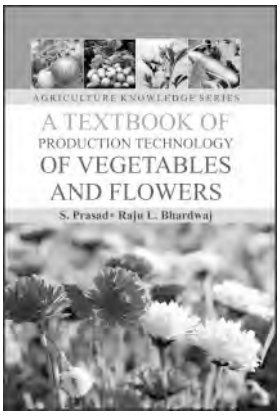

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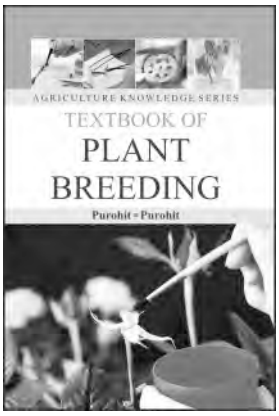

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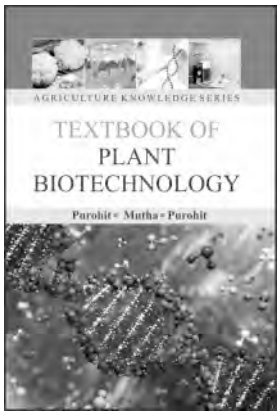

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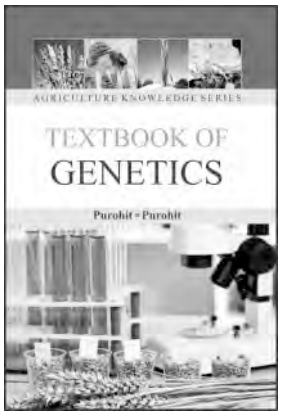

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1. BIOTECHNOLOGY 15857

Gene Cloning in Agriculture

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Gene cloning provides a new dimension to crop breeding by enabling direct changes to be made to the genotype of a plant, circumventing the random processes inherent in conventional breeding. In **gene addition**, cloning is used to alter the characteristics of a plant by providing it with one or more new genes. In **gene subtraction**, genetic engineering techniques are used to inactivate one or more of the plant's existing genes.

Gene Addition

Plants are subject to predation by virtually all other types of organisms- viruses, bacteria, fungi and animals but in agriculture, the greatest problems are caused by insects. To reduce losses by insects, crops are regularly sprayed with insecticides. Several of these insecticides have potentially harmful side effects on the environment. An ideal insecticide should be toxic only to the insect targeted and not to any other insects, animals and humans. The insecticide should also be biodegradable, so that any residues remain after the crop is harvested, or which are carried out of the field by rain water, don't persist long enough to damage the environment.

Insects along with plants occasionally use bacteria as their diet. Several types of bacteria have evolved defence mechanisms against insect predation, for example Bacillus thuringiensis during sporulation forms intracellular crystalline bodies that contain an insecticidal protein called the -endotoxin which is highly poisonous to insects. It is an inactive precursor and after ingestion by the insect this pro-toxin is cleaved by proteinases, resulting in shorter versions of the protein that display the toxic activity, binding to the inside of insect's gut and damaging the surface epithellium so that the insect is unable to feed and consequently starves to death. Biodegradability of *B. thuringiensis* acts as a disadvantage so they must be reapplied at regular intervals during the growing season which is not cost effective. The -endotoxins that do not require regular application are developed by modifying the structure of toxin via protein engineering to be more stable.

Maize is a crop plant that is not served well by conventional insecticides. A major pest of the plant is the European corn borer, which tunnels into the plant from eggs laid on the under-surfaces of leaves, thereby evading the effects of insecticides applied by spraying. The first attempt at countering this pest by engineering maize plants to synthesize -endotoxin was made by plant biotechnologists at a Ciba-Geigy laboratory in North Carolina. They worked with the Cry1A(b) version of the toxin which had previously been shown to be a 1155-amino-acid protein, with the toxic activity residing in the segment from amino acids 29 to 607. Instead of isolating the natural gene they made a shortened version of the first 648 codons, by artificial gene synthesis. The artificial gene was ligated into a cassette vector between a promoter and polyadenylation signal from cauliflower mosaic virus, and introduced into maize embryos by bombardment with DNA coated microprojectiles. The embryos were grown into mature plants, and transformants identified by PCR analysis of DNA extracts, using primers specific for a segment of the artificial gene.

In the immunological tests the results showed that the artificial gene was indeed active, but the amount of -endotoxin being produced varied from plant to plant. This was probably due to positional effects, the level of expression of a gene cloned in a plant often being influenced by the exact location of the gene in the host chromosomes.

Gene Subtraction

Gene subtraction is a modification which involves the inactivation of a gene rather than its removal. The most successful so far in practical terms is the use of antisense technology.

Antisense Technology

In antisense technology the gene to be cloned is ligated into the vector in reverse orientation. When this cloned gene is transcribed, the RNA synthsized is the reverse complement of the mRNA from the normal sequence. This antisense RNA is able to prevent synthesis of the product of the gene it is directed against, this is due to the hybridization between antisense and sense copies. This block the expression by degrading double-

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stranded RNA by cellular ribonucleases. It prevents ribosomal attachment to sense strand.

CRISPR Technology

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) and CRISPR-associated (Cas) genes are essential in adaptive immunity in select bacteria and archaea, enabling the organisms to respond to and eliminate invading genetic material. These repeats were initially discovered in the 1980s in *E. coli*, but their function wasn't confirmed until 2007 by Barrangou and colleagues, who demonstrated that *S. thermophilus* can acquire resistance against a bacteriophage by integrating a genome fragment of an infectious virus into its CRISPR locus.

Application

The role of polygalacturonase gene in tomato fruit ripening: In tomato within six weeks after flowering, a number of genes involved in the later stages of ripening are switched on, including one coding for the polygalacturonic enzyme. This enzyme slowly breaks down the polygalacturonic acid component of the cell walls in the fruit pericarp, resulting in a gradual softening. Partial inactivation of the polygalacturonase gene increases the time between flavour development and spoilage of the fruit.

Cloning the antisense polygalacturonase gene: A 730-bp restriction fragment was obtained from the 5' region of the normal polygalactujronase gene. A plant polyadenylation signal was attached to the beginning of this fragment, a cauliflower mosaic virus promoter was ligated to the end, and the construction was inserted into the Ti plasmid vector pBIN19. Inside the plant, it synthesizes antisense RNA complementary to polygalacturonase mRNA.

The recombinant pBIN19 molecules were introduced into Agrobacterium tumefaciens bacteria and then the bacteria were allowed to infect tomato stem segments. Small amount of callus material collected from surface of these segments were tested for their ability to grow on an agar medium containing kanamycin. Resistant transformants were identified and allowed to develop into mature plants.

Point mutation in rice and tomato: A fusion of CRISPR-Cas9 and activation-induced cytidine deaminase (Target-AID) for point mutagenesis at genomic regions specified by single guide RNAs (sgRNAs) in two crop plants. In rice, we induced multiple herbicide-resistance point mutations by multiplexed editing using herbicide selection, while in tomato we generated marker-free plants with homozygous heritable DNA substitutions, demonstrating the feasibility of base editing for crop improvement.

2. BIOTECHNOLOGY 16018

Biofortification of Crops to Overcome the Micronutrient Malnutrition

Vishwa Vijay Thakur, Swapnil Sapre and Sumana Sikdar

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INTRODUCTION: Micronutrient malnutrition affects more than half of the world population, particularly in developing countries. The mineral elements most frequently lacking in human diets are Fe, Zn and I, although other elements, such as Ca, Mg, Cu and Se, can be deficient in the diets of some populations. It is estimated that, of the world's 6 billion people, 60–80% are Fe deficient, 30% are Zn deficient, 30% are I deficient and about 15% are Se deficient. These deficiencies are caused by diets characterized by high intakes of staple foods but low intakes of vegetables, fruits, and animal and fish products, which are rich sources of minerals. The chemical form of an element in food determines our ability to absorb and assimilate it. Plants contain 'promoter' compounds that stimulate the absorption of essential mineral elements by the gut, such as certain organic and amino acids, as well as 'anti nutrients', such as polyphenolics (tannins) or phytate (IP6), that limit their absorption. Thus, when considering dietary refinement, it is important to consider not only the total amount of each element delivered but also its chemical forms and their interactions with other compounds in food.

Different Strategies for Reducing Malnutrition

Traditional interventions to address mineral malnutrition have focused on supplementation, food fortification and dietary diversification. For various reasons, none of these have been universally successful. They require safe delivery systems, stable political policies, appropriate social infrastructures and continued investment. Recently, a complimentary solution to mineral malnutrition termed 'biofortification' has been proposed.

What is Biofortification

Biofortification is the development of nutrient-

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dense staple crops using the best conventional breeding practices and modern biotechnology, without sacrificing agronomic performance and important consumer-preferred traits.

Methods of Biofortification in Crops

1. Agronomic intervention
2. Conventional Plant Breeding
3. Biotechnological Approaches

Agronomic intervention in crops

Utilization of mineral fertilizers into soil to increase mineral accumulation within cereal grains for nutritional purpose, for example: Zn Fertilization with NPK fertilizers are enriches with Zn and applied normally crop production.

Limitations

- Cost and impact of fertilizers use on the environment
- Technically not feasible in case of complex molecules such as Vitamins

Conventional plant breeding

Biofortified crops can be obtained through conventional breeding by discovering the sufficient genetic variation in collected germplasm.

Steps of conventional plant breeding

- Discovery of genetic variation affecting heritable mineral traits.
- Checking their stability under different conditions.
- The feasibility of breeding for increasing mineral content in edible tissue without affecting yield or other quality traits

Limitations of conventional plant breeding

- Limited to gene that can be sourced from genetic diversity
- Results may be affected by genotype X environmental interaction
- Problem of linkage drag
- More time consuming approach
- Difficult to identify polygenic traits (QTLs)

Biotechnological approaches

Micronutrient biofortification using biotechnology approaches is recently used technique where, we developed micronutrient dense crop without compromising the agronomic performance of crop plants. Micronutrient biofortification using biotechnological approach can be achieved by various way for example, by modification of the metabolic pathways where required and by multi-trait stacking to facilitate introgression into mega-varieties or through genetic in which we can introduce gene from any source (including animals and microbes) directly into breeding variety.

Biofortified crops developed through biotechnological approch

- "Golden Rice" which enriched in beta-carotene or pro-vitamin A. First developed by Ingopotrycus and Colleagues. Introduced *Psy* gene (Daffodil) with the gene for a multifuctional bacterial carotene desaturase (*Crt*1).
- Goto *et al.* (1999) transferred the soybean *ferritin* gene into the Rice variety Kitaake through *Agrobacterium* mediated transformation.
- Lucca *et al.* (2001) introduced a fungal gene for the enzyme phytase which breaks down phytate thus improving the bioavability of Fe in rice diets.

Conclusion: The application of biofortified crops would benefit farmers by increasing their income in the long run. The functional crops can also play an important role in fighting against different types of nutrition deficiency and over nutrition. Biofortification would help overcome the nutrient deficiency economically especially in rural areas.

3. BIOTECHNOLOGY 16070

MicroRNAs and their Role in Increasing Productivity and Stress Tolerance

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MicroRNAs (miRNAs) are short regulatory non-coding RNAs that guide gene silencing in most of the eukaryotes. The mature miRNAs are comprised of 20–24 nucleotides and are the products of non-protein coding genes called MIR genes or introns. The MIR genes transcribe into miRNA precursor called pri-transcripts which are acted upon by the enzymes DROSHA or DCL1 to generate pre-miRNA. Dicer-like protein removes the loop of pre-miRNA resulting in generation of

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either miRNA or duplex of miRNA. miRNA is subsequently methylated by HEN1 and is loaded into Argonaute component leading to formation of an RNA induced silencing complex called as RISC. The guide strand of the RISC complex silences the genes. The miRNAs regulate gene expression at the post-transcriptional level through mRNA cleavage or by translation repression of target mRNA.

Biogenesis of MicroRNAs

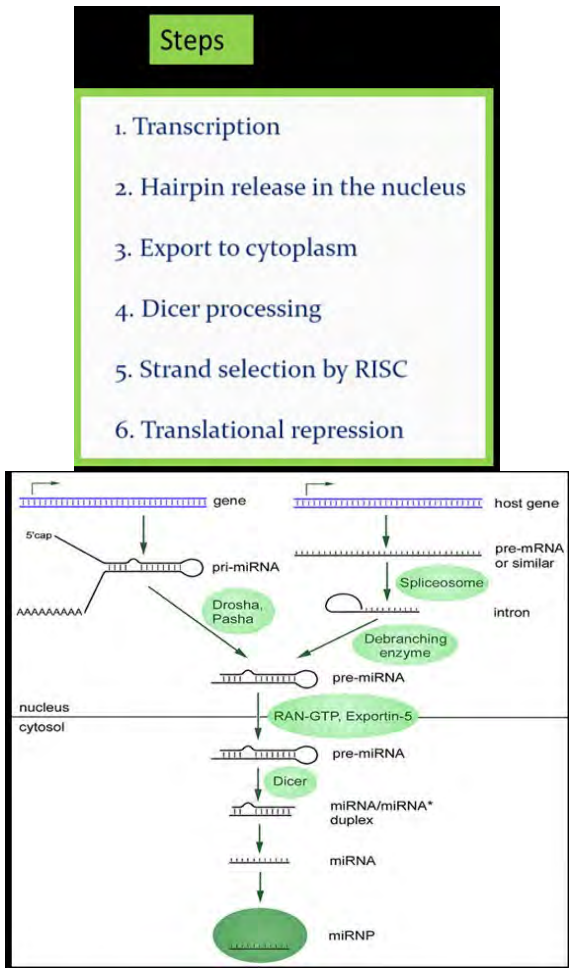

FIG 1: Biogenesis of MicroRNAs

Difference between Biogenesis in Plant and Animal

- miRNA biogenesis in plants differs from animal biogenesis mainly in the steps of nuclear processing and export.
- Instead of being cleaved by two different enzymes, once inside and once outside the nucleus, both cleavages of the plant miRNA are performed by a Dicer homolog, called Dicer-like1 (DL1).
- DL1 is expressed only in the nucleus of plant cells, which indicates that both reactions take place inside the nucleus.
- Before plant miRNA:miRNA* duplexes are transported out of the nucleus, its 3' overhangs are methylated by a RNA methyltransferase protein called Hua-Enhancer1 (HEN1).
- The duplex is then transported out of the nucleus to the cytoplasm by a protein called Hasty (HST), an Exportin 5 homolog, where they disassemble and the mature miRNA is incorporated into the RISC.

miRNA Role in Increasing Productivity and Stress Tolerance

miRNAs play important role in a wide range of developmental processes of living organisms by regulating the expression of a number of key development and stress-related genes *e.g.* grain yield, fruit development and flower development. miRNAs also regulate resistance to viral, fungal and nematode diseases, tolerance to drought and salinity and detoxification of heavy metals. Till date, more than 6,800 miRNAs in approximately 62 plant species have been functionally characterized in different abiotic and biotic stress responses.

Under stress conditions, plants miRNAs either up-regulate or down-regulate expression of specific stress-associated genes to increase tolerance to adverse environmental conditions. A miRNA named as *miR398b* enhances resistance to blast pathogen *M. oryzae* by reducing fungal growth, increasing H_2O_2 accumulation and up-regulating defense genes (Li et al. 2014). miRNAs like *miR172* and *miR403* have critical roles in several pathways and cellular processes to cope up with different stresses in sunflower (Ebrahimi et al. 2015).

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4. MICROBIOLOGY 16165

Quorum Quenching: A Hurdle to Quorum Sensing

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What is Quorum Quenching?

Quorum sensing also called bacterial cross talk is a mechanism shown by microbial species in which they communicate to each other by transferring signals at threshold level within the same species or interspecies or with other microorganisms. Quorum quenching is just opposite to quorum sensing in its functioning. It inhibits or stops the processes which are carried out by quorum sensing mechanisms. Many bacterial species perform many functions regulated by quorum sensing like symbiosis, plasmid transfer, conjugation, motility, sporulation biofilm formation, host interactions, bioluminescence, infections in host, antibiotic production and formation of virulence factors. By finding appropriate quorum quenchers or quenching mechanisms we can find control over deadly diseases. So to understand the quorum quenching, how it work, we have to understand the quorum sensing first.

Different Ways and Components for Exhibiting Quorum Sensing (QS)

Quorum sensing process most commonly performed by two component system, where one component is called sensor (histidine kinase) which sense the changes in surroundings and send the signal which further transduce the second component called response regulator through phosphorylation relay which further regulate the gene expression. In two component system quorum sensing signals are auto inducing peptides (AIP) as in *Staphylococcus aureus* and other G +ve bacteria (Dong et al, 2007).

In Gram negative bacteria auto inducers are acylhomoserine lactone (AHL). Here quorum sensing signals are perceived by cytosolic transcription factor for example *Vibrio harveyi* and *Agrobacterium tumefaciens*.

Other communication involving signals are auto inducer-2 (AI-2) found in both Gram-positive and Gram-negative bacteria, including pathogens such as *Salmonella typhimurium*, Fatty acids or diffusible signal factor, DSF found in *Xanthomonas*, amino acids derivatives, such as the diketopiperazines (*e.g.* cyclo (L-Pro-LTyr)) found in *Proteobacteria* such as *Pseudomonas*, *Citrobacter*, *Enterobacter* and the more complex autoinducer (cyclo) peptides in several G +ve bacteria, butyrolactones found in Streptomyces spp. and quinolones etc.

Quorum-Quenching (QQ) Compounds

Chemicals that inhibit quorum sensing may be broadly divided into two types on the basis of their structure and functions:

1. Structurally mimicking quorum sensing compounds for example halogenated furanones mimic AHL's and synthetic AI peptides (AIPs) are similar to AIP signals.
2. The second group is consist of quorum-quenching enzymes those inhibit the sensing signals. Most common example of this category is triclosan and closantel. These two inhibits enoyl-acyl carrier protein (ACP) reductase, thus stop AHL biosynthesis and histidine kinase sensor of the two component system respectively.

Other QQ compounds are synthase inhibitors (analogues of anthranilic acid), receptor inhibitors (brominated furanones). Some antibiotics like azithromycin, ceftazidime, and ciprofloxacin also inhibit QS in *Pseudomonas aeruginosa*. Also, drugs used for clinical also act as a QQ compound, for example niclosamide. It can reduce surface motility, biofilm formation, and production of the secreted virulence factors. One example of QQ compound is Cis-9-octadecenoic acid produced by rhizospheric bacterium *Stenotrophomonas maltophilia* is a QQ compound.

Various Strategies followed by Quorum-Quenching Molecules

There are different ways for interrupting the sensing signals like competitive inhibition, signals cleavage etc. Some of these are summarized below:

1. AHL-lactonase hydrolyses the homoserine lactone ring of AHL signals. It is a metalloprotein.
2. AHL-acylase inhibit the quorum sensing by degrading the AHL signals by hydrolysing the amide bond of AHLs which results in production of corresponding fatty acids and homoserine lactone.
3. Paraoxonase enzymes (PON) do inhibition by hydrolysing the homoserine lactone ring of AHL signals.
   a) In less population density QS signal, QQ may inhibit the fatty acid biosynthesis and also inhibit the proteins taking part in signalling. These can also act by AHL signal degradation enzyme and as active

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efflux inhibitor (Basavaraju *et al.*, 2016).

b) When signalling occurs among high dense population then QQ mechanisms seen are: R protein inhibition; influx inhibition, by AHL signal degradation enzyme; inhibiting I and R proteins and also by chemical inducing early expression of AHL degradation enzyme.

Applications of Quenching

- There are many examples of microbial infections against which QQ works like AHL-lactonase aiiA is found effective against infections caused by *Erwinia carotovora*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Bacillus thuringiensis*, *Burkholderia thailandensis*, *Erwinia amylovora* and paraoxonase (PON1), AHL-acylase aid and 3-oxo-C12-(2-aminocyclohexanone) are effective against common pathogen *P. aeruginosa*.
- The QQ enzymes are also reported as new antimicrobial agents against different pathogens for example AiiA expression in transgenic potato and tobacco plants shows resistance to the bacterial pathogen *E. carotovora*, which using AHL quorum-sensing signals for activation of virulence genes.
- Molecules produced by various plants, algae, and fungi like turmeric-curcumin-citrus flavinoids-flavonine, naringenin-sponge Agelas oroides-alkaloid oroidin, red marine alga known as D. pulchra-halogenated furanones and so on are effective against many bacteria which are responsible for biofilm formation in dental plaque.

Conclusion: Hence we can see that there is enormous range of quorum quenching compounds having wide applications in various fields. But now-a-days there are reports of resistivity against quorum quenching, so we have to take care of this point of view to get complete benefit from quorum quenchers.

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5. CROP PHYSIOLOGY 16065

Chlorophyll: An Essential Plant Pigment for Human's Survival

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INTRODUCTION: Pigments are responsible for many of he beautiful colors we see in the plant world. Plant pigments are substances produced by living organisms that have a color resulting from selective color absorption. When light of sufficient energy reaches on the plant surface, it is utilized for the synthesis of carbohydrate by the process of photosynthesis. Light not having enough energy or having too much energy is reflected back and this is the process by which substances appears in color. Selective absorption of different wavelength determines the color of the pigment. Plant pigments absorbs only 400-700 nm of wavelength *i.e.*, visible light of the electro-magnetic spectrum. It doesn't absorb X-rays and UV-rays because the plant doesn't contain pigments absorbing those rays.

In addition to giving color to the plant parts, pigments are involved in several physiological functions like capturing of light energy for the purpose of photosynthesis, protection against photo-oxidation, increasing the membrane stability, acting as a precursor for the synthesis of secondary metabolites etc. There are mainly four major class of pigments *viz.,* **chlorophyll, carotenoids, anthocyanin and betalains.**

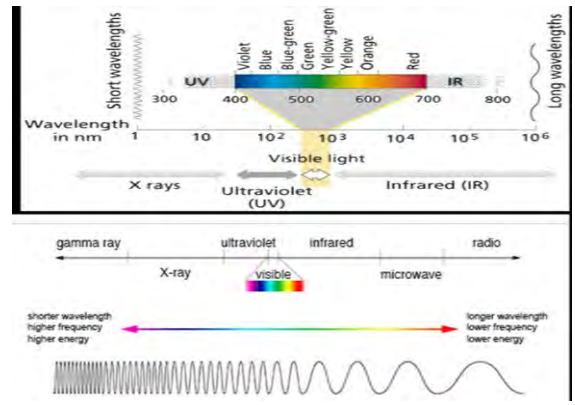

FIG. 1. Electro-magnetic spectrum

Chlorophyll in Plants

Chlorophyll is remarkably similar in structure to hemoglobin, the oxygen carrying pigment found in the red blood cells of mammals and other vertebrates. Chlorophyll most abundant pigment

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found in plants, a green photosynthetic pigment essentially required for the process of photosynthesis- a process which is basis for sustaining the life processes of all plants. Since animals and humans obtain their food supply by eating plants, photosynthesis can be said to be the source of our life also.

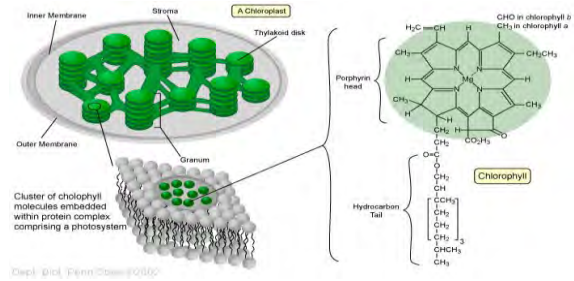
It is generally found in cyanobacteria and chloroplast of algae and higher plants, specifically arranged in and around photosystems (PS) that are embedded in the thylakoid membranes of chloroplast. Chlorophylls are a group of cyclic tetrapyrrole pigments that are involved in the light reactions of photosynthesis. These are most abundant pigment in plants and absorbs light with wavelengths of 430nm (blue) and 662nm (red).

Pigment	Absorption peak in nm	Distribution in plant kingdom
Chlorophyll a	435,662	All green plants
Chlorophyll b	453,642	All green plants except red, brown and blue-green algae
Chlorophyll c	447,579,682	Diatoms and chrysophyceae
Chlorophyll d	447,668	Some red algae

Among which the most common form of chlorophyll found in higher plants are chlorophyll a and chlorophyll b. Chlorophyll a having a general formula $C_{55}H_{72}O_5N_4Mg$ with a methyl group (CH_3) on the third carbon atom of second pyrrol ring, Chlorophyll b ($C_{55}H_{70}O_6N_4Mg$) consist of an aldehyde (CHO) group instead of methyl group. Generally chlorophyll a/b ratio is 3:1 in higher plants. Plants growing in shade contain less chlorophyll a and more chlorophyll b. Removal of Mg from the chlorophyll molecule results in its conversion to pheophytin, which is grey-brown in color.

Inter-Conversion of Chlorophyll a and b

Chlorophyll a oxygenase (CAO) is the enzyme that catalyses the conversion of chlorophyll a to chlorophyll b, and a reductase is found in chloroplasts which can catalyse the reverse reaction.



Why Plants Looks Green in Colour?

Chlorophyll absorbs red and blue light of electromagnetic spectrum and reflects green color of electromagnetic spectrum and that's the reason why plants containing chlorophyll looks green in colour.

As the chlorophyll in leaves decays in the autumn, the green colour fades and is replaced by the oranges and reds of **carotenoids** (another class of plant pigment).

Conclusion: Looking to the importance of chlorophyll in imparting color to the plant and involved in many physiological process especially in photosynthesis it has been popularly described as **Essential Pigment.**

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6. CROP PHYSIOLOGY 16072

Modulating Oxidative Burst: A New Approach in Herbicide Designing

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The Role of Reactive Oxygen Speies (ROS) in Plant Cell Death

Cell death is an essential process in the plant's life cycle. Two modes of cell death have been described in plants: Programmed Cell Death (PCD) and necrosis. PCD and necrosis may be two extreme cases of the same process that is initiated by ROS. PCD and necrosis can be halted by administering either high concentrations of antioxidants or inhibitors of both the translation and transcription of signal transduction components known to be involved in ROS generation, such as kinases and phytohormones.

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The existence of a dose-dependent ROS threshold below which PCD will be triggered and above which necrotic cell death will prevail might be the reason for the overwhelming effect that phytotoxic ROS levels have on PCD hallmarks.

Tetrapyrrole-Dependent Photodynamic Herbicides: One more novel application of this oxidative burst is in designing photodynamic herbicides. Tetrapyrrole-dependent photodynamic herbicides (TDPH) are compounds which force green plants to accumulate undesirable amounts of metabolic intermediates of the chlorophyll and heme metabolic pathways, namely tetrapyrroles. In the light the accumulated tetrapyrroles photosensitize the formation of singlet oxygen which kills the treated plants by oxidation of their cellular membranes. Tetrapyrrole-dependent photo-dynamic herbicides usually consist of a 5-carbon amino acid, 6-aminolevulinic acid (ALA), the precursor of all tetrapyrroles in plant and animals cells, and one of several chemicals referred to as modulators. 6-Aminolevulinic acid and the modulators act in concert. The amino acid serves as a building block of tetrapyrrole accumulation, while the modulator alters quantitatively and qualitatively the pattern of tetrapyrrole accumulation.

The most striking response to TDPH treatment is observed when freshly sprayed plants are allowed to remain in darkness for a few hours before exposure to light. In darkness the treated plants accumulate massive amounts of tetrapyrroles. In the light, the photodynamic response to the accumulated tetrapyrroles is very rapid. Symptoms of photodynamic injury become apparent within the first 20 min of illumination and become essentially irreversible after about 60 minutes in bright light. Initial symptoms appear on green foliage as isolated bleached spots which rapidly become contiguous. Bleaching is accompanied by severe loss of turgidity followed by desiccation. Within 24 hours the green plant tissue turns into a brownish desiccated mass of dead tissue.

Molecular Basis of Tetrapyrrole-Dependent Photodynamic Herbicide Selectivity: Originally photodynamic herbicides were assumed to be nonselective in their mode of action. Further experimentation under controlled laboratory and field conditions indicated that various ALA and modulator combinations exhibited a significant degree of photodynamic herbicidal selectivity. This selectivity appeared to be rooted (a) in the different tetrapyrrole accumulating capabilities of various plant tissues, (b) in the differential susceptibility of various greening groups of plants to the accumulation of various tetrapyrroles, and (c) in the differential response of various greening groups to photodynamic herbicide modulators.

Modulation of TDPH Activity: The dependence of TDPH susceptibility upon the greening group affiliation of treated plants as well as upon the nature of accumulated tetrapyrroles suggested that it may be possible to chemically modulate the activity of TDPH. It was conjectured that this may be achieved with the use of chemicals that may modulate the Chlorophyll biosynthetic pathway by forcing ALA-treated plants belonging to certain greening groups to accumulate the "wrong" type of Monovinyl (MV) or Divinyl (DV) tetrapyrrole, while inducing other plant species belonging to other greening groups to accumulate the "right" type of MV or DV tetrapyrrole.

The Four Classes of Modulators

Based on their mechanism of action TDPH modulators have been classified into four distinct groups: (a) enhancers of ALA conversion to DV Protochlorophyllide (DV Pchlide), which enhance the conversion of exogenous ALA to DV Pchlide, (b) enhancers of ALA conversion to MV Protochlorophyllide (MV Pchlide), which enhance the conversion of exogenous ALA to MV Pchlide, (c) inducers of tetrapyrrole accumulation, which induce the plant tissues to form large amounts of tetrapyrroles in the absence of exogenously added ALA, and (d) inhibitors of MV Pchlide accumulation, which appear to block the detoxification of DV tetrapyrroles by inhibiting their conversion to MV tetrapyrroles.

Response of Various Greening Groups of Plants to TDPH Modulators

It is extremely desirable to be able to predict the mode of action of modulator, *i.e.* its class affiliation, from its chemical structure. The advantages of such an undertaking become obvious when one considers the amount of time and effort involved in determining experimentally, the mode of action of a modulator toward a particular plant species. As a consequence we have undertaken a research effort aimed at probing: (a) whether different plant species belonging to the same greening group react in a similar manner toward a particular modulator, (b) whether a particular modulator would exhibit the same effects on the Chlorophyll biosynthetic pathway in plant species belonging to different greening groups, and (c) whether a particular plant species would react the same way toward a group of modulators that belong to the same chemical category.

Discovery of Novel TDPH Modulators

The successful synergistic use of ALA + Diphenyl ether (DPY) for TDPH purposes prompted a search for additional compounds that may affect the Chlorophyll biosynthetic pathway. One compound, 8- hydroxyquinoline, had been identified for its effects on bacteriochlorophyll biosynthesis in *Rhodopseudomonas spheroides*. Four compounds namely: 1,lO-phenanthroline, 2-

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pyridyl aldoxime, 2-pyridyl aldehyde, and picolinic acid had been described by for their effects on the Chlorophyll biosynthetic pathway in etiolated seedlings of red kidney bean, corn and cucumber. Two other compounds, namely: 1,7-phenanthroline and phenanthridine were picked up because of their effect on the chlorophyll biosynthetic pathway in *Chlamydomonas reinhardtii*.

The ultimate usefulness of any herbicide resides in its eventual ability to eliminate undesirable weeds under field conditions. Although TDPH have not yet been formulated for field use, few experiments were carried out in order to test this putative potential. The first field application was carried out in 1986 for the control of several broadleaf weeds, including ground ivy (*Glechoma hederacea* L.) in a Kentucky bluegrass (*Poa pratensis* cv Aspens) lawn in a shaded backyard. Treatment consisted of two applications, 2 weeks apart, of ALA + DPY at a rate of 1.3 kg ALA and 1 kg DPY/ha dissolved in polyethylene glycol (600)-methyl alcohol-Tween 80-water at pH 3.5.

The second field application involved defoliation of field-grown apple trees. Controlled defoliation of nursery stock is essential for the effective management of rootstocks and grafted trees. To this effect field-grown mature Golden Delicious apple trees were sprayed with ALA and ethyl nicotinate (ethylated niacin), a simple vitamin derivative, at a rate of 3 kg ALA and 2.2 kg ethyl nicotinate ha^{-1}. The active ingredients were dissolved in the same solvent used for the control of broadleaf weeds in Kentucky bluegrass. Ethyl nicotinate was chosen as a modulator because of its putative safety and because under greenhouse conditions it proved to be a very good enhancer of ALA conversion to tetrapyrroles in apple seedlings. By the 13th day after spraying a 100% defoliation of the Golden Delicious trees was achieved.

Conclusion: Along with the advantages, there are many drawbacks and lack of evidence, such as mechanism of selectivity is not accepted completely, high cost of patents, safety aspects, herbicide tolerance and resurgence.

Utilization of the destructing potential of this oxidative burst for designing of herbicides still need extensive research and no doubt by overcoming the drawbacks, photodynamic herbicides can revolutionize the field of herbicides by paving way for eco - friendly herbicides.

7. BIOCHEMISTRY 16037

Chitosan and its Multiple Roles in Plant Defense and Nutrition

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Introduction: Chitosan is derived from chitin, a polysaccharide found in exoskeleton of shell fish such as shrimp, lobster and cell wall of fungi. It is simplest linear polysaccharide composed of β, 1-4 linked D-glucosamine (GlcN) and N-acetyl-D-glucosamine (GlcNAc) with various compositions of these two monomers (Figure 1.). Chitosan are highly basic polysaccharides with unique properties like the ability to form films to react with polyanions as well as to chelate and remove metal ions. Food and Drug Administration (FDA) agency in U.S. approved chitosan as a feed additive in 1983.

Chitin, chitosan and cellulose are the polymer of glucose linked by β, 1-4 glycosidic linkages but in case of chitin the N-acetyl group is attached at the 2 carbon which is deacetylated in the chitosan. They all found in the cell wall to give shape and protect from the external environment. They all are insoluble in water. Chitosan is soluble in weak acid and so, once the alkali is neutralized, it can be safely applied to plants/soil as a solution or as a dry powder.

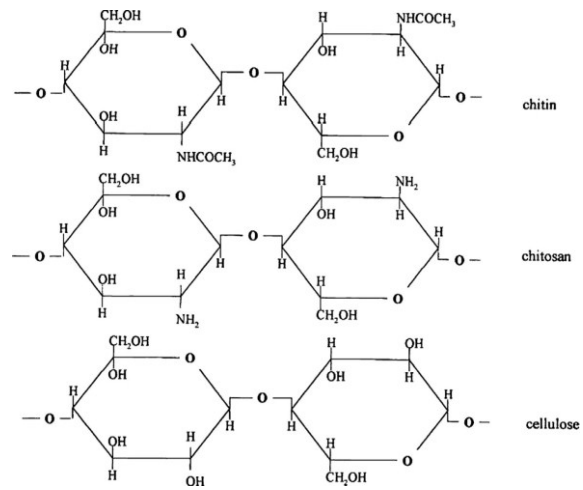

FIGURE 1. Structure of Chitin, chitosan and cellulose

Chitosan is produced commercially by exposing crustacean exoskeletons to high

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temperatures and alkali conditions which deacetylates the polymer and aids the removal of proteins and calcium minerals. Pure forms of chitin and its derivatives are white, odorless and tasteless crystalline solids.

Molecular Properties of Chitosan

Chitosan and chitin are not always pure polymers. Chitosan has ~20% of the NAG sugar residues of chitin and chitin often has ~20% of the glucosamine residues of chitin. Both polymers are relatively water insoluble until broken down into oligomers with ≤ 7 sugar residues. Longer polymers of chitosan are water soluble when in solutions at pH 7 or lower and thus are soluble when in acids such as lactic acid and acetic acids. The positive charge of chitosan due to the exposed amino groups, confers to numerous and unique physiological and biological properties with great potential in a wide range of industries such as cosmetology (lotions, hair additives, facial and body creams), Food (coating, preservative, antioxidant, antimicrobial), Biotechnology (chelator, emulsifier, flocculent), Pharmacology and medicine (fibers, fabrics, drugs, membranes, artificial organs) and Agriculture (soil modifier, films, fungicide, elicitor).

Functions of Chitosan in Plants

Applied as seed coating agents: In a number of studies, chitosan has been used in priming of seeds. Although chitosan had no significant effect on germination under low temperatures, it enhanced germination index, reduced the mean germination time, and increased shoot height, root length, and shoot and root dry weights in two tested maize lines. In both tested lines, chitosan induced a decline in malondialdehyde content, altered the relative permeability of the plasma membrane and increased the concentrations of soluble sugars and proline, and of peroxidase and catalase activities.

Applied as foliar treatment agents: Chitosan has also been extensively utilized as a foliar treatment to control the growth, spread and development of many diseases involving viruses, bacteria, fungi and pests. Chitosan might be an effective anti-transpiring to preserve water resources use in agriculture.

Antiviral Action of Chitosan: It can either inhibit the replication of virus through interfering vial life cycle or improve the host antiviral immune responses to accelerate the process of viral clearance. The life cycle of viruses differs greatly between species but there are major changes in the life cycle of viruses.

Against insects: Chitosan has been found to show strong insecticidal activity in some plant pests. Till now effective control with chitosan has been demonstrated for insect pests in the orders Hemiptera (including aphids) and Lepidoptera (chiefly moth pests). However, there is a notable absence of information on the effects on pests in the orders Coleoptera, Diptera, and Hymenoptera, which together represent thousands of economically important plant pests.

Physical barrier around pathogen penetration sites: Chitosan, when applied to plant tissues, often agglutinate around the penetration sites and has two major effects. The first one is the isolation of the penetration site through the formation of a physical barrier preventing the pathogen from spreading and invading other healthy tissues. This phenomenon resembles the abscission zones often observed on leaves preventing several necrotrophic pathogens from spreading further. Around the isolated zones, often an elicitation of a hypersensitive response occur with the accumulation of H_2O_2 that helps in cells wall fortification and serve as an alert signal for other healthy parts of the plant. The second effect is due to the chitosan's ability to bind various materials and initiate fast the wound healing process.

Chelation of nutrients and minerals: Chitosans are well used in the fresh and salt water purification process as chelators for minerals and metals. These abilities are also explored when chitosan is applied to plants to prevent diseases because it can chelate nutrients and minerals (*i.e.*, Fe, Cu), preventing pathogens from accessing them. These polysaccharide molecules were also reported to bind mycotoxins, which may reduce damage to the host tissues due to toxins. In the beverage industry, chitosan and derivatives are often used for their antimicrobial properties linked to their chelating abilities of nutrient and minerals, thus reducing fungal spoilage.

Soil amendments: Chitin, and all its derivatives, has a high nitrogen content of 6.1%–8.3%. Chitin has a high thermal and chemical stability, making it possible to store dry product for a good length of time, it can quickly be utilized as both a nitrogen source and energy source by plants and microbes when added to crops. Chitosan can also form gels that absorb substantial volumes of water due to its high molecular weight, and porous structure. These "hydrogels" can improve the water retention levels of soils. As a result, chitosan hydrogels are potential natural alternatives to polyacrylamide products that are used to improve the water retention in sandy soils, and containerized growing media in ornamental horticulture.

Against abiotic stress: Chitosan has been shown to possess antioxidant activity. The hydroxylated amino groups present on chitosan oligomers make them extremely effective scavengers of hydroxyl radicals, hydrogen peroxide and anion superoxide. Plant chitinases are also considered to be a component of the resistance mechanisms to a range of abiotic stresses. This is unclear how chitin-based

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treatments can improve plant survival and performance in stressful growing environments.

Wound-healing accelerators: Because of their ability to adhere to biological membranes and other biomolecules and their positive changes, chitosan and derivatives are excellent supports for healing wounds produced upon mechanical injuries or pathogen attacks. Application of dressings made of chitin derivatives on injured tree-barks resulted in a faster wound healing.

In crop/product protection: Perishable fruit such as grapes, strawberries and sweet cherries are susceptible to disease such as gray mold (*Botritis cinerea*), Rhizopus (*R. stolonifer*), and blue mold (*Penicillium expansum*). Chitin-based treatments show promise as alternatives to the use of synthetic pesticides on fresh produce in post-harvest storage. It both reduced the growth of decay and induced resistance in the host tissue. Chitosan can also help protect the safety of edible products. Fungal rots have been successfully prevented by applying chitosan treatments in a range of fruits, including; apples, cherries, citrus, grapes, kiwifruit, litchi, papaya, peaches, pears, and strawberries.

Conclusions: Chitin and its derivatives have been repeatedly shown to protect crops from pests, pathogens and physiological disorders. A number of modes of action have been identified for the beneficial effects of chitin-based treatment on crops, including direct antibiosis and the induction of plant defenses. However, their action in stimulating beneficial microbes has proved particularly impressive, with chitin/chitosan amplifying the effect of beneficial microbes in controlling pathogens, promoting plant growth and remediating soil pollutants. The effectiveness of chitin-based treatments has been found to be comparable to those achieved with current synthetic pesticides and fertilizers. This effectiveness combined with the low cost, low concentration required, and health/environmental safety lead to a forecast that a range of chitin based/augmented products will become a more common feature in agriculture in the near future.

8. AGRONOMY 15934

Seed Priming: Efficient Tool for Crop Production

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SEED PRIMING: Seed priming is the process of controlled hydration of seeds to a level that permits pre-germinative metabolic activity to proceed, but prevents actual emergence of the radicle.

Bio-Priming or Biological Seed Treatment

Bio-priming is a process of biological seed treatment that refers combination of seed hydration (physiological aspect of disease control) and inoculation (biological aspect of disease control) of seed with beneficial organism to protect seed. It is an ecological approach using selected fungal antagonists against the soil and seed-borne pathogens. Biological seed treatments may provide an alternative to chemical control.

Procedure of Seed Bio-Priming

1. Pre-soak the seeds in water for 12 hours.
2. Mix the formulated product of bio-agent with the pre-soaked seeds at the rate of 10 g per kg seed.
3. Put the treated seeds as a heap.
4. Cover the heap with a moist jute sack to maintain high humidity.
5. Incubate the seeds under high humidity for about 48 hrs at approx. 25 to 32°C.
6. Bio-agent adhered to the seed grows on the seed surface under moist condition to form a protective layer all around the seed coat.
7. Sow the seeds in nursery bed.

The seeds thus bio-primed with the bio-agent provide protection against seed and soil borne plant pathogens, improved and seedling growth.

Bio-priming is a new technique of seed treatment that integrates biological (inoculation of seed wit beneficial organism to protect seed) and physiological aspects (seed hydration) of disease control. I recently used as an alternative method for controlling many seed- and soil-borne pathogens. It is an ecological approach using selected fungal antagonists against the soil- and seed-borne pathogens.

Biological seed treatments may provide an alternative to chemical control. Seed priming, osmo-priming and solid matrix priming were used commercially in many horticultural crops, as a tool to increase speed and uniformity of germination and improve final stand. However, if seeds are infected or contaminated with pathogens, fungal growth can be enhanced during priming, thus resulting in undesirable effects on plants. Therefore, seed priming alone or in combination with low dosage of fungicides and/or biocontrol agents has been used to improve the rate and uniformity emergence of seed and reduce damping-off disease.

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Advantages of the Bio-Priming

1. Enhances the germination percentage
2. Provide protection against seed and soil borne plant pathogens
3. Improved and seedling growth.
4. Enhances the speed and uniformity of germination
5. Improves the resistance towards water and temperature stress
6. Increases the shelf life of seed
7. Highly suitable for small seeds
8. Enhances the yield

9. AGRONOMY 15938

Arid Land Management

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Arid Land Management

Of the total land area in the world, arid zones cover 18.8%. The hyper-arid zones account for 22.3% of the total arid zones. The Indian arid zone covers around 12 % of country's geographical area occupying 31.8 million ha of land. It covers parts of Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab and Rajasthan states of India. These arid zones are diverse in terms of climate, soils, vegetation, animals, and lifestyles and activities of people. Little but variability in rainfall and the presence of distinctive periods of drought are the characteristics of the arid tropics. Precisely, the hot arid areas are those places that have little and highly variable rainfall, extreme variation in temperature (daily and annual) and high potential evapotranspiration. In general, hot arid climates have excessive heat and strong prevailing winds, unhampered by obstacles on the ground, and as a result Aeolian erosion is common with frequent seasonal occurrence of dust storms.

One binding feature of all arid zones in the world is aridity. A drought is a departure from average or normal conditions in which shortage of water adversely impacts the functioning of ecosystems, and the resident population of people. Aridity refers to the average conditions of limited rainfall and water supplies, not to the departures therefrom. In general, arid zones are characterized by pastoralism and little farming but there are always exceptions.

Principal Problems of Agriculture in Arid Regions

1. Water: Water is absolutely necessary for all plant and animal life. Plants have evolved that are capable of living and reproducing in semiarid, arid, and even desert regions. However, as aridity increases, fewer and fewer species are adapted, and the potential biomass is reduced. Plants are adapted to aridity by several mechanisms. There are plants with a short life cycle that can germinate, grow, and produce during a very short period of available moisture, with deep or extensive root systems which have the ability to gather water over a wide area, which store up water in their tissues and release it very slowly, protected from water loss by wax or other impediments, very small or narrow leaves, thus reducing water loss. Crop plants in arid regions may have any or a combination of such mechanisms.

Water that falls in arid regions may be of little use for crop plants because the amount is too small to penetrate the soil sufficiently, or it may run through a porous soil too quickly, or it may run off too quickly. On the other hand, some soils store water so efficiently that it is possible to grow crops over an extensive period of drought. Water from rivers, lakes and wells in arid regions may have problems of quality, especially the presence of excess minerals. The use of irrigation water might lead to the accumulation of salts in the soil resulting in alkalinity or salinity, which might then limit crop production. The removal of salt from the soil is very difficult. In all arid regions a major challenge is to manage water appropriately. The purpose of such management is to obtain water, to conserve it, to use it efficiently, and to avoid damage to the soil.

2. Heat and wind: The major effects of heat and wind are to increase the rate of evaporation, and thus to increase the effects of aridity. Wind may also cause mechanical damage to crops. Both are combatted by changing the microclimate. The effects of winds can be reduced by windbreaks (lines of trees perpendicular to the direction of prevailing winds). Some useful tall species are tamarisk, casuarina, and eucalyptus. A windbreak can consist of trees and other plants of varying height.

Heat is received principally from the sun and can be reduced by shading. But, shading also reduces the yields of plants. A light shade such as that below a coconut planting or a protective screen or lathwork can be useful in reducing heat and retaining moisture, with only a minimum loss of yield.

3. Soils: Soils of the arid tropics are highly variable, as they are in any climate. Nevertheless, it is possible to make some generalizations about

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such soils. Because of the low rainfall and consequently reduced plant growth, organic material is produced slowly. Yet, again because of low rainfall, it may be broken down slowly as well. The amount of organic material in the soil, and thus the potential fertility, is likely to be high in semiarid zones, low in deserts. Because of low rainfall in desert soils, minerals derived from breakdown of rocks are not leached from the soil. In some cases where the soil is periodically flooded or irrigated the soil might be saline as well. Such soils support few crops. Soils of the semiarid and arid zones might support few plants on the surface, but a good part of the biomass might be in the soil itself as roots. Shrubby desert plants often have very hard woody roots that may be a physical barrier to agriculture.

4. Disease and pest problems: Arid regions have their fair share of disease and pest problems. However, these may often be quite different from those of wetter regions. Nematodes are often a severe problem in sandy soils. No general rules are useful, and indeed, agriculture anticipates diseases and pests, and their parasites as well.

Arid Land Management Techniques

1. **Agronomic Measures**:
   a) **Summer ploughing:** "Summer ploughing" is defined as the ploughing the field across the slope during hot summer with the help of specialized tools with primary objective of opening of the soil crust accompanied by deep ploughing and simultaneously overturning of the soil underneath to disinfect it with the help of piercing sun rays.
   b) **Ridges and furrows:** It acts as continuous barrier to the free movement of water downwards thus provides more infiltration time. Hence, the removal of soil along with nutrients is checked to a greater extent leading to increment in soil fertility and crop yield. Effective in black and red soils cause an increase of up to 15 per cent in crop yields.
   c) **Inter cropping:** Growing of two or more crops simultaneously on the same piece of land with a definite row pattern known as intercropping. Eg. growing maize + black gram in 1:2 ratio *i.e.* after every one row of maize two rows of black gram is sown. Thus, cropping intensity in space dimension is achieved.
   d) **Strip cropping:** Practice of planting crops in strips across the slope, with alternate strips of grain and or forage crops. Forms of strip cropping: 1. Field strip cropping: Cultivating crop in strips of uniform width across general slope, 2. Contour Strip Cropping: Arranging crops in strips on contour at right angle to slope, 3. Wind Strip Cropping: Growing of crop in strip of windy area uniform width with straight and right angle to prevailing wind direction, 4. Buffer Strip Cropping: Laying out crops in strip of grasses or legumes in between strips of regular crops.
   e) **Soil amendments:** It includes all inorganic and organic substances mixed into the soil for achieving a better soil constitution regarding plant productivity. It does not include mulching, which includes substances lying on top of the soil. There are different substances for different soils and plants to optimize the soil conditions.
2. **Engineering Measures**:
   a) **Contour trenches:** Contour trenching is an agricultural technique that can be easily applied in arid sub-Sahara areas to allow for water, and soil conservation, and to increase agricultural production. Water flowing down the hill is retained by the trench, and is infiltrating the soil below. Between two trenches crops can benefit during the growing season (when there is less rain) from the subsoil water reserve gathered during the rainy season.
   b) **Broad bed furrow:** A raised land configuration 'Broad Bed Furrow' (BBF) system helps the soil to preserve the water level for a longer period. In a broad bed furrow system, runoff water is diverted into field furrows (30 cm wide and 30 cm deep). The field furrows are blocked at the lower end. When one furrow is full, the water backs up into the head furrow and flows into the next field furrow.
   c) **Compartmental bunding:** It means the entire field is divided into small compartments with pre-determined size to retain the rain water where it falls and arrest soil erosion. The compartmental bunds are formed using bund former. Compartmental bunds provide more opportunity time for water to infiltrate into the soil and help in conserving soil moisture.
3. **Other Measures**:
   a) **Mulch:** About 60 to 75 per cent of the rainfall is lost through evaporation. These evaporation losses can be reduced by applying mulches. Mulch is any material applied on the soil surface to check evaporation and improve soil water. Application of mulches results in additional benefits like soil conservation, moderation of temperature, reduction in soil salinity, weed control and improvement of soil structure.
      i) **Types of mulches**

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(1) **Soil mulch or dust mulch:** If the surface of the soil is loosened, it acts as a mulch for reducing evaporation. This loose surface soil is called soil mulch or dust mulch. Intercultivation creates soil mulch in a growing crop.

(2) **Stubble mulch:** Crop residues like wheat straw or cotton stalks etc., are left on the soil surface as a stubble mulch. The advantages of stubble mulch farming are protection of soil from erosion and reduction of evaporation losses.

(3) **Straw mulch:** If straw is used as mulch, it is called as straw mulch.

(4) **Plastic mulch:** Plastic materials like polyethylene, polyvinyl chloride are also used as mulching materials.

(5) **Vertical mulching:** To improve infiltration and storage of rainwater in these soils, vertical mulches are formed. It consists of digging narrow trenches across the slope at intervals and placing the straw or crop residues in these trenches.

b) **Antitranspirants:** Antitranspirant is any material applied to transpiring plant surfaces for reducing water loss from the plant. About 99 per cent of the water absorbed by the plants is lost in transpiration. If transpiration is controlled, it may help in maintenance of favourable water balance. Antitranspirants will reduce transpiration without reducing the assimilation rate. Examples: ABA (5 to 10 ppm), CCC (1000 ppm), Alar (200 ppm), Simazine (50 ppm), Silicon (100 ppm), etc.

i) There are three types of antitranspirants.

(1) **Stomatal closing type:** These antitranspirants reduce the closure of stomata and reduce the rate of transpiration. Since the stomata are made to close, the rate of CO_2 diffusion into the leaf is also reduced leading to low photosynthetic rates. Examples: Phenyl Mercuric Acetate (PMA), Abscisic Acid (ABA) and high CO_2 concentration.

(2) **Film forming type:** This type forms a thin film coating on the surface of leaf and inhibits the loss of water vapour from the leaf. But they allow CO_2 to pass into the leaf through lower epidermis. *E.g.* Waxes, Plastic films, Silicone oils

(3) **Reflective type:** The principle of using this type of chemicals is to increase the light reflection by the leaves, thus decreasing the leaf temperature or head load on the leaf. The water loss is reduced without affecting the CO_2 assimilation. *E.g.* Kaolinite (Kaolin), Lime water (Lime wash)

c) **Wind breaks and shelterbelts:** Wind breaks are any structures that obstruct wind flow and reduce wind speed while shelterbelts are rows of trees planted for protection of crops against wind.

Shelterbelts are planted across the direction of wind. They do not obstruct the wind flow completely. Depending upon their porosity, certain amount of wind passes through the shelterbelts while the rest deflects and crosses over the shelterbelts. It thus reduces wind speed without causing turbulence. The protection offered by the shelterbelts is dependent on the height of central tree row in the shelterbelts. Generally, shelterbelts give protection from desiccating winds to the extent of 5 to 10 times their height on windward side and up to 30 times on leeward side. Due to reduction in wind speed, evaporation losses are reduced and more water is available for plants. The beneficial effect of shelterbelts is seen more clearly in drought years.

d) **Weed control:** Prompt weed control eliminates the competition of weeds with crops for limited soil moisture. Transpiration rate from weeds is more compared to crops. Effective weed control in dryland agriculture leads to increasing availability of soil moisture to crops. This is the most useful measure to reduce transpiration losses.

e) **Spraying nutrient solution:** Nutrient solution spray is recommended in the event of revival of rain and release of moisture stress. Urea or DAP spray (2% solution) is useful for quicker regeneration of crops like legumes and castor after rain.

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10. AGRONOMY 15984

System of Rice Intensification

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The System of Rice Intensification (SRI) is a methodology aimed at increasing the yield of rice produced in farming. It is a low water, labor-intensive, method that uses younger seedlings singly spaced and typically hand weeded with special tools. It was developed in 1983 by the French Jesuit Father Henri de Laulanié in Madagascar. However full testing and spread of the system throughout the rice growing regions of the world did not occur until some years later with the help of Universities like Cornell.

History and main ideas Assembly of the practices that culminated in SRI began in the 1960s based on Fr. de Laulanie's observations. Principles included applying a minimum quantity of water and the individual transplanting of very young seedlings in a square pattern.

SRI concepts and practices have continued to evolve as they are being adapted to rain-fed (unirrigated) conditions and with transplanting being superseded by direct-seeding sometimes. The central principles of SRI according to Cornell University, New York are

- Rice field soils should be kept moist rather than continuously saturated, minimizing anaerobic conditions, as this improves root growth and supports the growth and diversity of aerobic soil organisms.
- Rice plants should be planted singly and spaced optimally widely to permit more growth of roots and canopy and to keep all leaves photo synthetically active.
- Rice seedlings should be transplanted when young, less than 15 days old with just two leaves, quickly, shallow and carefully, to avoid trauma to roots and to minimize transplant shock.

Spread; The spread of SRI from Madagascar to around the globe has been credited to Norman Uphoff, former director of the Cornell International Institute for Food, Agriculture and Development at Cornell University, Ithaca, New York from 1990 to 2005. In 1993, Uphoff met officials from Association Tefy Saina, the non-governmental organisation set up in Madagascar in 1990 by de Laulanie to promote SRI. After seeing the success of SRI for three years when Malagasy farmers previously averaging 2 tons/hectare averaged 8 tons/hectare with SRI, Uphoff became persuaded of the merits of the system, and in 1997 started to promote SRI in Asia. Uphoff estimates that by 2013 the number of smallholder farmers using SRI had grown to between 4 and 5 million. The rapid spread of SRI around the globe and especially in India can be partially attributed to the smart communication strategies by its proponents in which several newspapers in India disproportionately provided coverage on SRI and effective coalition building among several national and international organizations.

Evaluation Proponents and critics of SRI debate the claimed benefits and many questions about it remain unresolved. Wageningen University has also published an article discussing the challenges of evaluating SRI in which one concluding sentence read: "Although the technical aspects of SRI have been contested, it clearly exists as a real social phenomenon".

The question at hand seems to be: is SRI better at delivering increased yield and other benefits to rice farmers, such as healthier soils, when compared with established recommended best management practices for rice production.

A review of the extensive literature led researchers at Cornell to conclude SRI on average increased yields 20–200%, improved resistance to environmental stresses, and both increased carbon sink activity while reducing emissions, making it a triple-win situation for agriculture, climate security, and food security.

Cases of success Proponents of SRI claim its use increases yield, saves water, reduces production costs, and increases income and that benefits have been achieved in 40 countries. Uphoff published an article in the *International Journal of Agricultural Sustainability* that states that SRI "can raise irrigated rice yields to about double the present world average without relying on external inputs, also offering environmental and equity benefits".

A special issue on SRI in the non-SCI scientific journal *Paddy and Water Environment* collected recent findings in support of SRI. In 2011 five farmers reported that they had beaten the old yield record, the best was a young farmer named Sumant Kumar, who reported setting a new world record in rice production of 22.4 tons per hectare using SRI, beating the existing world record held by the Chinese scientist Yuan Longping by 3 tons. In 2014 S Sethumadhavan from Alanganallur, India reported a record yield of nearly 24 tones of paddy rice per hectare using SRI. These reported records were not obtained under audited

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supervision nor under standard methods for measuring yields. They were not subjected to peer review, being reported only in the popular press, and are suspected to be physically impossible in the localities where they were obtained.

11. AGRONOMY 16010

Productivity of Pulses as Influenced by Combined Application of Chemical and Bio-Fertilizers

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Pulses are referred to as the poor man's meat, as they are major sources of protein in the agricultural crop galaxy and complement the staple cereals in the diet with essential amino acids, minerals and vitamins. Pulses can be grown on a wide range of soil to sustain and stabilize the productivity by improving physical, chemical and biological properties because of their ability to fix atmospheric nitrogen. The beneficial effect of legumes in cropping systems is not solely due to biological nitrogen fixation but also due to several other associated mechanisms such as increased nutrients availability, improved soil structure, reduced disease incidence and increased mycorrhizal colonization. Moreover, pulses require limited irrigation and even can withstand drought condition due to their deep root system and sustain well in low input sustainable agriculture. In India pulses are largely cultivated under energy starved condition, resulting in poor productivity. India is the largest producer and consumer of pulses in the world and shares the highest contribution in terms of area and production with a value of 26.2 million hectare and 19.6 Mt. The worlds average productivity of pulses is 890kg/ha which is high as compared to India (764 kg/ha) (Anonymous, 2014). Therefore there is a need to enhance the pulse productivity in order to fulfill the domestic need of India. The total domestic demand of pulses were 22Mt, while the total production of pulses was 19.25 Mt so there was a gap between the demand and supply of pulses in India which is fulfilled by import.

In order to enhance and sustain the pulse productivity at high levels, the development and promotion of low cost technology need greater attention. The most potential technologies involved in improving pulse production include crop establishment and management practices, integrated and balanced used of fertilizers which include use of biofertilizers etc. (Pooniya *et al.,* 2015). Bio-fertilizers are the living cells of efficient strains of micro-organisms which possess capacity to enhance the availability of nutritionally important elements by biological process. Phosphate solubilizing bacterias in general provide 12-20 kg P_2O_5/ha/season. Some biofertilizers add considerable amount of atmospheric nitrogen in soil and the most preferable example is *Rhizobium* sp. used in legumes. Mycorrhiza (association of fungi with roots of higher plants) can provide adequate phosphorus and other micronutrients and help in increased water absorption specially by increasing the volume of the roots. Mixed biofertilizer give better impact. Keep soils biologically active. Help in soil health maintenance.

TABLE1: suitable *Rhizobium* for different crops

Sr. No.	*Rhizobium* sp.	Crops
1	*R. leguminoarum*	Pea, Lentil, Vicia,
2	*R. Trifoli*	Berseem
3	*R. Phaseoli*	Beans
4	*R. lupini*	Lupinus, ornithopus
5	*R. Japonicum*	Soybean, cowpea, Groundut
6	*R. Meliloti*	Melilotus (Sweet Clover), Lucorne

TABLE 2: Nitrogen fix by different legume crops
Amount of Nitrogen Fixed By Important legume Crops

Sr. No.	Crops	N Fixed (kg/ha)
1	Pigeonpea	200
2	Alfalfa (Lucerne)	194
3	White clover	103
4	Cowpeas	90
5	Vetch	80
6	Peas	72
7	Soybean	58
8	Beans	40

The different biofertilizers which have potential for enhancing pulse productivity includes *Rhizobium*, PSM (phosphate solubilizing microbes), PGPR (plant growth promoting rhizobacteria), AM (arbuscularmycorrhizae) etc. (Lawal and Babalola., 2014). Gangwar andDubey (2012) reported that the application of RDF with one gram ammonium molybdate + *Rhizobium* + PSB recorded the highest yield and yield attributes in chickpea. Mishra *et al.* (2010) reported that the application of 100 percent RDF and seed inoculation with *Rhizobium* + PSB + PGPR

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improved yield attributes and yield of field pea. Khandewal*et al.* (2012) observed that the application of 75 percent RDF with *Rhizobium* and PSB resulted in significantly higher yield and yield attributing characters of cowpea. Reddy *et al.* (2011) concluded that 50 percent RDF along with seed treatment of*Rhizobium*recorded significantly higher seed yield followed by 50 percent RDF along with dual inoculation with *Rhizobium* and PSB. The results of experiments cited in literature revealed the importance of use of bio-fertilizers in crop fertilization and pulses being posses the natural capacity to fix atmospheric nitrogen, are more prone to exploit the benefits of these micro-organisms.

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12. AGRONOMY 16033

Resource Conservation Technologies in Rice

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Rice (*Oryza sativa* L.) is staple food of more than 60 per cent of the world's population and is the most important crop of India with area of 45 million hectares. It is estimated that 140 million tones of rice would be required by 2025 in India. Therefore to meet future food requirement concerning the rate of population growth, India has to increase its rice productivity by 3 per cent per annum. Further, to produce 1 kg of rice about 3000 –5000 litre of water is required (IRRI 2001) and the per capita availability of water source is declining and is expected to decline by 15-45 per cent by 2025 compared to 1990 (Guerra *et al.* 1998). Therefore, rice could face a threat due to lack of water availability and hence there is a need to develop and adopt water saving methods in rice cultivation so that production and productivity levels can be increased despite the water crisis. The present production trend showed decline in productivity, mostly because of imbalanced use of fertilizers and pesticides, over-exploitation of the natural resources particularly water, deterioration in physical conditions of the soil and emergence of new bio-types of pests and diseases. These led to yield stagnation, causing concern about the future potential for increased productivity and long-term sustainability. Thus the major challenge is to develop appropriate technologies to produce more food from diminished land resources for the burgeoning population pressure and to improve as well as conserve the natural resources. Suitable technologies need to be innovated to address the specific concern which is prevailing in specific areas.

Issues in Rice Production

1. Destruction of soil aggregates due to puddling in rice causes soil degradation.
2. Decline in water table due to pumping of underground water.
3. Inadequate plant population.
4. Pollution of ground water due to leaching of nitrates.
5. Emergence of multiple nutrient deficiencies.
6. Appearance of new weed biotypes and resistance to applied herbicides.
7. Inadequate and imbalanced use of fertilizers that leads to lodging and greater incidence of pests and diseases.
8. Erratic distribution of rainfall in time and space also affects the crop yield at great extent.
9. Gradual depletion of soil organic matter.

Resource Conservation Technologies in Rice

Resource conserving techniques (RCTs) refer to those practices that conserve resources and

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ensure their optimal utilization and enhance the input use-efficiency.

Zero tillage: Zero tillage is an extreme form of conservation tillage (CT) which is very helpful in the area of intensive cultivation by facilitating timely sowing. Potential of zero tillage under rainfed condition of North East in rice and rice based cropping system with appropriate residue management has been reported by Ghosh *et al.,* (2009). It also has the potential to save fuel and labour, reduces soil erosion and improves soil health.

Direct seeded rice: Rice can be directly seeded either through dry or wet or germinated seeds. Dry seeding of rice can be done by drilling the seed into a fine seedbed at a depth of 2–3 centimeters. Wet seeding mainly done after harrowing and flooding the field. The pregerminated seeds then can be sown by using a drum seeder. Weed management is critical in direct seeded rice. However, one to two hand weeding and timely application of herbicides (eg pretilachlor or butachlor at 2-3 DAT) can provide effective control of weeds.

Aerobic rice: "Aerobic rice technology" was developed by International Rice Research Institute (IRRI) to address the issue of water crisis in tropical agriculture as an alternate strategy, that combines the characteristics of rice varieties adopted in upland with less water requirement and irrigated varieties with high response to inputs. It may be a viable option where the shortage of water does not allow the growing of lowland rice.

System of rice intensification (SRI): SRI is a system of growing rice that involves involves single seedling transplantation of young seedlings with care. It provides more space to rice plants and uses lesser seed and chemical inputs, and promotes soil biotic activities in and around plant roots through liberal applications of compost and weeding with a rotating hoe that aerates the soil. These changed practices with lower inputs lead to the yields of 7-8 t/ha,

Crop residue management: Effective management of residues can have a beneficial effect on soil fertility through addition of organic matter and plant nutrients, and improvement in soil condition thus helping in maintaining the stability of agricultural ecosystems. Rice straw is found to contain organic materials and nutrients such as N 0.5–1.5percent, P 0.2–1.0percent and K 0.8– 1.0per cent (Mongkol and Anan 2006).

Laser land leveling: It is a precursor of resource conserving technique and a process of levelling the land surface having 0 to 0.2 % slope facilitating 10-15% uniform distribution of water. Due to this there is about 4% rise in area under cultivation due to removal of bunds and channels. It increases resource (N and water) use efficiency and also reduces cost of production and enhances productivity.

Brown manuring: Sesbania sown along with rice crop and after 30-35 days sesbania crop sprayed by 2,4-D which turned sesbania crop in brown colour and leaves starting falling while rice crop is resistance to 2,4-D. Brown manuring keep the moist soil for long time. This practice also helps in Improving soil fertility and weed control.

Leaf colour chart: Leaf colour is a fairly indicator of the nitrogen status of plant. Nitrogen use can be optimised by matching its supply to the crop demand as observed through change in the leaf chlorophyll content and leaf colour. A LCC value of 4 indicates that there is 1.4 to 1.5 mg N / g leaf weight. The critical LCC value for rice hybrids and HYVs is 4 and for and basmati rice is 3. These values are taken from 7-10 DAS or 20-25 DAT to heading.

Conclusion: Combining various Resource Conserving Techniques are more effective as compared to their individual application. SRI method of rice cultivation is an efficient method in utilizing natural resources and it is a solution for enhancing the production and productivity. Direct Seeded Rice is cost-effective and gives a higher net return. Laser land leveling enhances the yield and water productivity. Site specific nutrient management in rice (SSNM) by using LCC is helpful to achieve higher yield.

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13. AGRONOMY 16052

Objective, Mechanism of Nutrient Uptake and Factors Affecting Efficacy of Foliar Nutrition

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Foliar feeding of nutrient is a target oriented, efficient and cost effective technique. It is a technique of feeding plants by applying fertilizer in directly to leaves to stimulate the production process. Magpye defined foliar feeding as, a liquid, water soluble, fertilizer applied to a plant's foliage in a fine spray in such a way that the plant can absorb the nutrients through its leaves. It helps the nutrients to reach directly the site of food synthesis with no wastage and avoid all those soil factors which reduce nutrient utilization efficiently. Though soil application of nutrients can not be replace by foliar application completely, the latter could definitely boost the plant growth. It is most effective when nutrient availability is low, top soil dry and decreased root activity during reproductive stage.

Objectives of foliar feeding are to stimulate the production process of crops for improving yield, to correct deficiency of nutrients quickly during critical requirements, to promote crop growth under abiotic stress conditions, to improve nutrient use efficiency and quality of field crops.

Mechanism of Nutrient uptake through Foliar Feeding

Stomata: The upper (adaxial) and lower (abaxial) surface of leaves consist of numerous stomata, an opening for gaseous exchange between leaves the internal and external atmosphere of leaf. The solute penetrate through stomata by diffusion along the pore walls, which are less selective and thus offer less resistance as compared to cuticle. **Cuticular layer:** Plant cuticles are lipid rich protective layers mainly composed of a biopolymer matix of cutin, waxes, some amount of polysaccharides and phenolics. Presence of cracks on the cuticular surface allows the penetration of solutes. The cuticular penetration of non charged, lipophilic solutes occurs by dissolution and diffusion while the mechanism of polar, hydrophilic molecules is not fully understood. The outer surface of the cuticle is negatively charged due to carbonyl/carboxyl group present in cutin. This result in penetration of cations as they are attracted to the negative charge and diffuse passively.

Ectodesmata: Ectodesmata or teikodes are well-defined structures in the epidermal wall which terminates on the surface of outer epidermal cell walls. Ectodesmata serves as a polar pathway in absorption and excretion of substances. In cuticles, the majority of these pores have a diameter of less than 1 nm with a density of about 10^{10} pores cm^{-1}, readily accessible to low molecular weight solutes but larger molecules such as synthetic chelates cannot pass through. **Lenticels:** Lenticels are the openings in the bark of stem which are filled by loosely arranged cells called complementary cells. Lenticels are involved in transpiration; however, their role in absorption of surface applied nutrient solution needs to be ascertained. **Aqueous pores:** Aqueous pores are the openings localized in cuticular ledges, preferentially at the basal cells of trichomes, guard cells, and in anticlinal walls. These pores arise due to hydration of permanent dipoles and functional ionic groups. Average pore radii ranges from 0.45 to 1.18 nm.

Factors Affecting Efficacy of Foliar Feeding

1. **Spray solution**:
   a) **Concentration:** The concentration of a nutrient present in a foliar spray will always be significantly higher than the concentration found within the plant organ.
   b) **Solubility:** Water solubility of the applied substance is a key factor for foliar uptake, since absorption will occur only when the applied compound is dissolved in a liquid phase on the plant surface that will subsequently diffuse into the plant organs.
   c) **Molecular weight**: The radii of cuticular aqueous pores has been estimated at approximately 0.3 to 0.5 nm in leaves. The process of cuticular permeability is size-selective with high molecular weight (larger) compounds being discriminated against low molecular weight molecules.
   d) **pH**: Since plant cuticles are poly-electrolytes, their ion exchange capacity will be altered with pH fluctuations. Cuticles shows to have iso-electric points around pH 3 and when solution pH values are higher than it will render the cuticle negatively charged and the cuticular

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carboxyl groups will then readily bind positively charged cations.

e) **Point of deliquescence:** The point of deliquence is defined as the relative humidity value at which the salt becomes a solute. Thereby, the lower the point of deliquescence of a salt is, the sooner it will dissolve upon exposure to ambient relative humidity.

2. **Environment:** Light, humidity and temperature can affect foliar absorption: i) through direct effects on the spray solution prior to leaf absorption; ii) through effects on the leaf development processes; and iii) by altering photosynthesis, stomatal opening, respiration, leaf expansion and sink activity which consequently changes energy and metabolite availability involved in the uptake, assimilation and subsequent transport of foliar applied nutrients.
3. **Adjuvants:** The proper wetting, spreading and penetration of foliar fertilizers may require the addition of co-formulants such as surface-active agents (adjuvants). Adjuvants can be defined as any substance included in a formulation or which is added to the spray tank that modifies the nutrient active ingredient activity or the spray solution characteristics.
4. **Nutritional status of crop:** Leaf ability to take up mineral nutrients also is dependent on the nutritional status of a plant. In Nutrient deficient plants much nutrients translocate from the leaves, particularly to the roots.
5. **Plant developemental stage:** Foliar sprays of a given nutrient are most successful when applied at plant development stages requiring high amounts of nutrient. In general, the most appropriate timing for foliar nutrition are canopy closure to anthesis in cereal crops and early pod development in legumes.

Advantages of foliar feeding over soil application: More than 90% fertilizer is utilized by the plant when applied in foliar form as compare to the plant utilizes only 10% through soil application. From total foliar fed nutrient solution 95% can be found penetrate in plant part within 60 minutes if conditions are right. In sandy loam soils, foliar applied fertilizers are up to 20 times more effective when compared to soil applied fertilizers.

Summery and conclusion: Foliar fertilization is likely to play an important role in maintaining crop nutrient status and productivity under a variety of environmental situations when soil supply of nutrients is inadequate. The full potential of this technology has not been fully realized due to an inadequate understanding of the principles involved. Thus there is need to have adequate knowledge for the development of improved foliar fertilization strategies for its good potential impact on crop.

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14. AGRONOMY 16086

Modern Agriculture

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INTRODUCTION: The task made necessary by the fact that an increasing share of the population has little connection to farms or rural areas—and thus little opportunity to understand the nature of farming, especially the modern advances that are both helping to better feed the world's people and better protect the environment. Perhaps the chief paradox of agriculture's abundance is the fact that many of its enormous successes are providing the basis for new challenges. Chief among these, of course, is pressure from growing populations and increasingly wealthy developing-country consumers who want higher quality diets. To meet food demand expected by 2050, the sector must boost its capacity significantly in a relatively short period of time so that output grows by perhaps 70 percent or more over the next four decades, meets continuing future challenges in terms of protecting the environment and dealing with changing climates and does all this within a new economic and social setting—a growing competition for resources from urban, infrastructure and industrial users. And, it faces increasingly urgent constraints on the size and intensity of its environmental footprint.

The New Challenges The main driver of global food demand in the future is the expanding purchasing power of middleclass populations in developing countries who are demanding higher quality diets. This trend has become especially important now as agricultural resource limits tighten at the same time competition for the same resources grows among urban, infrastructure and industrial users. The facts are clear

Population Today, the world has more than 6 billion people, with more than 5 billion of those in

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developing countries. Developing country populations are projected to continue to grow relatively rapidly—1.2 percent annually to 2030 before declining to a 0.9 percent annual average to 2050. By contrast, populations in industrial countries are projected to grow a more modest 0.3 percent annually to 2030 and 0.2 percent annually to 2050.

Global Wealth: While world population growth will be important to future markets for food, economic growth will be much more important. Not only has the rate of economic growth in developing countries come to outpace that in developed areas, but it has made them increasingly urban, as well. By 2050 global per capita income is expected to increase to nearly three times the 2005 level. While developed country growth continues at less than 2 percent annually, the pace in developing countries could exceed 5 percent per year, a trend reversal that began in the 1990s. This shift has enormous implications for global agriculture as it creates more and more higher-income consumers, (defined in terms of local economic conditions) with dramatically different food spending patterns. It implies obvious benefits for millions of consumers, but also caries serious threats should agricultural productivity lag and basic foods become more expensive—an especially damaging trend for the poorest consumers.

What is Modern Agriculture: The – modernity of agricultural systems is a characteristic well understood by farmers but not easily defined with specificity. Still, the distinctions between modern and traditional systems have powerful implications for the future development of the global food system—even though it is important to recognize that few, if any, systems fall entirely into either the modern or traditional categories.

Traditional systems: Perhaps the most important difference between the categories is the way farmers see themselves and their roles. Traditional farmers, for example, often say that they seek to work effectively with resources at hand. That is, they use the land, rainfall, seeds, tillage methods and power sources they have to produce what nature offers. Conventional processes are used to till the land, select and plant seeds, protect plants from competing plants and animals and gather the harvest. Surpluses are marketed through nearby outlets. Such producers frequently report only limited capacity to change these processes—and some seek to avoid change.

Modern Agriculture. In modern agricultural systems farmers believe they have much more central roles and are eager to apply technology and information to control most components of the system, a very different view from that of traditional farmers. In contrast to the isolation inherent in traditional arrangements, modern agriculture tends to see its success as dependant on linkages—access to resources, technology, management, investment, markets and supportive government policies. As a result, much of the success of modern systems depends on the development and maintenance of soil fertility through the specific provision of nutrients when they are depleted; of machine power and technology to create soil conditions necessary to promote plant growth with minimal disturbance and minimal soil loss; of the use of improved genetics for crops and livestock to enhance yields, quality and reliability; and, on modern genetic and other techniques to protect plants and livestock from losses to competing plants, diseases, drought insects and other threats. This success also depends on access to efficient, effective irrigation to supplement rainfall in many climates; on advanced harvesting, handling and storage equipment and techniques to prevent losses and to market commodities efficiently. It depends, in turn, on both public and private investment to provide access to technology, equipment, information and physical facilities throughout the production-marketing system. And, it depends on well supported commercial and financial systems and broad public policies that support effective commercial markets at all levels that generate economic returns throughout the system. Modern agriculture in developed countries including the United States involves far more than farms and farmers—it depends on enormous, highly sophisticated systems that move, store and processes producers' output throughout an extensive value chain that extends to food products and final consumers.

Why modern agriculture is important: There is really little mystery about why agriculture is important—it is the physical foundation of human energy, health, and physical well being—all key components of every important human activity. To the degree these components are missing, the human existence is defined primarily by the effort necessary to provide them. Making them more widely available at lower costs increases the capacity of any population to invest in more productive work, education, economic development and cultural activities. The basic facts are clear: More people the world over eat more and better because of modern agriculture. Increased production continues to enable steadily improving diets, reflecting increased availability of all foods, dietary diversity and access to high-protein food products; The additional food modern systems provide has enabled hundreds of millions of people to realize more of their potential and better lives—thus enhancing the achievements of all, from students to retirees. It increases workforce productivity and generally supports human development and growth;

Benefits of Modern Agriculture: While the phrase, – industrial farming is frequently intended

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to deride modern farm organization, it is impossible to ignore the fact that agriculture, like other sectors, has become much more productive as machines and computers have eliminated the most laborious (and, dangerous) parts of the job.15, 16 And farming communities have educated their children to choose, in many cases, other careers—and the number of people who want to work on farms in the old, labor intensive way is very small. The result is that hand-labor-intensive crops (*e.g.*, coffee, strawberries…), or high labor cropping systems (*e.g.*, organic) appear to be on a collision course with demographic trends, since the pool of unskilled, low cost farm labor upon which those crops and systems have depended appears likely to continue to decline—and increasingly to make non-mechanization an increasingly non-viable option.

15. AGRONOMY 16109

Chelates: An Approach to Enhance Micronutrient Availability in Soil

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INTRODUCTION: Micronutrients are very important component of plant nutrition playing an important role in plants life. There are 17 essential plant nutrients elements without which plant cannot attain proper growth, development and production. Major parts of essential nutrients are micronutrients (*e.g.* Fe, Zn, Cu, Mn, Mo, B, Cl, and Ni). Therefore, deficiency of micronutrients is major cause for reduction in yields as well as failure of production. In the present days deficiency of micronutrients is appearing as major threats in agricultural crop production. Micronutrients in soil are presents in small quantity. Because of their small quantity and specific demand the adequate supply of micronutrients to improve the availability of them to plants is needed. There are two way to maintain adequacy: through increase availability of micronutrient and through reduce the losses. It can be achieved by applying micronutrients in right amount with right method at right palace through right source. There are three main classes of micronutrient sources: inorganic, synthetic chelates and organic complexes. Inorganic sources such as sulphates of Cu, Mn, Fe and Zn are the most common metallic salts used in the fertilizer industry because of their readily plant availability and water solubility.

Chelate

Chelate refers to a ring system that results when a metal ion combines with two or more electron donor groups of a single molecule. Metals bound in chelate rings have essentially lost their cationic characteristics. In this form they are less prone to precipitation in some chemical reactions. This is the characteristic feature that makes these compounds useful in agriculture. The plant availability of certain micronutrient fertilizers reduces by transformation of the added micronutrient into forms that plants are unable to absorb. There are many naturally occurring chelating agents that are products of organic matter decomposition such as organic acids, amino acids, ligninipolycarboxylates, ligninosulfonates, sugar acids and derivatives, poly flavonoids, phenols, siderophores and phyto siderophores.

Some chelating agents used for the production of synthetic micronutrient chelates are:

- Ethylene diamine-tetra-acetic acid (EDTA)
- N-(hydroxyethyl) ethylene-diamine-triacetic acid (HEEDTA): also known as EDTA-OH.
- Diethylene-triamine penta-acetic acid (DTPA)
- Ethylene-diamine-di-(o-hydroxyphenylacetic acid) (EDDHA): also known as N, N'-Ethylene-bis-2(ohydroxyphenyl)-glycine (EHPG)
- Ethylene dl amine di (o-hydroxy-p-methylphenyl) acetic acid (EDDHMA)
- Ethylene-diamine-di-(5-carboxy-2-hydroxyphenyl) acetic acid (EDDCHA)
- Nitrilo-tri-acetic acid (NTA)
- Glucoheptonic acid
- Citric acid

How does a Chelate Work?

Metal chelation is important because it makes metal ions more available for uptake by plants. The ligand (a molecule that binds to a central metal atom) coats the metal ion, protecting it from the surrounding OH- ions (which make the ion unavailable). The complex can then be easily absorbed by the plant, where it is being degraded and consumed as micronutrients.

Advantage of Chelates

- Much lower quantities are necessary compared to inorganic compounds because

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they are completely assimilated by crops. Chelates are thus cost effective even though they are a little more expensive.

- The chelating agents of the metal ions will protect the chelated ions from unfavorable chemical reactions and hence increase the availability of these ions to plant.
- Chelation can reduce the toxicity of some metal ion to the plants. This process is usually accomplished by humic acid and high molecular weight components of organic matter.
- Increase the mobility of plant nutrients.
- Suppress the growth of plant pathogens.
- Metal ion forming chelates are not leached as they adsorbed on to the surface of soil particles.
- The chances of 'scorching' of crops while using chelates is less because they are organic substances.
- Chelates are compatible with a wide variety of pesticides and liquid fertilizers, as chelates do not react with their components.

TABLE 1: micronutrients and their chelates sources

Micronutrient	Chelate Formula	% Content
Iron (Fe)	NaFeEDTA	5-14
	NaFeEDDHA	6
	NaFeDTPA	10
Zinc (Zn)	$Na_2ZnEDTA$	9-14
Copper (Cu)	Na_2Cu EDTA	13
Manganese (Mn)	$Na_2MnEDTA$	5-12

Source: Tisdale and Nelson, 2014

Conclusion: Chelated compounds are more stable than non chelated compounds. Therefore, cheleates are widely used in agriculture and useful for supplying micronutrients. These can be applied in both foliar and soil applications. These are available in natural and synthetic both forms. Natural organic chelates in soil are products of microbial activity and degradation of soil organic matter and plant residue.

16. AGROFORESTRY 16126

Alley Cropping

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Alley Cropping

Food crops are grown in alleys formed by hedge rows of trees or shrubs in arable lands. It is also known as hedgerow intercropping or avenue cropping. Hedgerows are cut back at about one meter height at planting and kept pruned during cropping to prevent shading and to reduce competition with food crops. It is recommended for humid tropics, primarily as an alternative to shifting cultivation. In semiarid regions of India, alley cropping provide fodder during dry period since mulching the crop with hedgerow prunings usually does not contribute to increased crop production.

Advantages of Alley Cropping are:

- Provision of green fodder during lean period of the year
- Higher total biomass production per unit area than arable crops alone
- Efficient use of off-season precipitation in the absence of a crop
- Additional employment during off-season
- It serves as a barrier to surface runoff leading to soil and water conservation.

Based on the objectives, three types of alley systems are recognised.

- Forage-alley cropping,
- Forage-cum-mulch system, and
- Forage-cum-pole system.

a) Forage alley cropping system: In this system, both yield of crop and forage assume importance. The tree species suitable for hedge rows are Leucaena leucocephala, Colliendra and Sesbania. Pigeon pea or castor crops are suitable for growing in the alleys of Leucaena.

b) Forage-cum-mulch system: In this system, hedgerows are used for both forage and mulch. Loppings are used for mulching during the crop season and used as fodder during off season. Substantial increase in crop yields of sorghum, groundnut, greengram and blackgram have been observed at several places.

c) Forage-cum-pole system: Leucaena alleys are established at 5 m intervals along the contours. Hedgerows are established by direct seeding and topped every two months at 1.0 m height during crop season and every four months during the off season. A Leucaena plant for every 2 m along hedgerows is allowed to grow into a pole.

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17. DRYLAND AGRICULTURE 15669

Basics in Dryland Agriculture

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INTRODUCTION: In India more than 60 % is dryland agriculture under the hands of small and medium sized farmers, who are literally very poor and they find very difficult to run even their day to day life. One should know the basics in dryland agriculture is the need of the hour rather get into solve their problems in India.

Basically Dry land agriculture can he grouped into three categories;

- **Dry farming**: Cultivation of crops in regions with annual rainfall less than 750 mm. Crop failure is most common due to prolonged dry spells during the crop period. These are arid regions with a length of growing season (period of adequate soil moisture) less than 75 days. Moisture conservation practices are necessary for crop production.
- **Dryland farming**: Cultivation of crops in regions with annual rainfall more than 750 mm. In spite of prolonged dry spells crop failure is relatively less frequent. These are semiarid tracts with a growing period between 75 and 120 days. Moisture conservation practices are necessary for crop production. However, adequate drainage is required especially for Vertisols.
- **Rainfed farming**: Crop production in regions with annual rainfall more than 1150 mm. Crops are not subjected to soil moisture stress during the crop period. Emphasis is often on disposal of excess water. These are humid regions with growing period more than 120 days.

Significance of Dry farming in Indian Agriculture

About 70% of rural population lives in dry farming areas and their livelihood depend on success or failure of the crops. In India only 43 m. ha of land out of the cultivated area of 143 m. ha was irrigated, leaving the remaining 100 m. ha as rainfed. The contribution (production) of rainfed agriculture in India is about 45 per cent of the total food grain, 75 per cent of oilseeds, 90 per cent of pulses and about 70 per cent of cotton. More than 90 per cent of the area under sorghum, groundnut, and pulses is rainfed. In case of maize and chickpea, 82 to 85 per cent area is rainfed. Even 78 percent of cotton area is rainfed. In case of rapeseed/mustard, about 65.8 per cent of the area is rainfed. Interestingly, but not surprisingly, 61.7, 44.0, and 35.0 per cent area under rice, barley and wheat, respectively, is rainfed. Although, India is blessed with average annual rainfall of about 1200 mm. Of the mean annual rainfall, 30 per cent of the country gets less than 750 mm and 40 per cent between 750 and 1250 mm. Only 20 per cent area is blessed with rainfall between 1250 and 2000 mm, About 10 per cent area with annual rainfall over 2000 mm. A critical appraisal of the existing rain water availability shows that. At present, 3 ha of dry land crop produce cereal grain equivalent to that produced in one ha irrigated crop. There is scope for doubling the average yield of dry land crops. Per capita land availability which was 0.28 ha in 1990 is expected to decline 0.19 ha in 2010. Dry land offers good scope fro development of Agroforestry, Social forestry, Horti-Syl vi-pasture and such other similar systems which will not only supply food, fuel to the village people and fodder to the cattle but forms a suitable vegetative cover for ecological maintenance.

Development of Dry farming in India

- **1920:** Scarcity tract development given importance by the Royal Commission on Agriculture
- **1923:** Establishing Dryland Research Station at Manjri (Pune) Tamhane to Kanikar 1926
- **1933:** Research Stations established at Bijapur and Solapur
- **1934** :Research Stations established at Hagari and Raichur
- **1935:** Research Station established at Rohtak (Punjab)
- **1942:** Bombay Land Development act passed
- **1944:** Monograph on dry farming in India by N.V. Kanitkar (MH, AP and TN Dry Farming Practices)
- **1953:** Establishing Central Soil Conservation Board
- **1955:** Dry Farming demonstration Centres started
- **1970:** 23 Research Centres established under AICRPDA
- **1972:** Establishment of ICRISAT
- **1976:** Establishment of Dryland Operational Research Projects
- **1983:** Starting of 47 model watersheds under ICAR
- **1984:** Initiation of World Bank assisted Watershed Development Programmes in four states.

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- **1985:** Birth of Central Research Institute for Dryland Agriculture at Hyderabad
- **1986:** Launching of NWDPRA programmes by Government of India in 15 states.

Definition of Drought: There is no universally accepted definition for drought. Early workers defined drought as prolonged period without rainfall. Prolonged deficiencies of soil moisture adversely affect crop growth indicating incidence of agricultural drought. It is the result of imbalance between soil moisture and evapo-transpiration needs standing crops and to reduce the yields. The irrigation commission of India defines drought as a situation occurring in any area where the annual rainfall is less than 75% of normal rainfall.

Classification of Drought

1. Based on duration
   a) **Permanent drought**: This is characteristic of the desert climate where sparse vegetation growing is adapted to drought and agriculture is possible only by irrigation during entire crop season.
   b) **Seasonal drought**: This is found in climates with well defined rainy and dry seasons. Most of the arid and semiarid zones fall in this category. Duration of the crop varieties and planting dates should be such that the growing season should fall within rainy season.
   c) **Contingent drought**: This involves an abnormal failure of rainfall. It may occur almost anywhere especially in most parts of humid or sub humid climates. It is usually, brief, irregular and generally affects only a small area.
   d) **Invisible drought**: This can occur even when there is frequent rain in an area. When rainfall is inadequate to meet the evapo-transpiration losses, the result is borderline water deficiency in soil resulting in less than optimum yield. This occurs usually in humid regions.
2. **Based on their relevance to the users** (National Commission on Agriculture, 1976)
   a) **Meteorological drought:** It is defined as a condition, where the annual precipitation is less than the normal over an area for prolonged period (month, season or year).
   b) **Atmospheric drought:** It is due to low air humidity and hot dry winds. It may occur even under conditions of adequate available soil moisture. It refers to a condition when plants show wilting symptoms during the hot part of the day when transpiration exceeds absorption temporarily for a short period. (Mid day wilt).
   c) **Hydrological drought:** Meteorological drought, when prolonged results in hydrological drought with depletion of surface water and consequent drying of reservoirs, tanks etc.
   d) **Agricultural drought:** It is the result of soil moisture stress due to imbalance between available soil moisture and evapo-transpiration of a crop. It is also usually referred as soil drought.
   Important causes for agricultural drought are Inadequate precipitation, Erratic distribution of rainfall, Long dry spells in the monsoon, Late onset of monsoon, Early withdrawal of monsoon and Lack of proper soil and crop management
3. **Based on time of occurrence**
   a) Early season drought: It occurs due to delay in onset of monsoon or due to long dry spells after early sowing
   b) Mid season drought: Occurs due to long gaps between two successive rains and stored moisture becoming insufficient during this long dry spell.
   c) Late season drought: Occurs due to early cessation of rainfall and crop water stress at maturity stage.

Effect of Drought on Crop Production

1. **Water relations** – Alters the water status by its influence on absorption, translocation and transpiration. The lag in absorption behind transpiration results in loss of turgor as a result of increase in the atmospheric dryness.
2. **Photosynthesis** – Photosynthesis is reduced by moisture stress due to reduction in Photosynthetic rate, chlorophyll content, leaf area and increase in assimilates saturation in leaves (due to lack of translocation).
3. **Respiration** – Increase with mild drought but more serve drought lowers water content and respiration.
4. **Anatomical changes** – Decrease in size of the cells and inter cellular spaces, thicker cell wall greater development of mechanical tissue. Stomata per unit leaf tend to increase.
5. **Metabolic reaction** – All most all metabolic reactions are affected by water deficits. Proline accumulates and per oxidase activity affected.
6. **Hormonal Relationships altered** – The activity of growth promoting hormones like cytokinin, gibberlic acid and indole acetic acid decreases and growth regulating hormone like abscisic acid, ethylene, betain etc. increases.
7. **Nutrition** – The fixation, uptake and assimilation of nitrogen is affected. Since dry matter production is considerably reduced the uptake of NPK is reduced.
8. **Growth and Development** – Decrease in growth of leaves, stems and fruits. Maturity is delayed if drought occurs before flowering

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while it advances if drought occurs after flowering.

9. **Reproduction and grain growth** – Drought at flowering and grain development determines the number of fruits and individual grain weight, respectively.
10. **Yield** – The effect on yield depends hugely on what proportion of the total dry matter is considered as useful material to be harvested.

Conclusion: By knowing the basics in dry land agriculture, we understand that the seriousness of the drought and the various types of drought, time of occurrence of the drought and how it affects the crop plants both directly and indirectly. It is very important to note that the drought is not only affects agriculture but also affects the allied enterprises of agriculture such as lives stock management and forage production.

18. ORGANIC FARMING 16096

Organic Cotton: Future Need

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Cotton, the most important fibre crop of India plays a dominant role in its agrarian and industrial economy. It is the backbone of our textile industry, accounting for 70% of total fibre consumption in textile sector and 38% of the country's export, fetching over Rs. 42,000 crores. Area under cotton cultivation in India (8.9 million ha) is the highest in the world, *i.e.* 25% of the world area and employs seven million people.

Cotton cultivated on 5% cultivable land consumes 54% of total pesticides used in Indian agriculture and in some pockets, the rates are higher than this, leaving immense ecological and human hazards as reported by World Health Organisation. Use of chemicals at such scale is hazardous with increase in environmental pollution. It also has adverse effects on soil health and agro-ecology leading to reduced profitability in cotton farming. This has basically prompted the demand of organically cultivated, eco-friendly or 'green'.

Even after harvesting, cotton fabric at textile mills is treated with a variety of chemicals for improving appearance and performance. Cotton fabrics are often processed with toxic dyes and formaldehydes before they reach end users. Growing cotton without synthetic fertilizers and other chemicals has been termed green, environment friendly, biodynamic etc, but organic production is the most popular name used in the cotton industry.

ORGANIC COTTON: Organic cotton is grown using methods and materials that have a low impact on the environment. Organic production systems replenish and maintain soil fertility, reduce the use of toxic and persistent pesticides and fertilizers and build biologically diverse agriculture. Third-party certification organisations verify that organic producers use only methods and materials allowed in organic production.

Organic cotton is grown and processed without toxic chemicals that can be absorbed easily when in contact with the user's skin. Pesticides, fertilizers and chemicals used to grow and process conventional cotton fabrics may go directly to the users blood stream, which consequently affects the body's organs and tissues.

Use of chemicals in the form of fertilizers, herbicides, insecticides, growth regulators, defoliants and desiccants has increased the cost of production to the extent that cotton is losing its profitability against other field crops. Environmental concerns are also increasing. Organic cotton production provides an alternative to grow cotton without chemicals. Besides, the naturally soft organic cotton fabric is a lot more comfortable to use and is available at competitive prices.

Some Facts of Organic Cotton

1. A source says that 25 million people worldwide are poisoned by pesticides every year.
2. In 2009, organic fiber sales in the United States grew by 10.4 percent over the previous year, to reach $521 million, according to the *Organic Trade Association's 2010 Organic Industry Survey*. The future looks promising, with organic fiber products appearing in more mainstream outlets, led by large U.S. textile retailers
3. 25% of the pesticides and fertilizers used in the world are sprayed in conventional cotton crops.
4. Over 0.75 kg of toxic chemicals are used to grow the cotton needed for a conventional cotton sheet set and about 0.5 kg to make a T-shirt and pair of jeans. Among all the pesticides used, roughly 65% of the chemicals are used against insects, 20% are herbicides, 14% are defoliants and growth regulators while fungicides and others comprise only 1% of the total toxic chemicals used on cotton.

Reasons for Organic Cotton Production

- Amount of conventional cotton produced per year: 25 million tons.

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- Amount of water needed for 1 kilo of non organic cotton: 29,000 litre. High levels of agrochemicals are used in the production of non-organic cotton: according to the "Pesticide Action Network" cotton uses 25% of the world's insecticides and more than 10% of all pesticides - the cultivation of cotton accounts for only 2.4% of agriculturally used areas. Thus cotton production uses more chemicals per unit area than any other crop.
- Many of these plant protection products are highly effective neurotoxins, have been used as chemical weapons in the past.
- The chemicals used in the processing of non-organic cotton pollute air, surface waters and people.
- Around 70 field workers are dying every day as the result of pesticides and insecticides application, the majority are children under the age of 14, additional 80 factory workers die every day because pesticide soaked cotton and fabric pollutes the air in warehouses and working areas (according to estimations of the WHO). According to estimations 450,000 children under the age of 14 work every day at Indian cotton farms in debt slavery and free of charge. Since 1998 alone in India 40.000 farmers committing suicide, trying to escape their debts encurred at biotechnology companies.
- Massive human rights violations are commonplace: confinement of textile workers in the dorm rooms after 10 p.m., as well as corporal punishment and abuse.
- Still the consumer suffers from chemicals in garments since non-organic cotton textiles irritate consumers' skin, as they can also cause neurodermatitis (chemical residues stay verifiable even in the ready-made garment).

Organic Cotton *vs* Conventional Cotton

Criteria	Conventional	Organic
Seed preparation	Treatment of seed with fungicide of insecticide.	Uses untreated seeds
	Use of GMO (BT) seeds.	NO use of GMO/BT
Soil & Water	Applies synthetic fertilizers.	Uses bio fertilizers like cow dung.
	Loss of soil due to MONO crop culture	Strengthens soil through crop rotation
Weed control	Applies herbicides and insecticides.	Physical removal of weeds and bio-pesticides.
	Repeated application infecting air, water and soil	Use of mechanical and hand methods and totally harmless.
Pest control	Heavy use of insecticides. Consumes about 25% of world's total insecticides.	Use of natural predators to kill insects.
	Use pesticides which are highly toxic and carcinogenic.	Uses beneficial insects to control pests.
	Use of spray which affects air, water and also affects human life and nature.	Use of trap crop to control pests.
Harvesting	Defoilates with toxic chemicals.	Natural defoilation

Limitations to Organic Production: There are many reasons why organic cotton production has not extended to other countries. Nineteen countries tried to produce organic cotton during the 1990s. But many of them have already stopped, not for lack of desire or demand for such cotton, but for economic reasons. Insecticides need to be eliminated from the cotton production system because they are dangerous to apply, have long-term consequences on the pest complex and deleterious effects on the environment. Also, heavy reliance on pesticide use has pushed many countries out of cotton production.

Conclusion: The concern for a life devoid of the use of extremely harmful toxic chemicals, the need for an eco-friendly industrial and agricultural culture and an increasing awareness of depleting natural resources and the consequences therein; these are factors which are shaping the lifestyles of people worldwide. It is in this context that the relevance of organic cotton becomes important. The conventional cotton farming takes an astonishing amount of the responsibility for contaminating our planet by using a full quarter of the pesticides worldwide. Twenty thousand deaths can be accredited to poisoning by farming pesticides; three million people suffer from chronic health problems reported by The World Health Organisation. We know it's alarming!

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19. WEED SCIENCE 16154

Integrated Weed Management in Dry Direct Seeded Rice

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Rice (*Oryza sativa* L.) is one of the most important and widely cultivated crop in the world. Asia is considered to be the home of rice as more than two billion people are getting 60-70 % of their energy requirement from rice and its derived products. About 90 % of total rice is grown and consumed in Asia (Seema *et al.*, 2014). But recently the area and production of the rice is decreasing mainly due to scaresity of labour and water since it is highly labour and water intensive crop. To overcome these two main problems especially that of human labours required in nursery preparation, puddling and transplanting operations, dry direct seeding of rice was found to be one of the efficient method of crop establishment. In this method paddy seeds are sown directly in rows in unpuddeled land.

To make paddy cultivation cost effective, this provide a better option which saves labour and water use along with reducing cost, time by eliminating operations like puddling and rising nursery. This method of rise establishment could also help to carry out all the necessary operations in time. Rice crop sown through dry direct seeding technique is associated with the problem of profuse growth of weeds and infestation of very heterogeneous weed flora which becomes the biggest biological constraint and the success of direct seeding entirely depends on efficient weed management practices because uncontrolled weeds in dry direct wet seeded rice can reduce yields to the tune of a greater extent.

Hence efficient weed management is very important in this methods, by following a single method of weed management it is difficult to control heterogeneous weed flora to overcome this weed problem Integrated weed management is much required which includes the following methods.

Cultural Methods of Weed Management

Selection paddy variety: Selected paddy variety should have high initial vigor, fast growing, good canopy and it be short duration, dwarf and resistant to multiple pest and diseases.

Land preparation: Deep ploughing in summer is required, Cyperus and Cyanodon should be removed from the field since these weeds become more dominant in the field and reduces yield to a greater extent.

Stale seed bed technique: Stale seed bed technique (SSB) is another important cultural management strategy that can be used before any crop to reduce the weed seed bank. In SBB, weeds are allowed to germinate by giving a light irrigation or after a rainfall and after that emerged weed seedlings are killed using a non-selective herbicide like glyphosate or shallow tillage.

Nutrient management: Before sowing seed should be treated with biofertizers, avoid broadcasting of FYM or any other manures it should be applied in rows so that the germination of weeds can be reduced to a greater extent even top dressing as to be done in rows.

Cropping system: Utilizing the pre-monsoon showers can grow leguminous crops like cowpea and field beans having good canopy coverage which suppress the major weed flora and reduces the weed seed bank in the soil to a greater extent along with this it fix the nitrogen in soil.

Intercropping: leafy vegetables like coriander, dill leaf, amaranths, spinach etc., and short duration vegetables like radish can be grown successfully in between two rows of paddy. These crops not only reduces the weed crops adds additional income along with better utilization of

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resources.

Mulching: Utilizing the crop residues or any other materials mulching can be done in between the rows of paddy.

Mechanical Method of Weed Management

Inter-cultivation using mechanical weeders and other inter cultivation implements: The use of mechanical weeders is much feasible since rice is planted in rows. The soil moisture plays major role in achieving best results using weeders. One major disadvantage in mechanical weeding is that weeds emerge with in the row and very close to the row are difficult to remove and these weeds become more dominant. In the recent years motor operated weeder are gaining important and are much effective in removing weeds compared to cycle weeder.

Chemical Method of Weed Management

Herbicide based weed management is one of the smartest and most viable option of weed management in direct seeded rice. The selected herbicide should be broad spectrum and having least or no phytotoxicity on paddy crop and also it should not have any residual effect. Pre-emergence application of bensulfuron methyl + pretilachlor at 3 days after sowing and bispyribac sodium at 25 days after sowing is found to be much effective in managing the complex weed flora in direct seeded rice.

Conclusion: Weeds which are the major biological constraint in dry direct seeded rice production cannot be managed effectively by a single weed management strategy. By integration of various weed management method the problem of weeds can be efficiently reduced and thus helps to option better yield and economic returns.

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20. WATER MANAGEMENT 15797

Management of Brackish Water and its use for Irrigation

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Brackish water: Brackish water is water that has more salinity than fresh water, but not as much as seawater. It may result from mixing of seawater with fresh water. In some regions of the country with limited availability of freshwater, desalination of brackish groundwater is being used as an alternative supply.

How does Brackish Water differ from Seawater?

Brackish water has a TDS (Total Dissolves Solids) up to 10000 ppm while saline water has a TDS more than 10000 ppm. Sea water is more salty then saline water and has a TDS of 35000 ppm or more. Increased salt content increases the specific gravity, thus adding to the potential for suspended sediments.

Water salinity based on dissolved salts

Fresh water	Brackish water	Saline water
< 0.05 %	0.05-3 %	3-5 %

Area and Extent of Brackish Water in India

Total brackish water area available in India is 1.2 Million ha. The brackish and saline waters are used for irrigation in almost all the north-western states of India, which are located in the arid and semiarid zones (Tanwar *et al* 1985). The semiarid and arid regions of the states of Rajasthan, Haryana, Punjab, Uttar Pradesh, Gujarat, Maharashtra, Andhra Pradesh and Karnataka contain brackish and saline ground waters. The coastal states of India viz., Kerla, Tamil Nadu, partly Andhra Pradesh, Orissa, and West Bengal contain brackish and saline ground water. The different states are following different classification of salinity of ground water for irrigation purposes with upper limit of salinity from 2.25 dS/m (Uttar Pradesh) to 6 5 dS/m (Rajasthan).

Constraints Affecting the Scaling-up of Brackish Water Use

Brackish water use in irrigation is facing many problems and constraints which can be summarized as follows:

1. Increase in soil salinity.
2. Yield reductions due to salt accumulation in the root zone to such an extent that the crop is

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no longer able to extract sufficient water from the salty soil solutions resulting in water stress for a significant period of time.

3. High cost of agricultural inputs due to the need for deeper ploughing and more pumping costs to cover the additional water requirement for leaching.

Water Quality Characteristics of Brackish Water

Generally speaking, brackish groundwater exhibits salinity concentrations from 1000 to 10000 milligrams per liter. Slightly brackish groundwater has a TDS of 1000 mg/l to 3000 mg/l than moderately brackish groundwater (3000 to 10000 mg/l). Some of the most important parameters include naturally-occurring heavy metals (especially arsenic) and naturally-occurring radionuclides. Brackish ground waters with concentrations of less than 10000 mg/l total dissolved solids are the best candidates for treatment when waters will be used for purposes other than drinking water. The goal is to be able to treat brackish and saline groundwater so it can be used for irrigation water (*i.e.*, water quality with less than 500 mg/l of total dissolved solids and less than 0.05 mg/l of hydrocarbons).

Brackish water can be used for irrigation under proper technical and management conditions. However, it also runs the risk of soil salinization and crop yield reduction. To utilize brackish water safely and effectively has become an effective way to solve water shortage problem in the areas with rich brackish water resources.

Methods in Using Brackish Water for Irrigation

There are three methods in using brackish water for irrigation, *i.e.* direct irrigation with brackish water, rotated interval irrigation with fresh water and brackish water, and irrigation with mixed brackish water and fresh water.

Direct irrigation with brackish water: Brackish water can be directly used for irrigation if there is no fresh water or fresh water resources are very scarce. However, it is important to ensure that the soil salinity and solution concentration should not exceed the limit of crops salt tolerance after irrigation. Brackish water should not be used to irrigate crops at seedling stage in order to avoid the hazards to crop growth. Generally speaking, the good results can be achieved by using brackish water to irrigate wheat, cotton, corn and other crops timely and properly in the growing seasons.

1. The attention should be paid to the following aspects with direct brackish water irrigation:
   a) Drainage systems should be properly constructed in farmland in order to regulate groundwater tables below critical dynamics and prevent salinization.
   b) Irrigation with brackish water only applied one or two times at the crop critical water demand period.
   c) The accumulated salt should be leached out by making full use of the rainfall in flood season and the irrigation water in fall and winter irrigation.
   d) The application of organic fertilizers should be increased so as to promote the improvement of soil properties.
   e) The leakage should be reduced by adopting proper management measures such as land levelling, border check irrigation or other advanced irrigation methods.
   f) Rotated interval irrigation with brackish and fresh water: The method of rotated interval irrigation with brackish and fresh water is using brackish water to irrigate salt-tolerant crops or crops at the salt-tolerant growth stages and using fresh water to irrigate salt sensitive crops or crops at salt sensitive growth stages. The application time and volume of the brackish and fresh water changed with mineralization of water, crop patterns and water supply conditions. For example, using brackish water to irrigate crops in dry season and using fresh water to irrigate crops when surface water is plenty after rainfall; to irrigate salt-tolerant crops (such as cotton and sunflower) with brackish water and to irrigate salt sensitive crops (such as wheat, corn, soybean) with fresh water under rotation or intercropping condition; to irrigate with fresh water before sowing and in seedling stage and to irrigate with brackish water in middle and late growth stages of crops used fresh water (less than 1g/L) to irrigate wheat in seedling stage and saline water (5~6g/L) in stem elongation stage.
2. Irrigation with mixed saline and fresh water: The method of irrigation with mixed saline and fresh water is that saline water and fresh water are mixed for irrigation to mitigate the hazards induced by direct irrigation with saline water. The mechanism of irrigation with mixed saline and fresh water is that salinity and alkalinity can be diluted and decreased and the reaction of ions after mixing can reduce the residual sodium carbonate (RSC) in mixed irrigation water. Irrigation with mixed water can not only improve the irrigation water quality but also increase the amount of irrigation water.

It can not only reduce the exploitation of deep fresh water and make full use of shallow brackish and saline water, but also reduce the production costs, solve water shortage problem and promote the sustainable utilization of water resources. The average yield of winter wheat and summer maize

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was 8355kg ha^{-1}, which was 162.7 % higher than non-irrigated farmland and 20 % higher than the yield of the farmland irrigated with saline water (4~6g/L) during the whole growing period.

The Key Points for Irrigation with Brackish Water

Irrigation with brackish water not only increases the soil moisture but also increase the soil salinity. Therefore, the relationship between meeting crop water demand and controlling salinity must be balanced in order to keep the salinity in root zone of soil below the threshold level of crops tolerance. Otherwise the normal crop growth could be affected and consequently result in yield reduction and soil degradation with increased salinity in soil.

The key factors for irrigation with brackish water include: the soil salinity should not exceed the threshold of crop salt tolerance and the salt accumulated in soil due to irrigation with brackish water should be leached out by rainfall or irrigation with fresh water in order to maintain annual or perennial salt balance in soil.

Therefore, the following key points should be highlighted with brackish water irrigation:

- The mineralization degree of brackish water should not exceed 5g/L with pH value from 7 to 8.
- The groundwater tables should be controlled below the critical depth. The salt accumulation in soil caused by irrigation with brackish water should be leached by rainfall or irrigation with fresh water so as to keep dynamic balance of soil salinity.
- Irrigation with brackish water only applied when crops need irrigation and irrigation times should be minimized.
- Comprehensive measures should be adopted, such as land levelling, application of mulching film, rainfall collection and storage, time tillage after irrigation, etc. Salt tolerant crops should be selected. Green manure grass plantation or fellow should be properly arranged after crop plantation.
- The application of organic manure should be increased by returning crop residues back to land.

To maintain the sustainable application of brackish water for irrigation, the following researches should be carried out

- Integrated technology researches on using brackish and saline water for irrigation by considering regional characteristics to achieve sustainability.
- Water and salt balance under large-scale brackish water irrigation and management strategies for using brackish and saline water for irrigation in large area.
- Development and cultivation of salt-tolerant crops.

Guidelines for saline irrigation waters (RSC < 2.5 me/l) in India:

Soil texture (%clay)	Crop tolerance	Upper limits of ECiw (dS/m) in rainfall regions (mm)		
		<350 mm	350-550 mm	550-750 mm
Fine soil (>30)	Sensitive	1.0	1.0	1.5
	Semi-tolerant	1.5	2.0	3.0
	Tolerant	2.0	3.0	4.5
Moderately Fine soil (20-30)	Sensitive	1.5	2.0	2.5
	Semi-tolerant	2.0	3.0	4.5
	Tolerant	4.0	6.0	8.0
Moderately Coarse soil (10-20)	Sensitive	2.0	2.5	3.0
	Semi-tolerant	4.0	6.0	8.0
	Tolerant	6.0	8.0	10.0
Coarse (<10)	Sensitive	-	3.0	3.0
	Semi-tolerant	6.0	7.5	9.0
	Tolerant	8.0	10.0	12.5

21. WATER MANAGEMENT 16053

Bore Well Recharge

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INTRODUCTION: As the water crisis continues to become severe, there is a dire need of reform in water management system and revival of traditional systems. Scientific and technological studies needs to be carried out to assess present status so as to suggest suitable mitigative measures for the revival to traditional system/wisdom. Revival process should necessarily be backed by people's initiative and active public participation.

Living creatures of the universe are made of five basic elements, viz., Earth, Water, Fire, Air and Sky, Obviously, water is one of the most important elements and no creature can survive

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without it. Despite having a great regard for water, we seem to have failed to address this sector seriously. Human being could not save and conserve water and it sources, probably because of its availability in abundance. But this irresponsible attitude resulted in deterioration of water bodies with respect to quantity and quality both. Now, situation has arrived when even a single drop of water matters. However, "BETTER LATE THAN NEVER", we have not realized the seriousness of this issue and initiated efforts to overcome those problems.

Agriculture is the backbone of India, but the country is facing water scarcity on daily basis. Almost 68% of net sown areas in India comes under rain fed agriculture and due to fluctuations in rain; uncertainty is increasing in production of crops. Rainwater harvesting seems to be the only sustainable solution to tackle the problem of water scarcity. India is awaiting people and organizations that can play the role of Bhageerath and save Indian Agriculture from the disaster of water scarcity

Two methods to recharge a bore well:

1. **Direct recharge** : Recommended only if the bore well has gone dry or is yielding a negligible amount of water.
2. **Indirect recharge:** For well functioning bore wells we recommend indirect recharge.

Direct Recharge: Got a dry bore-well? We can revive it. Excessive digging of new bore-wells and incessant use of existing ones has resulted in severe depletion of groundwater levels rendering many a bore-well dry. The direct bore-well recharge technique combines common rainwater harvesting practices with innovative practices to replenish ground-tables and aquifers with naturally filtered rainwater.

The following steps are involves in bore well recharge pits

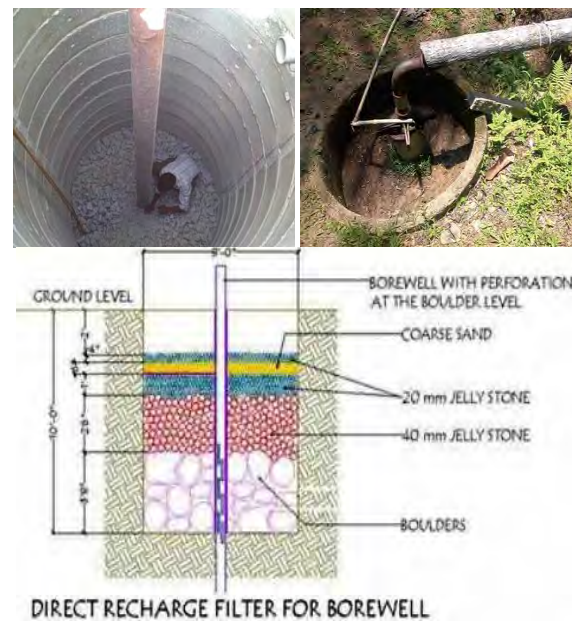
- The excavation of a pit sized 10 x 10 x 10 feet (in most cases) around the tube-well's casing pipe.
- Tiny slits are made into the casing pipe up to 30 percent of total depth of pit (bottom to top) and which is then wrapped with nylon-mesh.
- The Cement rings are laid one upon another around the pipe thus creating a circular structure in the centre of the pit as shown in the below figure.
- The bottom of 30 percent of pit filled with pebbles up to complete cover of tiny slits
- The rest of the pit is packed with natural filtration material *i.e.* concrete, gravels, sand and gravels.
- If the bore well water is using for drinking purpose, layer of charcoal is needed.

Adjoining this pit referred to as the primary percolation pit, a large pond is excavated. During the rains, rainwater from the plot is directed to this catchment pond via a series of trenches or piping. The water then enters the primary percolation pit and after undergoing filtration via the stones and the sand seeps in through the gaps between the cement rings. After a final round of filtration by the mesh, the water enters the casing pipes through the tiny slits thus going back underground to replenish the water tables and aquifers. The result…?

- **Increased water-output**: Bore-wells recharged using this technique have an increased water-output. Completely dry bore-wells can be revived too.
- **Better water-quality**: Sending back of naturally filtered rainwater into the groundwater tables results in a decrease in the proportion of impurities in the water. The bore-well's water thus loses its hardness with time.
- **Cost-effective**: The use of locally procured natural materials enables us to deliver the bore-well recharge service at an extremely low cost.
- **Permanent**: Once recharged a bore-well never goes dry. Year after year, underground water-tables and aquifers are replenished thus keeping your bore-well up and running.

i) **Eco-friendly**: Apart from resolving your water-scarcity issue, our bore-well recharge technique also ensures the storage of naturally filtered rainwater in natural water-reservoirs *i.e.* aquifers and water-tables for use by future generations.

Here is the bore-well recharge technique explained in pictures:



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22. SOIL SCIENCE 15120

Measurement Methods of Soil Water Diffusivity

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Soil water diffusivity as a function of water content or pressure head, occurs in the equations of flow for water in unsaturated soil. It is required in the analysis of unsaturated unsteady state flow system. D (θ) = K (θ) dh/ dθ, Where: D (θ) – soil water diffusivity, K (θ) – conductivity function, C (θ) - specific water capacity.

The ratio of the conductivity to the specific water capacity is called the soil water diffusivity. Soil water movement subject to specific boundary conditions has been facilitated considerably by the introduction of a diffusivity term, *D*

Method of Diffusivity Measurements

1. **Tempe pressure cell method:** Passioura (1976) developed a method of calculating diffusivity from one step outflow data. The method is based on the assumption that the rate of change of water content at any given time is effectively uniform throughout the draining column of soil. (*i.e.*, δθ/θt is assumed constant throughout the soil column : θ is volumetric soil water content and t is time) With the one step method, a pressure is applied at the upper end (x=L) where L is the length of the soil column) of a soil sample with an initial water content θ_i,. The out flow is the measured at the lower end, x=0, where it is assumed that water content is reduced to the final water content (θ_f) at the onset of the outflow.
2. **Three stage of outflow**: The first stage is controlled by the membrane (ceramic plate) and its resistance to flow, so that the cumulative outflow (Q) is proportional to time t, The flow rate decreases as the permeability controlled the flow the membrane resistance becomes negligible and the soil water content at the bottom end of the core reaches θ_f (stage II). During the stage II the core sample behaves as a semi-infinite column and Q is linear function of t^2. When this linear relation ceases, III stage of the outflow starts and the boundary condition at the top end of soil, x = L begins to influence the flow. This is the stage when the assumption of uniform water content over most of the soil column is used to determine D(θ).

Sample Collection and Measurement Procedure

The laboratory procedure used measurement of outflow, using a single pressure step from tempe-pressure cells. Undisturbed core samples collected, Samples trimmed and wetted, Tempe cell equipment prepared, Samples wetted in tempe cells, Outflow experiment completed. Outflow experiment completed samples drained on suction tables at a range of suction (1, 3, 35, 10, 33, 60 k pa). Cores sub sampled for pressure plate measurements. Disturbed soil material used on pressure plate apparatus (100,500 and 1500 kpa suction)

Steps to complete the one step outflow experiment: Wet up the core from below by adding water to the burette until the core is saturated. Then drain by lowering the burette to establish the water level equal to the top of the ceramic plate so that the soil sample has zero cm suction at the base for commencement of the out flow experiment. The sample are not fully saturated at commencement of the outflow because attaining consistency in initial water content across different core samples is very difficult and small changes in water levels at the top of the core can gave significant difference in initial out flow volumes. Tighten the wing-nuts the secures the end caps of the Tempe cell just before commencing the run to ensure minimal air leakage. Reconnect the cell to the burette (or else connect tubing and run into flask on weighing platform) and remove any air under the plate by tipping the cell on its side and withdrawing the air through the two-way tap using syringe. Then adjust the water level in the burette to be level with the bottom of the core sample. Set the gas pressure to 100 kP (1 bar) with the air lines to the Tempel cell disconnected or we can use mercury manometer to measure the pressure. Record the water level in the burette then start the run by pressing together both parts of the swagelok pressure fitting to connect the airlines to the cell. Lower the burette to keep the suction at the base of the core close to zero. Sufficient measurement points are required throughout stage II and stage III outflow to allow clear determination of the time at which the outflow stage changes. When the burette fills, remove excess water with a syringe.

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Weight the syringe before and after to record water removed. This is more accurate than reading the burette directly. This will not be necessary if using a large enough flask on a weighing platform. After 4 hours check for air under the plate prior to each reading. Disconnect the air line so the cell can be turned on its side and any air removed through the tow way tap using the syringe. Return any water removed to the burette or weight the water. Reconnect the air line with as little delay as possible. When out flow ceases disconnect the cell and weight it. With very slow drainage cores it may be desirable to continue measuring outflow for another day to ensure the core is at equilibrium with the 100kp pressure applied. Weight the core after removal from the cell to obtain a final weight. Then record core length, core diameter and ring weight the observed weight change measured should closely approximate the measure out flow. Check this on a routine basis. The initial sample weight used for the calculation is back calculated as the final weight of the core plus the difference in initial and final apparatus weight.

Outflow or Inflow Method by Using Gamma Ray Absorption

Procedure: Consisted of imposing successively smaller (or greater) pressures on soil samples having dimensions of approximately 5 x 5 x 11 cm. A fritted glass bead plate for pressure control rested against one face of the sample. At the opposite end, six 2.4 mm diameter holes allowed the escape and entry of air during wetting and drying. Extreme precaution was exercised to minimize water loss by evaporation and diffusion through construction materials. The samples were initially wet with the $CaSO_4$ solution, taken through a drying and re-wetting cycle before use. Following equilibrium, no change in burette volume in 48 hours, pressure increments of either 100 cm of water or smaller increments were applied. Soil water contents versus time were measured by gamma absorption 0.3, 1.0 and 3.5 cm from the fritted plate *(x = 0).* The intensity of the radiation passing through the samples was recorded by a digital recorder every 10 seconds. This time interval was increased to 30 seconds and 60 seconds as the rate of water content change diminished. Initial and final water content distributions along the sample (x = 0 to x = 5 c m) for each pressure increment were measured every 5 mm. Thus, the basic experimental data collected in this experiment were d(x, t) and volumetric outflow (or inflow) versus time. These data were analyzed by assuming (1) the soil water diffusivity was constant during each pressure increment, and (2) the soil water diffusivity was a function of time with (θ) not varying with x during each pressure increment. Soil water diffusivity was calculated using the relation $D = -\frac{4L^2}{\pi^2 \ (\theta-\theta_\infty)} \frac{d\theta}{dt}$

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23. SOIL SCIENCE 16030

Soil Organic Matter Pools and their Management in Soils

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Soil organic matter (SOM) is the foundation for soil productivity and fertility. It promotes healthy crops, supplies resources for microbes and other soil organisms and regulates the supply of water, air and nutrients to plants. SOM supply nitrogen, phosphorous and other macro and micronutrients for crops, thus strongly influencing fertilizer requirements. SOM is the foundation on which sustainable cropping systems are built so any effort to improve soil quality and function needs to start with restoring SOM, which influence on soil's physical, biological and chemical characteristics. SOM serves as the primary habitat and food source for soil organisms. Accordingly, the activity, biomass and diversity of soil biological communities are usually closely associated with SOM concentration. Crop growth, soil moisture holding capacity, nutrient supply, soil disease suppression, aggregation, soil chemistry and nutrient supplying capacity are influenced by SOM concentrations. Soil organic matter is a biological system that functions as an integrated whole at the same time, there are components of SOM that can be considered as separate pools. These pools have different histories, characteristics and turnover times. The amount and type of organic matter varies from soil to soil, but generally SOM can be divided up into three pools with different turnover times. SOM management should focus on strategies that

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build all three pools. This is the key to simultaneously building SOM and deriving benefits from its decomposition, including nutrient turnover, aggregate formation and water storage.

On the basis of organic matter content, soils are characterized as mineral or organic. Mineral soils may contain from a trace to 30 percent organic matter. Organic soils are naturally rich in organic matter principally for climatic reasons. Although they contain more than 30 percent organic matter, soil organic matter is a biological system that functions as an integrated whole. At the same time, there are components of SOM that can be considered as separate pools. These pools have different histories, characteristics and turnover times. The amount and type of organic matter varies from soil to soil, but generally SOM can be divided up into three pools with different turnover times. So, soil scientist should focus on strategies that build all three pools because this is the key to simultaneously building SOM and deriving benefits from its decomposition, including nutrient recycling, aggregate formation and water storage.

Active Pool

Turnover time of active SOM pool has months to years, and it includes constituents such as soil microorganisms that are involved in even faster turnover times. It is primarily composed of recent plant residues that are in the early stages of decomposition and of soil organisms. This active SOM pool is very important for nutrient release, and helps develop a soil's slow SOM pool. Management of high-quality residues enriched in nitrogen (N), such as legume cover crops, will help ensure a supply of nutrient release from this active SOM pool. Long-term SOM management, however, should strike a balance between these high-quality residues and those that are chemically complex and thus decompose more slowly. This balance can be achieved through providing the soil with a diversity of plant residues and organic amendments such as compost and manure.

Slow SOM Pool

The slow SOM pool has a turnover time that varies from years to decades. A soil's physical condition and nutrient buffering capacity are strongly influenced by slow pool of soil organic matter. Different from the stable SOM pool, the slow pool is also a source of nutrients including nitrogen and phosphorous. It includes decomposed materials, residues and microbial products that are protected through physical (for example, interior of soil aggregates) and biochemical processes.

Passive Pool

Passive SOM pool consists of material that is hundreds to thousands of years old. Sometimes this pool is called as humus. It is a highly recalcitrant pool (resistant to decomposition) that influences the cation exchange capacity of the soil and is important in soil physical processes such as aggregation. It is not strongly influenced by recent management practices and tends to increase with increasing clay concentration in the soil.

Management of Soil Organic Matter

Management of Soil Organic Matter can be done by two general approaches (i) to building soil organic matter exist: Slow down decomposition rates (for example, by reducing tillage intensity). (ii) Enhance carbon inputs from organic materials (such as by using cover crops or compost amendments). All of the strategies designed to increase SOM fall into at least one of these categories, but ideally management plans should include both approaches.

Building the Passive SOM Pool: Producers must follow practices designed to increase SOM for years to transfer significant amounts of C (carbon) from plant litter and the active and slow pools into the stable pool. Building the slow SOM pool through appropriate management practices will gradually increase the stable organic matter pool. Adding organic materials is crucial to building the slow pool. This can be achieved through leaving crop and cover crop residues in place or by applying manure amendments. Crop residues include inputs from roots, which are crucial to enhancing the slow and stable organic matter pools. Legumes generally have large taproot systems with tissues that are slow to degrade and help build SOM. Rotation with a legume crop or pasture is highly effective at improving SOM.

Building the Active SOM Pool: High-quality residues for building the active pool are generally immature tissues with soluble, available N-enriched compounds (for example, proteins), as well as soluble carbon compounds (such as sugars). The C:N ratio is used as a measure of N-enrichment and availability. A C:N ratio below 25 promotes rapid decomposition and mineralization of N. Residues with a C:N ratio greater than 25 may require additional soil N to break down but will persist longer in the soil and contribute more to SOM pools.

An Integrated Approach to SOM Management Efforts to manage SOM to improve crop productivity and environmental quality need to focus on increasing the concentration of C in all three pools. This is the best way to achieve the short-term objectives of providing nutrients through SOM turnover and the long-term objectives of increasing nutrient and water holding capacity. One way to achieve this is through adding a diversity of inputs, including crop residues with varying chemical compositions and C:N ratios as well as compost and manure.

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Reducing the number of tillage operations or the intensity of tillage can also increase soil organic matter. Decomposition is accelerated by tillage, which brings organic materials into contact with organisms and generally improves the environment for biological activity. Reduced tillage and no-till practices reduce the amount of soil disturbance, and leave a surface cover of residues. This protects against the erosive forces of wind and water, conserving soil. Compost and slurry manures are two sources of organic amendments that have recently become widely available. Dairy compost in particular is a carbon and nutrient enriched amendment that provides both short- and long-term soil quality benefits. The combination of manure application and planting a cover crop is recommended to provide a beneficial mixture of residue qualities and maximum soil cover. The principles of SOM building are well known to reduce soil tillage and enhance organic inputs. Research has recently reinforced the value of root system residues, and of combining manure or compost with cover crop and forage rotations.

24. SOIL SCIENCE 16074

Role of NPK in Enhancing the Soil Productivity and Yield of Millets

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Productive agriculture is dependent upon sound soil nutrient management practices. Over years of intensive cultivation and imbalanced fertilizer use, Indian soils have become deficient in several nutrients among seventeen nutrients and organic matter which are essential for plants. Yields of various crops have reached a plateau and are on the decline. This is of serious consequence due to increasing population and diminishing per capita land availability. Several methods of nutrient management have been practiced on farms.

In plant tissue, the nitrogen content ranges from 1 and 6 per cent. Proper management of nitrogen is important because it is often the most limiting nutrient in crop production and easily lost from the soil system. Phosphorus is recognized as an essential nutrient element and is equally important as nitrogen which limits crop growth. Most of the applied phosphorus through fertilizers gets fixed and become unavailable to crops. The use efficiency of phosphorus is as low as 8–20 per cent which is very low as compared to all other fertilizer nutrients. The third most important element for plant growth is potassium and its content in the soil varies from low to high. It is referred to as a quality nutrient. The use efficiency of potassium varies from 20–30 per cent and is dictated by the process of erosion, leaching and fixation in the soil.

Millets: " Millets are one of the oldest foods known to humans & possibly the first cereal grain to be used for domestic purposes". Millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture. Millets are also unique due to their short growing season. They can develop from planted seeds to mature, ready to harvest plants in as little as 65 days. This is important in heavily populated areas. When properly stored, whole millets will keep for two or more years.

India is the largest producer of many kinds of millets, which are often referred as coarse cereals. However, realizing the nutrient richness of these grains they are now considered as nutria-cereals. Small millets, as a group includes several grain crops namely finger millet, kodo millet and little millet. Though they occupy relatively a lower position among feed crops in Indian agriculture, they are quite important from the point of food security at regional and farm level.

Small millets can be grown even in poor soil and climatic conditions. They have short growing season and can be very well fitted into multiple cropping systems both under irrigated as well as dry farming conditions. They can provide nutritious grain and fodder in a short span of time. Their long storability under ordinary conditions has made them "famine reserves". This aspect is very important as Indian agriculture suffers from vagaries of the monsoon. Minor millets or small millets as opposed to major millets (Maize, Jowar & Bajra) may be defined as millets cultivated for their small grains which are borne on short, slender grassy plants, in other words they refer to a group of small seeded cereal crops.

Millets Production in the World and in India

Global millet production was estimated at 27.83 million tons (FAO, 2014). India is the largest producer (41.04%) in the world followed by Niger (11.94%). In India, millets are cultivated in an area of 15.48 million hectare producing 17.2 million tonnes with a yield of 1111 kg/ha (Directorate of Economics and Statistics, 2015). Maharashtra, Rajasthan and Karnataka are the top most states of millets cultivation in India. Contribution of millets in total food grain production of India

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reduced from 22.17 % to 6.94 % over the last six decades from 1950-51 to 2011-12. In spite of all the extraordinary qualities and capacities of millet farming systems, the area under millet production has been shrinking over the last five decades and rapidly, since the Green Revolution period due to relentless promotion of other crops such as rice and wheat for intensive farming in select few resource rich areas under irrigated conditions (MINI).

Millets are Store-Houses of Nutrition

By any nutritional parameter, millets are miles ahead of rice and wheat In terms of their mineral content, compared to rice and wheat. Each one of the millets has more fiber than rice and wheat. Some as much as fifty times that of rice. Finger millet has thirty times more Calcium than rice while every other millet has at least twice the amount of Calcium compared to rice. In their Iron content, foxtail and little millet are so rich that rice is nowhere in the race. While most of us seek a micronutrient such as Beta Carotene in pharmaceutical pills and capsules, millets offer it in abundant quantities. The much privileged rice, ironically, has zero quantity of this precious micronutrient.

Research Findings

Ramachandrappa *et al.* (2014) observed that the recommended N, P_2O_5 and 150% K_2O produced higher grain and straw yields in Eastern Dry Zone of Karnataka. Potassium application @25 kg ha^{-1} was not enough for cultivating finger millet and thus needs to be increase K application to maintain the soil K reserves, since there was an apparent negative balance of K in the soil with the use of recommended K_2O. Bhanu Prasad *et al.* (2016) concluded that for higher production with good quality grain, pearl millet crop has to be supplied with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}. However, for optimum and economic production, pearl millet has to be supplied with 100 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1}.

Karanam *et al.* (2016) revealed that application of 50 kg N ha^{-1} markedly improved the growth and yield of foxtail millet, and the nutrient uptake of foxtail millet (SiA 3085) with the application of 50 kg N ha^{-1} was higher productive and it is profitable and maintains the soil health. The nitrogen and phosphorus in soil are higher in the treatment with the application of 100 % RDF in the post-harvest soil but potassium content did not differ much among the treatments.

Millets are grown on soils which typically marginal in nutrients, they are tolerance to drought and fluctuations in temperature due to their short growing season. Since, millets contain high nutrient than any other crops and respond very well to applied fertilizers, the present fertilizer application needs to be changed based on the soil nutrient status and nutrient uptake to maintain soil health and to get remunerative crop.

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25. SOIL SCIENCE 16078

Integrated Nutrient Management

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Concept of Integrated Nutrient Management

INM can be defined as efficient and judicious use of fertilizers, organic manures, crop residues and bio-fertilizers and legume in crop rotation in an integrated manner to meet the crop nutrient demand so as to get maximum economic yield without any deleterious effect on soil and environment. Integrated nutrient management (INM), comprising of application of nutrients through chemical fertilizers, organic manures, crop residues and bio-fertilizers, has been evolved as a promising alternative to mere use of chemical fertilizers, keeping in mind the economics of cultivation, soil health and environment.

Advantages of INM

- Economizing the fertilizer use
- Enhancement of nutrient use efficiency.
- Secondary and micronutrient deficiencies can be corrected.
- Improvement of soil physical, chemical and biological properties.
- Improvement in soil fertility and sustainable

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crop productivity.

Components of INM

Fertilisers, organic manures, bio-fertilizers, legumes and crop residues are the major components of INM.

Fertilizers: Role of fertilizers in integrated nutrient management is very crucial as they supply the available nutrients instantly to the crop plants. There has been a constant increase in the fertilizer consumption with increase in food grain production in India after the green revolution. Imbalance use of fertilizers (N, P and K) and ignorance to application of secondary and micronutrients coupled with cultivation of high yielding varieties led to nutrient mining. The price of fertilizers is increasing day by day due to increased cost of fossil fuels. So, the gap between the domestic nutrient supply and demand can be full filled by the application of organic manures and bio-fertilizers that are relatively cheap as compared to fertilizers.

Organic Manures: Organic manures like farmyard manure, press mud, green manures and other which contain plant nutrients in complex organic forms can be used to supplement the nutrient need of the crop. Organic manures have the potential to supply almost all the nutrients for crop growth. Though the concentration of micronutrients in organic manure is sufficient to meet the nutrient demand but the concentrations of primary nutrients are less than that of fertilizers. Organic manures play a key role in improving the physical, chemical and biological properties of soil. They also have residual effect in context of nutrients which are utilized by the subsequent crop.

Bio-Fertilizers: Bio-fertilizers are the materials containing living or latent cells of agriculturally beneficial microorganisms that play an important role in improving soil to their capability by fix atmospheric nitrogen, solubilising/mobilising phosphorus and decompose farm waste that results in the release of plant nutrients.

There are different types of biofertilizers available in the market and selection of appropriate bio-fertilizer depends upon the type of crop, soil and nutrient to be supplemented. However, their performance at a site depends on the number of microbes applied, pH of soil and other environmental factors. The genus Rhizobium, Azospirillum and Azotobacter have the capacity to fix atmospheric nitrogen. Fungal culture of Aspergillus spp. and bacterial culture of Bacillus spp. and Pseudomonas spp. secrete organic acids that convert insoluble form of phosphorus to its soluble form and hence increase its availability in soil. Fungi like vesicular arbuscular mycorrhizae helps in increasing the effective root length and there by exposing the roots to a greater soil volume for absorption of nutrients particularly phosphorus. For wetland ecosystems, blue green algae and azolla can be selected to supplement at least 25 and 30-40 kg N/ha. All these microbes have the potential to supply or make available specific nutrients and can supplement the fertilizer needs under specific conditions leading to better growth, yield and nutrient uptake by crops, reducing cost of cultivation, sustainability of the environment through recycling.

Legumes: Nitrogen fixation through Rhizobium-legume symbiosis is known from ancient times and legumes are also called as fertility restorer crops as they fix atmospheric nitrogen in conjunction with Rhizobium in the nodules. Inclusion of legumes into the cropping system not only benefits the current crop but also the subsequent crop with regard to reduction in the recommended dose of nitrogen.

Crop Residues: Crop residues are used for several purposes and their availability for supplementing the nutrient requirement of the crop is region specific. Crop like potato, sugarcane and vegetables generate sizeable amount of residues which can be used for crop production. Most often these are burnt by the farmers in order to clear the land for timely sowing of the next crop in rotation. This results in losses of nutrients and also causes pollution of environment. However, proper recycling of these crop residues can increase organic matter content leading to better physical, chemical and biological properties of soil.

Conclusion: Keeping in mind the food grain demand of ever increasing population, and the economic status of Indian farmers, INM deserves to be the best nutrient management alternative for sustainable crop production.

26. SOIL SCIENCE 16092

Biochar for Soil Fertility and Natural Carbon Sequestration

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Biochar is charcoal (similar to chars generated by forest fires) that is made for incorporation into

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soils to increase soil fertility while providing natural carbon sequestration. The incorporation of biochar into soils can preserve and enrich soils and also slow the rate at which climate change is affecting our planet. Studies on biochar, such as those cited in this Fact Sheet, are applicable to both fire science and soil science.

When plant materials- such as wood, bark, corn stalks, switchgrass, and the like, which scientists generically term biomass—are heated in a low- or no-oxygen atmosphere (this process is termed pyrolysis), the resulting product is called biochar. For example, pyrolysis of wood yields a familiar biochar: charcoal, once the staple fuel for backyard cookouts.

Carbon in the form of carbon dioxide (CO_2), which is released into the atmosphere when carbon-based fuels are burned and when biomass decays, is a major contributor to global climate change. For this reason, carbon sequestration (the process of capturing CO_2 before it escapes into the atmosphere) has the potential to slow global warming. Increasingly, scientists are looking at biochars as additives that can simultaneously enrich soil and sequester carbon that would otherwise be released into the atmosphere if biomass were simply left aboveground to decay.

Plant biomass is primarily a mixture of cellulose and lignin with small amounts of inorganic material called ash. Waste biomass such as beetle-killed trees or agricultural residues can be put to beneficial use by conversion to biochar. The pyrolysis of plant biomass to generate biochar converts much of the aliphatic carbon (which contains no carbon ring structures) to a very stable form of aromatic carbon (which contains rings made of carbon, like graphite) which is stable in soils for hundreds of years. The term biochar has been adopted to mean char produced from waste biomass for the purpose of land application.

The application of biochar to soil has been proposed as a way to store carbon in the soil for longer periods than if biomass was left to decay. Besides increasing the storage of carbon in soils, the application of biochar to soil can improve soil fertility and increase crop production. Since biochar is different from better-known, activated charcoal, information is needed on the effects of its formation conditions on both its physical and chemical properties before farmers begin to use it for large-scale incorporation into soils. One of a nation's most important assets is the fertility of its soil. The cultivation of soil causes a steady decrease in the soil's organic content and fertility. This steady decrease in fertility is compensated for by addition of fertilizers, but the decrease in organic content is a more permanent problem. Incorporation of biochar can slow or reverse this trend.

As a means of predicting biochar characteristics, the U.S. Geological Survey (USGS) made biochar by charring a variety of feed stocks including purified plant components (such as cellulose and lignin) and plant materials (such as wood, bark, and switchgrass) under a nitrogen atmosphere at temperatures ranging from 200°C to 500°C for times ranging from 1 hr to 168 hr. The USGS has obtained bulk quantities of biochar reference material from two gasification processes which produce biochar as a byproduct. The reference materials were homogenized and split to ensure uniformity. The uniformity of these materials was verified by subsampling and subsequent chemical and physical analyses. These two reference chars provide a consistent material to the scientific research community for comparison of analytical techniques between laboratories or as a basis for comparison of characteristics of one type of char to another. The two main families of carbon compounds are aliphatic and aromatic. Comparison of mass loss, combined with 13C NMR spectroscopy, showed that the initial rapid loss of material during pyrolysis is due to the loss of aliphatic components, which are either vaporized or converted to aromatic carbon early in the charring process. Aromatic carbon is a more stable form than aliphatic carbon.

The biochars were also analyzed for acid functional group content. Acid functional groups are related to cation-exchange capacity, which is important to soil fertility, as it assists in the retention of nutrients (nitrogen and phosphorus) and cations (like potassium) in soil. In the USGS experiments, the highest concentrations of acid functional groups developed at low charring temperatures (250°C) and long charring times (greater than 72 hr). Cellulose appears to be the primary source of the acid functional groups in the biochar. Surface area and porosity of the biochar plays a significant role in soil fertility. In contrast to the optimum conditions for the formation of the acid functional groups, more

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intense charring conditions (higher temperatures and longer charring times) were required for the formation of porosity and surface area in the biochar.

The effect of formation conditions and feedstock on physical and chemical characteristics of the resultant char will be important if biochar is to be successfully incorporated into agricultural soils. Using this information provided by USGS, formation conditions and feedstocks may be tailored to optimize desirable characteristics (such as acid functional group content) and to minimize less-desirable characteristics (such as degradability or mass loss). The results generated by USGS provide insight into optimum formation conditions for chars with the best properties to simultaneously enhance soil fertility and provide long-term carbon sequestration.

Source: U.S. Geological Survey

27. SOIL SCIENCE 16119

Sewage Sludge: A Biological Resource for Sustainable Agriculture and Environment

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INTRODUCTION: Sewage sludge consists of by-products of wastewater treatment. It is a mixture of water, inorganic and organic materials removed from wastewater coming from various sources like domestic sewage, industries, storm water runoff from roads and other paved area, through physical, biological, and/or chemical treatments. Sewage sludge is also referred to as biosolids. Biosolids are nutrients rich organic materials resulting from the treatment of domestic sewage in a treatment facility. Some regards biosolids as stabilized organic solids derived from biological wastewater treatment process, which can be managed safely to utilize their nutrients on sustainable basis and used for soil conditioning, energy, or other value. The utilization of biosolids/sewage sludge in agriculture is gaining popularity as a source of waste disposal. Biosolids/sewage sludge generally contains useful compounds of potential environmental value. They also contain useful concentration of organic matter, nitrogen, phosphorus and potassium and to a lesser extent, calcium, sulphur and magnesium. Untreated liquid sludge and dewatered treated sludge release nitrogen slowly with benefits to crop. Anaerobically digested sludge has high contents of ammonia, which is readily available to plants. Thus it is a nutrient enriched fertilizer. The organic matter content in sludge can improve soil physical, chemical and biological properties with ensuring better cultivation. There is an interesting trend in the agricultural application of sewage sludge obtained from wastewater treatment plant due to the possibility of recycling of valuable components: organic matter, N, P and other plant nutrients. Assessment of sewage sludge is very important prior to sludge application to farm land because there is a risk of toxic elements accumulation in soil. Moreover, there is potential health hazard due to pathogens in the sewage sludge.

The issue of micro-nutrient and heavy metal concentration in sewage sludge needs careful attention for its use in agriculture. If the concentration of heavy metals is high in the sewage sludge then its continuous use year after year may result in toxic accumulation of heavy metals in the soil, which may have phytotoxic effects on various cereals, vegetables, fruits, pastures and fodder crops. Consumption of these commodities by human beings and animals can cause health hazards to them. It is, therefore, essential to determine the heavy metal content of sewage sludge before its recommendation for use in agriculture.

Effect on Soil Quality and Fertility: For maintaining soil quality and soil fertility microbial activities have vital role. Sewage sludge has the potential to enhance soil productivity because it contains high organic matter and plant nutrients. Because of heavy metals and toxic organic compounds sewage sludge can pose a serious threat to human health and ecosystem. There is limited information as how sewage sludge application can influence soil microbial and biochemical characteristics with respect to maintaining soil quality. Sludge application increased activities of important soil enzyme (arylsulfatase, acid phosphatase, and alkaline phosphatase). Phosphorus and nitrogen are released more slowly through degradation of organic matter than in case of inorganic fertilizers and, therefore, the compounds are available for longer period. Organic matters in the sludge mainly consist of soluble matter with a small amount of lignin and cellulose that contribute to its composition. That is why the organic matter within the sludge has the potential to mineralize

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relatively quickly. This potential rapid degradation could lead to a peak in nitrate and phosphorus levels within the soil.

Effect on Soil Microbial Properties: In general, addition of organic manure in the form of sewage sludge will increase soil microbial activities, their population and microbial biomass. Consequently, the soil life goes through a considerable changing. Application of sludge containing low concentration of heavy metals improved soil microbial activities. However, elevated metal concentrations have been shown to reduce soil microbial biomass levels, inhibit nitrogen fixation by both free living and symbiotic micro-organisms and reduce enzyme activities. Ultimately the microbial population/biomass will increase and their activities will enhance. High levels of sludge application (200 t ha^{-1}) significantly reduced the functional diversity of soil community but overall size of the soil microbial biomass and its inherent mineralization potential were either unchanged or increased.

Effect on Soil Physical Properties: Sewage sludge is a rich source of organic matter. Organic content of sludge in urban sewage is generally high, usually more than 50% of dry matter. Addition of organic matter in the form of sewage sludge will have profound effect on soil physical properties and positive soil conditioning effect on most soils. The improved aeration and drainage following sludge amendments can have indirect effects on soil-plant relationships of heavy metals through affecting growth. Effects of sewage sludge/biosolids on soil physical properties such as increased soil aggregate formation and stability may be greater than for animal manures due to stability of organic compounds in biosolids. Improved water infiltration is important especially on upland areas where the top soil is shallow and low in organic matter due to soil removal by erosion and grading in terrace formation. Increasing rate of sewage sludge for growing wheat decreased the bulk density and increased total porosity. In several other studies on agricultural use of amendments consistently showed decrease in the bulk density and penetration resistance with increasing rates of amendment.

Effect of on Soil Chemical Properties: Characteristics Addition of sewage sludge to an agricultural soil will increase organic matter content in the soil, which leads to production of humic and carbonic acids. These acids in calcareous soils will lower the soil pH. Humic substances have high cation exchange sites. Thus addition of sewage sludge to soil with low cation exchange capacity over period will increase organic matter, which ultimately increases the cation exchange capacity of the soil. Moreover, there is high percentage of nitrogen content bound by humic like substances in sewage sludge and compost which is one of the main criterions of usefulness of sewage sludge compost for agricultural purposes. A better overall decomposition process of sewage sludge is possible through better accessibility of the substrate component for microbiological conversion and application of new types of microorganisms, such as hyperthermophilic microorganisms or genetically modified microorganisms which may be an interesting research for the treatment of sewage sludge in the future. Sewage sludge decomposition is essential because noncomposted or immature compost applied to agricultural soils may cause phytotoxicity to plants, nitrogen and oxygen deficiency and adversely affect the environment.

Conclusion: Sewage sludge is very important biological organic fertilizer/soil conditioner for sustainable agriculture. It improves organic matter status of the soil. It also adds macro and micronutrients to the soil. Improvement in organic matter content in soil helps in improving soil physical conditions, rejuvenating soil health and stimulating biological activity. Higher level of soil organic matter can sequester carbon and mitigate greenhouse gas emissions. Therefore, use of sewage sludge in agriculture will be appropriate and beneficial, if applied according to appropriate guidelines to minimize environmental and ecological damage and maximize potential benefits for sustained agricultural productivity. However, sewage sludge prior to use in agriculture must be subjected to evaluation tests for determining the basic physicochemical properties, content of pollutants or pathogenic bacteria, and also ecotoxicological properties in order to avoid the risk of potential threats for the environment and for human health.

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28. SOIL SCIENCE 16193

Radioactive Waste: Characteristics, Impact on Environment and Management

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INTRODUCTION: Radioactivity is a process by which unstable atomic nucleus losses energy by emitting ionic particles or electromagnetic rays. The different kinds of radiation associated with radioactivity are: 1. Alpha radiation 2. Beta radiation 3. Gama radiation and conversion electrons

A material that spontaneously emits such radiation is considered **radioactive**.

Characteristic of Radioactive Material

- Emission of radioactive substance from radioactive material is independent of external factors such as pressure, temperature, state of substance, electrical field, magnetic field, catalyst etc.
- A radioactive element emits β and γ radiations.
- Due to the emission of an particle, atomic number decreases by 2 units and mass number decreases by 4 units.
- Due to the emission of β particle, atomic number increases by 1 unit but the mass number remains the same.
- A radioactive element does not emit and β particles simultaneously.
- The original radioactive nucleus or element is called a parent element and the new element formed is known as daughter element.
- The physical and chemical properties of daughter element are different than that of the parent element.

Sources of Radioactive Material

1. Uranium (U) **2.** Plutonium (Pu) 3. Tritium (T) and 4. Thorium (Th).

How Energy is released from Radioactive Material…..???

When the nucleus of U-235 atom captures a moving neutron it splits in two (fissions) and releases some energy in the form of heat, also two or three additional neutrons are thrown off. If enough of these expelled neutrons cause the nuclei of other U-235 atoms to split, releasing further neutrons, a fission 'chain reaction' can be achieved. When this happens over and over again, many millions of times, a very large amount of heat is produced from a relatively small amount of uranium. It is this process, in effect "burning" uranium, which occurs in a nuclear reactor. The heat is used to make steam to produce electricity.

TABLE 1: Electricity generation from radioactive source

Country	Electricity Generaton (%)
France	75
Sweden	47
The Republic of Korea	42.24
Japan	34.65
Germany	31.21
UK	28.87
USA	19.80
Russia	14.41
Canada	12.44
India	2.65

Radioactive Waste

Radioactive waste is usually a by-product of nuclear power generation and other applications of nuclear fission or nuclear technology, such as research and medicine. According to the Environmental Protection Agency (EPA) the radioactive atom Uranium 235 has a half-life of 703.8 million years. This means that the element will remain hazardous until it is fully disintegrated.

Sources of Radioactive Waste

1. Nuclear fuel cycle: Front end: Contains alpha-emitting waste from the extraction of uranium. It often contains radium and its decay products.

Back end: Mostly spent fuel rods, contains fission products that emit beta and gamma radiation, and actinides that emit alpha particles.

Example: Asuranium-234, Neptunium-237, Plutonium-238

2. Nuclear weapons decommissioning Waste from nuclear weapons decommissioning is more likely to contain alpha-emitting actinides such as Pu-239 which is a fissile material used in bombs, plus some material with much higher specific activities, such as Pu-238 or Po.

3. Legacy waste: Due to historic activities typically related to radium industry, uranium mining, and military programs, there are numerous sites that contain or are contaminated with radioactivity.

4. Industrial source waste: can contain alpha,

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beta, neutron or gamma emitters. Gamma emitters are used in radiography while neutron emitting sources are used in oil well logging.

5. Coal: contains a small amount of radioactive uranium, barium, thorium and potassium.

6. Medical: Radioactive medical waste tends to contain beta particle and gamma ray emitters. In diagnostic nuclear medicine a number of short-lived gamma emitters such as Technetium-99 m are used.

7. Oil and gas industry: Residues from the oil and gas industry often contain radium and its decay products. The sulfate scale from an oil well can be very radium rich, while the water, oil and gas from a well often contain radon.

How Much Waste is Produced ????

Every year, nuclear power generation facilities worldwide produce about 200,000 m^3 of low- and intermediate-level radioactive waste, and about 10,000 m^3 / 12,000 tonnes of high-level waste including used fuel designated as waste.

Harmful Effects of Radioactive Waste

Cohen (2001) reported that hazardous waste stunts plant growth. In addition, the elimination of plant life reduces the natural food supply for animals. Thus, hazardous waste exposure can potentially destroy an entire ecosystem. Waste in landfills emits gases that are both foul-smelling and toxic. It produces a liquid known as leachate, which can percolate to water supplies such as rivers, lakes and the ocean.

Health Risk

- Somatic effects (effect is primarily suffered by the individual exposed example: cancer)
- Genetics effects (effect is suffered by the offspring of the individual exposed)
- Teratogenic effects (birth defects, parental death)

Biological Effects of Radiation

Biological response to high dose of radiation,

- < 5 rad: no immediate observable effects
- 5 rad to 50 rad: slight blood changes may be detected by medical evaluations
- 50 rad to 150 rad: blood changes will be noted and symptoms of nausea, fatigue etc.
- 150 rad to 1,100 rad: severe blood changes will be noted and symptoms appear immediately

Environmental Effects

Chernobyl catastrophe (now called "red forest"): radioactive particles settled on trees, killing areas of forest. The radiation spewed into the air from hundreds of atmospheric tests, leaving plutonium and other deadly contaminants in the bones and bodies of all living. The elements that make up nuclear waste often have long half-lives, which mean that it may take millions or billions of years before the waste is safe for humans to be around.

Basic Steps in Radioactive Waste Management

a) **Pretreatment:** It consists of collection, segregation, adjustment and decontamination.
b) **Treatment:** involves changing the characteristics of the waste.
c) **Conditioning:** transform radioactive waste into a form suitable for handling, transportation, storage and disposal.
d) **Storage:** facilities may be co-located with a nuclear power plant or a licensed disposal facility.
e) **Retrieval:** involves the recovery of waste packages from storage.
f) **Disposal:** consists of the authorized emplacement of packages of radioactive waste in a disposal facility.

Conclusion: Nuclear waste requires sophisticated treatment and management to successfully isolate it from interacting with the biosphere. This usually necessitates treatment, followed by long term management strategy involving storage, disposal or transformation of nuclear waste into non-toxic form.

29. HORTICULTURE 15723

Canthium parviflorum: An Under Exploited Carotene Rich Fruit

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Forest as a potential source of variety of vitamin-A rich foods is not yet fully realized as they are neither cultivated nor marketed. Tribals who inhabit forest clad mountains exploit who inhabit forest clad mountains exploit natural plants for their existence. Some of which may be unconventional and exceptionally rich in beta carotene. Among 23 forest fruits analysed in

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South India *Canthium parviflorum* was found to be the richest source of beta carotene.

Fruiting of *Canthium parviflorum*

Canthium parviflorum is a throny spinous shrub or small tree belongs to family Rubiaceae. A gregarious rigid shrub with 2-5cm long, stout, straight spines is suitable for hedges. It is distributed throughout India in forests and dry plains chiefly western part of the Indian peninsula from Gujarat and Maharastra Southwards, and in Bihar and Orissa ascending up to 1500m. Leaves usually crowded on shortened lateral shoots, 1.5-2.5 cm long, ovate, orbiscular or obvate. Flowers very small, 0.8-1.5cm, white or pale yellow in cymes. Fruit about 1.5cm in diameter, oblong ellipsoid or compressed drupes, yellow in colour when ripe, two seeded.

Decoction of leaves and roots are prescribed in certain stages of flux. Powdered leaves considered useful for diphtheria. Bark and young branches are used in dysentery in Indo-china. It is also described as common emetic nut. The roots and leaves are astringent, sweet, thermogenic, diuretic, febrifuge, anthelmintc and tonic. They are useful in vitiated conditions of kapha, diarrhea, strangury, leuorrhoea, intestinal worms and general debility. Fruit pulp astringent, cholagogue, strenhthening and an expellant of phlegm and bile.

Carotene value of the fruit (per 100g edible portion): Carotenoid content (mg%) 9.51, beta carotene content (mg%) 6.10, retinal equivalents (mg%) 1.02.

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30. HORTICULTURE 15995

Female Fruit Fly Traps in Mango and Guava

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Fruit fly monitoring programs are vital to protect Indian horticultural industries from fruit fly's incursions and to maintain market access for producers within Pest Free Areas of production. Traps containing lures specific to male fruit flies generally predominate in these programs due to the impracticality of existing female fruit fly lures. However, the supplementary use of female fruit fly lures in monitoring programs could greatly improve the chances of detecting an incursion. In mango and guava are two important fruit crops which are severely damaged by fruit flies. Most common species attacking these two fruits are *Bactrocera dorsalis* Hendel, *B. correcta* Bezzi and *B. zonata*. Female fruit flies are the dominant factor for multiplication of the pest. Female fruit fly attractive baits are needed in any applicative system against this pest for monitoring and direct control. They need protein source to mature sexually and also for the development of their eggs. Exploiting this need, female targeted system normally consists of traps baited with a liquid solution made from protein and fermenting sugar. Increasing knowledge on behaviour associated with attraction of both sexually immature females and egg laying females would improve detection

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and delimitation of fruit flies and provide increased protection of crops adversely affected by their presence.

Selecting a suitable oviposition site is crucial to the fitness of female insects because it determines the successful development of their offspring. During the oviposition process, an insect must use cues from the external environment to make an appropriate choice of where to lay eggs. Generalist insects can detect and react to a plethora of cues, but are under selection pressure to adopt the most reliable ones to override noise and increase efficiency in finding hosts. The oriental fruit fly, *Bactrocera dorsalis* (Hendel), is a generalist that utilizes a multitude of fruits as oviposition sites. Recently, it was identified that, a volatile compound γ-octalactone that elicits an innate oviposition response in *B. dorsalis*. Flies deposited most of their eggs into pulp discs with oviposition-stimulants, in the presence of a volatile compound γ-octalactone only. It was suggest that the identified oviposition-stimulants are 'key' compounds, which the flies associate with suitable oviposition sites (Pagadala *et al.,* 2014) and it provides empirical data on a cue underpinning innate behavior and may also find use in control operations against this invasive horticultural pest (Pagadala Damodaram *et al.,* 2014).

Ravikumar and Viraktamath (2007) studies suggested that the food bait containing proteinex and 5 per cent ammonium acetate attracted more *Bactrocera spp* the total fruit flies (16.84 fruit flies trap^{-1} week^{-1}) in guava. While in mango, fruit fly diet and mango pulp combined with 5 per cent ammonium acetate was attracted to *B. dorsalis* 10.63 total fruit flies trap^{-1} week^{-1}. From this it was suggested that the female fruit flies can be controlled by food based baits Ex. guava pulp with ammonium acetate (1:1) in guava, and casein with ammonium acetate, mango pulp and proteinex with 5 per cent ammonium acetate (1:1:1) were best for fruit fly control without any chemical insecticides. Bio-Trap is an attractant for Queensland and Mediterranean fruit flies by through research collaboration has developed a female biased attractant Gel which is a non-hazardous, safe to handle gel designed to be used in conjunction with the V1 trap. The Gel attracts both male and female fruit flies of various species with a bias towards the female flies (www.biotrap.com.au).

31. HORTICULTURE 15996

An Overview of Arecanut (*Areca catechu*) Cultivation

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Arecanut palm is cultivated primarily for its kernel obtained from the fruit which is chewed in its tender, ripe or processed form. Though it is native of Malayan Archipelago, Philippines and other East Indian Islands, Commercial cultivation is confined only in India, Bangladesh and Sri Lanka. India has about 2, 00,000 ha under this crop with an annual production of 2, 28, 600 tonnes. Kerala, Karnataka and Assam account for more than 90 per cent of the total area and production in our country.

Botany: It is a monoecious palm and its inflorescence is a spadix produced in the leaf axil and is completely enclosed in a sealed boat shaped spathe. The spadix is having a main rachis divided subsequently into secondary and tertiary rachis. Female flowers are confined to tertiary and distal end of the secondary rachis, while male flowers are produced on filiform branches arising below and beyond the female flowers. Both female and male flowers are sessile, with two whorls of perianth. The fruit is a monolocular, one seeded berry and it consists of a fibrous outer husk, enclosing a single seed. It is a cross pollinated crop and fruit set normally varies from 12.0 to 40.0 percent and the time taken from full bloom to maturity of the fruit ranges from 35 to 47 weeks.

Climate and Soil: The arecanut palm is capable of growing under a variety of climatic and soil conditions. It grows well from almost sea level up to an altitude of 1000 metres in areas receiving abundant and well distributed rainfall or under irrigated conditions. It is grown in soils such as laterite, red loam and alluvial soils. The soil should be deep and well drained.

Varieties: There are few local varieties known by the name of the place where they are grown and are Thirthahalli, South Kanara, Mettupalayam, Mohitnagar. Regional Station, Vittal has released three improved cultivars, they are:

Mangala: An introduction from China early bearing, higher fruit set, higher yield, semi tall variety.

Subamangala: A selection from Indonesia, yield 17.5 kg of nuts/palm at the age of 10 years. Sreemangala: A selection from Singapore yields 16.5 kg/palm at the 10th year.

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SAS-1: Sirsi Arecanut Slection, resealed from UAS, Dharwad.

Planting: The planting is done during May-June with the onset of monsoon. Arecanut palms need adequate protection from exposure to the South Western sun as they are susceptible to sun-scorch. In the square system of planting at a spacing of 2.7m×2.7m, the North South line should be deflected at an angle of 35 degree towards went. Pits of 90 X 90 X 90cm are dug and the pits are filled with a mixture of top soil, powdered cow dung and sand to a height of 50 to 60 cm from the bottom. The seedlings are planted in the centre of the pit, covered with soil to the collar level and pressed around. A shade of banana can be raised to give protection to the seedlings from sun scorch.

Manuring and Fertilization: An annual application of 100: 40: 140 g of NPK per tree in the form of fertilizers and 12 kg each of green leaf and compost or cattle manure per bearing palm is recommended. Under rainfed conditions, half the quantity of fertilizers may be applied in April-May and the remaining quantity in September-October. Under irrigated condition, the first dose of fertilizer is applied only in February. Green leaf and compost can be applied in single dose in September-October. The first dose of fertilizers may be broadcast around the base of each plant after weeding and mixed with the soil by light forking, while the second dose is done in basins around the palm dug to a depth of 15 to 20 cm and at 0.75 to 1m radius.

Irrigation Mangement: The palms should be irrigated once in four to seven days depending on the soil type and climatic factors. Drainage channels should be 25 to 30 cm deeper than the bottom of the pits to drain excess water from the plot.

Harvesting and Processing: The stage of harvesting depends on the type of produce to be prepared for the market.

Dried ripe nuts/Chali/Kottapak: The most popular trade type of arecanut is the dried, whole nut known as chali or kottapak.

Kalipak: Another form of processing is by making kalipak. The nuts of 6 to 7 months maturity with dark green colour are dehusked, cut into pieces and boiled with water of dilute extract from previous boiling; a kalli coating is given and dried finally.

Scented suparis: There are many varieties of scented suparis. Dried arecanuts broken into bits, blended with flavour mixture and packed. Formerly the bits were roasted in ghee or oil, but it is almost fully given up nowadays, owing to development of rancidity. Additives like colour and flavour are added.

Yield: More than 10 kg of ripe nuts per palm at the 10th year is considered as normal yield in any plantation.

Pest Management

- **Mites (*Raoiella indica*):** Adults and young ones suck the lower surfaces of the leaves, causing them to turn yellow and bronzed appearance. The mites can be controlled by spraying with dimethoate or Dicofol at 0.05 per cent.
- **Spindle bug (*Carvalhoia arecae*):** The feeding injury is caused on the lamina and petiole. The affected leaves show dry brown patches. Spray crowns with carbaryl 50 WP.
- **Root grub (*Leucopholis burmeisteri*):** Loosen soil around the base of palms to a depth of 10-15 cm and drench with Chlorpyrifos 0.04% suspension twice, one in May just before the onset of southwest monsoon and again in September-October towards the close of the monsoon.

Disease Management

- **Koleroga (*Phytophthora arecae*):** Water soaked lesions appearing on the nut surface near the perianth and spread over the other parts. Spray Bordeaux mixture 1% on all bunches three times in a year, one just before the onset of southwest monsoon and the rest at 40 days intervals.
- **Bud rot (*Phytophthora palmivora*):** Affected spindle appear yellow, later changing to brown and finally the whole spindle rots. In early stages of infection, scoop out affected rotten tissues by making longitudinal side splits and apply Bordeaux paste on the exposed healthy tissues or drench crown with 1% Bordeaux mixture.
- **Basal stem rot (Anabe roga) (*Ganoderma lucidum*):** Small brown irregular patches appear on the stem and a brownish exudates oozes out from these patches. Isolate affected palms by digging trenches 60 cm deep and 30 cm wide around, one metre away from the base and drench with Captan (0.3%), Calixin (0.1%) or Copper oxychloride (0.3%).
- **Yellow leaf disease:** Leaves become yellow, smaller, stiff and pointed, crown gets reduced, and palm remains stunted with few or no nuts. Maintain the garden properly to keep affected palms in a healthy condition by adopting recommended manurial, cultural, plant protection and other management practices. Improve drainage conditions in the garden.

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32. HORTICULTURE 16012

Role of Rootstock in Fruit Production

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Rootstock is a plant part which gives rise to root system on which a bud or shoot is set. The term stock as frequently used as synonymous with rootstock. The rootstocks have most prominent effect of growth, productivity and fruit quality on one hand and influence the susceptibility of the trees to serious insects and diseases on the other hand.

Studies have been reported in tropical, subtropical and temperate fruits like mango, Citrus, sapota grapes, guava, apple etc.

Diversification is occurring where tristeza restricts or threatens the use of sour orange because no one rootstock can adequately replace it. The only exception has been Rangpur lime in Brazil; but even within this 600,000 ha industry, disease is once again stimulating an interest in other rootstocks.

Carrizo and Troyer citrange and Swingle citrumelo have attracted universal interest as promising rootstocks to replace sour orange. In the United States, Corsica, and Spain, the citranges are commercially prominent, while in other areas these three rootstocks are only experimental.

Trees on the citranges and Swingle citrumelo are more vigorous and productive than those on their common parent. Trifoliate orange, probably the second most important rootstock worldwide, in addition to being a major stock for the mandarin industries of Japan and China, trifoliate orange is also used in Uruguay, Australia, Argentina, New Zealand, and several Mediterranean countries because of its adaptation to heavy soils and Phytophthora resistance. Trees on citrange and citrumelo rootstocks may prove to be satisfactory under similar conditions; thus their greater yield potential may result in new plantings on these stocks rather than on trifoliate orange.

Importance of Rootstocks in Fruit Breeding

- Impart resistance to biotic and abiotic stresses of scion cultivar
- Resistant to adverse soil and climate conditions
- Cold hardiness
- Provide strong root system
- Regulate uptake of moisture and nutrients
- Regulate tree vigour and size
- Dwarfing effect
- Affect flowering, fruit set, fruit drop, fruit size
- Affect fruit quality and yield
- Trees propagated on rootstocks are true to type, comes to bear earlier, precocious.
- Affect composition of fruit crops
- Affect storage life and preservation properties of fruits crops

Problems

- Graft incompatibility
- Difference in the performance according to region, pests, diseases,
- Abiotic conditions and other characters
- less options of superior rootstocks
- Reproduction by sexual method
- Knowledge of characteristics of rootstocks

Important Rootstocks Used in Fruit Crops (India)

Sr. No.	Fruit	Rootstocks	Remarks
1.	Apple	M7, MM106	Resistant Wooly Apple aphid (WAA)
		M116, M793	Resistant to WAA and collar rot
		M111	Drought tolerant and resistant to WAA
		M9	Dwarf, Resistant wooly aphid, Resistance to phytophthora root rot (crown rot) Susceptible to fire blight
		M27	Ultra dwarf, Resistant to fire blight, used as an intermediate stem piece on MM.106 or MM.111
		M7	Stronger, deeper root system, precocious, tolerant to excessive soil moisture, susceptible to crown gall.
		North spy	Woolly aphid resistant and used as source of resistance for this pest.
2.	Ber	*Zizipus nummularia*	Drought tolerance
		Z. lotus	Drought tolerance
		Z. rotundifolia	Deep rooted suited for and
3.	Citrus	Rangpur lime (C. limonia *Osbeck*)	Plant growth yield and quality Resistant to

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Sr. No.	Fruit	Rootstocks	Remarks
			tristeza, salt tolerance, drought prone moderately tolerant to root knot nematode and exocortis; suitable for heavy and deep soils. Free from granulation
		Citrange (Sweet orange x Trifoliate orange) Cleopatra and Jatti Khatti.	Salt sensitive, tolerant to tristeza from tolerant
		Rough lemon syn. Jamberi, Jatti Khatti	Tolerant to virus diseases, tristeza, xylopsorosis and exocortis but susceptible to gummosis, deep rooted
		flying Dragon	Most dwarfing, highly resistant to Phytophthora and citrus nematode
		Rangpur lime	Tolerant to tristeza, suitable for heavy, deep and high pH soils, susceptible to foot rot, exocortis and burrowing nematode.
		Troyer citrange	Tolerant to foot rot, tristeza
4.	Custard apple	Pond apple (Annona glabra)	Suitable for various soil conditions
5.	Fig	Ficus glomerata	Nematode resistant
6.	Grape	Salt Creek	Salt and nematode resistant
		Temple	Pierce's disease resistant
		Dogridge {*Vitis champinii)*	Tolerant to nematode, drought and salinity
		Dogridge {*Vitis champinii)*	Tolerant to nematode, drought and salinity
		110R	*(V. berlandieri* x *V. rupestris)*- Drought and salinity tolerance
		St. George *(V. nipestris)*	Moderate drought tolerance
		St. George, Riparia and Gloria	Phylloxera resistant
7.	Guava	Chinese guava	Resistant to wilt diseases and nematodes
		Psidium friendrichshalianum	Dwarfing and Wilt resistant.
		Pusa Srijan (Aneuploid 82)	Wilt tolerance under field conditions
		P. pumilum	Dwarfing
8.	Jamun	Syzigium fruticosum	Termite resistant
9.	Mango	Olour, Villai Collumban	Dwarfing
		Kuru kkan	Polyembryonic, salt tolerance, dwarfing
		Nekkare	Salt tolerant
10.	Sapota	Khirni (Manilkara hexandra)	Commercially used
		Chrysophyllum lanceolatum	New rootstock (Kalesh et al., 2005). Found suitable in Kerala conditions.

33. HORTICULTURE 16025

Hydroponics: A Novel Technique of Soilless Culture in Vegetable Production

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INTRODUCTION: Soilless culture is an artificial means of providing plants with support and a reservoir for nutrients and water with equal or sometimes better growth and yield results compared to field soil. It did not reach India until 1946. The first research studies were started at the Government of Bengal's Experimental Farm at Kalimpong in the Darjeeling district. Soilless culture can be defined as "any method of growing plants without the use of soil as a rooting medium, in which the inorganic nutrients absorbed by the roots are supplied via the irrigation water".

The term Hydroponics was derived from the Greek words *hydro'* means water and *ponos'* means labour. It is a method of growing plants using mineral nutrient solutions, without soil.

Hydroponics along with organics is widely used technique for production perishable vegetables as present day consumers mostly prefer healthy and safer food. Hydroponics is the option for perishable vegetable production in urban and semi urban areas where the land

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resources are very near to the ground to fulfil consumer diet. As population increases and arable land declines due to poor land management, people will turn to new technologies like hydroponics to create additional channels of crop production. The several areas of wastelands having poor quality soil but plenty of water can be brought under hydroponics. The present day supermarkets mostly the place for hydroponic lettuces and herbs and many small growers are producing small quantities for local sales.

Advantages

The hydroponics method is mostly contributing to improve crop yield. It is only option in places ordinary agriculture is impossible.

- Quality and vigour of produce increased with hydroponics
- Soil preparation and weeding is reduced or eliminated.
- All the nutrients and water that the plants need are available at all times.
- Water is used efficiently.

Disadvantages

- Hydroponic production is management, capital and labour intensive.
- A high level of expertise is required.
- Specially formulated, soluble nutrients must always be used.

Selection of Suitable Vegetable Crops

The popular crops grown in hydroponic were especially all high value crops like tomatoes, cucumber and pepper in drain to waste systems and lettuce and herbs in gravel flow system. The choice mostly depends on family of crop and type of unit. The most important consideration is the market and climate.

There are many vegetable varieties available. Some were developed specifically for commercial hydroponic production in greenhouses. Local seed companies are able to recommend varieties that are widely adapted and easy to grow.

Maintenance of Hydroponic System

In hydroponics' the plant roots grown under supplementation of nutrient solution along with frequent irrigation or directly in nutrient solution. The irrigation applied using special devices having different wetting patterns and flow rates. The application frequency of irrigation must ensure proper wetting of nutrient medium to distribute nutrient solution uniformly.

In hydroponic system growth medium is substitute for soil. Purpose of medium is to supply 02, water and nutrients. The medium used is varies with type of hydroponic. In re-circulating system gravel is popular to provide the roots with 02. Saw dust is most popular for the open bag/drain to waste system. Mixtures of spaghnum peat and horticultural vermiculite have all of the required characteristics to make an excellent growing medium. The proper perlite mixtures are available, or growers can prepare their own supply from the basic components. Barks from pine, fir, cypress, and redwood have been used successfully as a growing medium for greenhouse cucumbers and tomatoes.

FIGURE 1: Hydroponic production of Lettuce and Cabbage

Hydroponic fertilizer formulations contain a balanced soluble nutrient content. All the nutrients plants need are dissolved in water and they are supplied to plants every day. Macro elements (N; P; K; S; Ca) are needed in substantial amounts, whereas plants need very small amounts of micro elements (Fe; Zn; Mn; Mg; Cu; Co, Mg). It is necessary to use specially formulated fertilizers. Fertilizers used for hydroponics are more pure (and expensive) than other fertilizers to prevent precipitation and blockages of the system. Nutrient solutions can also be prepared by the grower using readily available soluble salts. The constantly changing nutrient status in solution will be analyzed to avoid deficiencies and excess of elements in hydroponic system. Desirable level of nutrients has been reported for tomatoes, cucumbers, and a wide range of vegetables.

In India, hydroponic vegetable production is almost always done under protection. Well constructed greenhouses can keep out large insect pests and diseases. Pathogen spores and small

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insects cannot be kept out.

Future Scope: Hydroponics is the fastest growing sector of agriculture, and it could very well dominate food production in the future. There has been wide potential to use hydroponics in regions where water supplies are limited. This technique produces a yield 1,000 times greater than the same sized area of land could produce annually. Hydroponics has the ability to feed millions in areas of Africa and Asia, where both water and crops are scarce. NASA has extensive hydroponics research plans in place, which will benefit current space exploration. This is important for long-range habitation of both the space stations and other planets.

Conclusion: In the country like India, there is no option but adopting soil-less culture to help improve the yield and quality of the produce so that we can ensure food security of our country. However, Government intervention and Research Institute interest can propel the use of this technology.

34. HORTICULTURE 16068

Quality of Ginger: The Essential Oil and Oleoresin

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Flavours and fragrance played an important role in Indian culture since antient times. These come naturally from many plants and animals sources. Generally these flavours and fragrance have sweet smell that are known as aroma and those plants bear this aroma are known as aromatic plants. These aromas come from certain odoriferous substances known as essential oils. These essential oils are present in the specific cells called as glandular cells present in the plant part that may be anywhere on plant body. Upon rupture of these glands aroma come out which are volatile in nature and combination of all chemical constituents are fragrance.

The term essential oil is concomitant to fragrance or perfumes because these fragrance are oily in nature and they represent the essence or the active constituents of the plants. They are called volatile or ethereal oils as they evaporate when exposed to air at ordinary temperature. Essential oils are highly concentrated, low volume, high value products.

Harvesting and Curing

The crop is ready for harvest in about 7 to 8 months after planting when the leaves turn yellow, and start drying up gradually. The clumps are lifted carefully with a spade or digging fork, and the rhizomes are separated from the dried up leaves, roots and adhering soil. The rhizomes are thoroughly washed in water and sun-dried for a day.

Extraction of Oil

The oil is extracted by steam distillation from the unpeeled or dried rhizomes of the plant, and can yield about 1-2.7% oil. The appearance varies from pale yellow to dark amber color. Natural oil of fresh (green) rhizomes varies from that of dried rhizomes in composition and aroma. Chief constituent of ginger oil from dried ginger is zingiberine (38.6%), a sesquiterpene hydrocarbon. Essential oil profile of ginger from various producing countries as well established and studies revealed that there exist variation in constituents with change in geographical region, variety, climatic conditions and processing methods adopted.

Chemical Constituents

The essential oil contains mostly sesquiterpenes, eg. Zingiberene. The major pungent compounds in ginger, from studies of the lipophilic rhizome extracts, have yielded potentially active gingerols, which can be converted to shogaols, zingerone and paradol. In immature rhizomes, about 5 to 7 months after planting, fiber content is negligible and pungency is mild. At about 9 months after planting, volatile and pungent principles reach a maximum and thereafter their relative abundance fall as fiber content continues to increase. Drying of ginger usually leads to loss, by evaporation, of a few volatile oil (up to 20% during sun drying) and volatile oil content of commercial dried ginger is reported to be 1 to 3%.

Medicinal Uses: The ginger oils are used as an analgesis, anti-emetic, antiseptic, antispasmodic, bactericidal, carminative, cephalic, expectorant, febrifuge, laxative, rubefacient, stimulant, stomachic, sudoriphic and tonic. Ginger oil is also used in the treatment of fractures, rheumatism, arthritis, bruising, carbuncles, nausea, hangovers, travel and sea sickness, cold and flu, catarrh, congestion, coughs, sinusitis, sore throat, diarrhea, colic, cramps, chills and fever.

Cosmetic Uses: Ginger oil is used as a fragrance component in cosmetic products, including soaps, detergents, creams, lotions and perfumes. The oil is more use in perfumes. Ginger is added as an ingredient to more commercial skin

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care products to improve the healthy skin. Ginger can also improve the appearance of many scars. Ginger is detoxifying and it boosts immunity and stimulates the circulation. Due to an antioxidant property it also prevents damage from free radicals preserving the youthful appearance of the skin and improves the elasticity of the skin so it appears more firm and youthful. The anti-inflammatory properties of ginger help to prevent acne eruptions. Ginger is also antiseptic and cleansing which helps to keep the skin clean and free of blemishes. Ginger can be put on potential areas in compresses or creams. Stimulating and detoxifying ginger is also used to treat cellulite. The essential oil can also be added to hair care products as it will strengthen the hair and treat seborrhea.

Storage of Essential Oils

Essential oils exhibit deterioration through oxidation and polymerization upon prolonged exposure to air and light. Hence, producers customarily keep their oils in closed, completely filled containers and the perfumers, in particular, store their valuable essences in hermetically-sealed bottles, kept in dark, cool cellars. Without such precautions essences become less intense, grow darker and more viscous, develop a bleaching effect and eventually change into a brown, odorless resin

Oleoresin: Oleoresins are semi solid extracts composed of a resin in solution in essential and / or fatty oil, obtained by evaporation of the solvents used for their production. It is abound in heavier, less volatile and lipophilic compounds, such as resins, waxes, fats and fatty oils. The solvents used are non aqueous and may be polar (alcohols) or non-polar (hydrocarbons, CO_2). Ginger oleoresin is extracted from dried ginger by extraction with organic solvents (3.5-10 % is the oleoresin yield which in turn yields 15-30 % volatile oil).

Uses: Ginger Oleoresin is a medicine that is used for the treatment of hyperlipidemia, Platelet aggregation, decreased urine output, thrombosis, inflammation, coughing and other conditions.

35. HORTICULTURE 16071

Flower Drying Adding Colour in Lives of Rural Women

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Floriculture is emerging as a fast- growing sector of Indian agriculture. The domestic flower market is dominated by loose flowers. A bulk of small and marginal flower growers around cities producing traditional flowers face high marketing risk due to wide price fluctuations.

Flower drying can come as a boon for flower growers by converting surplus production into value-added products. It's estimated that about 80% of flower species can be dried and preserved successfully. Pot pourris is a major segment of dry flower industry valued at Rs. 55 crores in India alone. There is a vast opportunity in value added floriculture trade through crafting at entrepreneurial level for rural and urban people specially women besides growing and selling flowers. The demand for dry flowers is increasing at an impressive rate of 8-10% and therefore there is a great scope for the Indian entrepreneurs. Dried ornamentals last much longer than fresh ones if properly preserved, packaged and handled. The best part of Dry flower is that anything can be collected from roses to wild flowers, bamboo plants to pine seeds and grasses. Moreover, one can also gets exotic orchids and indigenous flowers as well. The techniques, though easy to adopt, vary for different flowers. These are not only affordable and durable, but also make great gifts and decorative pieces.

For drying, different flowers are gathered in different seasons. The toughest part of drying is to keep their beauty intact. Sometimes drying makes them look more beautiful. Many dry-flowers based and utility items like greeting cards, bookmarks, wall hangings, tea coasters, paperweights, table mats, dry-flower arrangements, potpourri, wreaths, pomander and lamp shades etc. are also popularising in the market.

Dried flowers have generated much interest among people primarily because they come cheap and are attractive. The dry flower industry is exploring very fast and getting popularized. Crafting in floriculture through dry flower making, floral decor, bouquet making, dry flower frames and articles, potpourris by using the ornamental plants is considered as an ideal venture in the recent past for livelihood and women empowerment. The women engaged in this activity can earn between Rs. 7,000 and Rs. 8,000 a month. Farm women in the villages can take flower dehydration in a scientific manner on a cottage scale supplementing their household income. And in terms of business this sector is prospering very well. Thus, women can form self-help groups to take up the production of flower-based products for their livelihood.

Harvesting Flowers

Flowers are collected in the morning, after the dew has dried out and if they are wet collect

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flowers at least after two days. Handle them carefully so they don't get bruised. Always choose blossoms that have reached near peak and haven't started to fade or turn brown around the edges. If they are too mature, they can drop their petals easily during the process. Also select those flowers that are without insect and disease problems. Drying process should be started as soon as possible after cutting flowers but if we cannot proceed arrange them in a vase with lukewarm water for up to 24 hours as soon as we've gathered the blossoms. Before drying remove the stems and leaves since they retain moisture and prolong the process. Flowers are completely dried when the petals feel papery, stiff and the stem snaps easily when you bend it, not flexible.

Methods

There are many ways to dry flowers and to find out which works best for each flowers will be a part of experimentation. Methods used for removing water from plant parts are air-drying, water drying, embedding (sand, borax, silica gel and combination of these materials), glycerine drying, microwave oven drying, freeze-drying and press drying.

Air-Drying: Most flowers air-dry best when they are just beginning to open. They will continue to open slightly as they dry, and a fully open flower may lose its petals. Window screen, wood frame with thin mesh stretched across with a wire rack laid on top will provide excellent air circulation. The plant materials are hang upside down in a warm, dark, dry location for quick drying and flowers are dried in two to four weeks. Make bunches of 10 flowers of a single type. Flowers may also be spread over blotting sheets/ news papers and kept in dark. Dry them until the flowers become crispy on touch. Large flowers should be dried individually. The colours will darken and intensify, and the stems will shrink in diameter. Air circulation helps the flowers dry and prevents mould, so keep the bunches in an area with a good cross-breeze. Hanging the stems at different lengths avoid crowding of blossoms. This method works best for small, sturdy lossoms such as lavender, rose, statice, or larkspur. A light mist of aerosol hairspray or floral sealer will set the flowers' shape.

Water Drying: Some flowers dry well if placed in water. Water Drying is a method of preserving in which the stems of the flowers are initially placed in five centimeters of water, then the water is allowed to evaporate and be taken up by the cut flowers. The container and flowers should be placed in a dry, warm and dark location. Hydrangeas, hybrid delphiniums, gypsophilla, yarrow, bells-of-Ireland and celosia dry well with this method.

Petal-Drying: For preserving loose petals, we can use air-drying with paper towels (newspaper works too) and then arrange the petals in a single layer and leave in a warm, dark place until done.

Embedding Flowers in Desiccant: A desiccant is a substance with a high affinity for water which can be used as a drying agent. These agents have the amazing ability to attract and absorb water – which also makes it the perfect medium for drying flowers. Several materials are used as drying agents. Sand, Borax, Silica gel, saw dust, perlite and combination of these materials are used in this method. Among these, sand and borax are cheaper but they take more time for drying. For delicate flowers like roses, dahlia, carnation etc, silica gel is the ideal drying agent. For this method, the stems are cut short about 1-2 inches and then flowers are carefully positioned on desiccant, leaving some space between them and then covered with a thick layer of silica gel (1 to 2 inch). Finally, burying the flowers more desiccant is slowly poured over the flowers. At a time only a couple of flowers are dried making sure that flowers do not touch each other. When placed in a drying agent, blossoms emerge completely desiccated and ready for use in dried arrangements, but unlike the hanging method, color and form are much better preserved. Unlike the hanging method where only a small number of varieties can be used, these desiccants allows for a much wider selection of flowers – everything from lilacs, roses and peonies, to sunflowers, salvia and zinnias.

Glycerine Drying: Glycerine drying has been used especially to preserve foliage maintaining their softness and flexibility. In glycerine drying, moisture in a flower is replaced by a mixture of water and glycerine sustaining the quality of the product. It was comparatively less expensive and has a high water attracting capacity. Many types of foliage have been successfully preserved by either immersing leaves or placing crushed stems in a 33 per cent glycerol solution.

Microwave Drying: Microwave drying is quick and relatively simple. It provides more fresh and colourful dried flowers than obtained by other methods. In this method, flowers are placed facing down on tissue paper and then folded over a paper towel. Then a heavy plate is put on top of flowers to keep them flat. A 30 second intervals should be kept to avoid burning of flowers and to avoid superheating a small cup of water in the back corner of the microwave is also kept. After 90 seconds, flowers get dried and crispy enough. Flowers with many petals such as roses, dahlias, zinnias and marigold work well with this process. Optionally, preserve them with hairspray.

Freeze Drying: Freeze dried flowers are fresh flowers that have been specially dried to preserve their natural shape, colour and beauty. Freeze drying is accomplished by a process called sublimation. It requires a special freeze-drying machine. It involves first freezing the flowers at (-

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)100C for at least 12 hours. A vacuum pump slowly pulls the water out of the flowers as a vapor in one chamber, and then the vapor condenses as ice in another chamber. Because of this process, the shape and natural color of the flower is maintained. For Roses it takes 15 – 17 days and for other flowers normally 10 – 12 days. Major flowers dried by this method are roses, carnation, bridal bouquets, etc.

Press Drying: Press Drying is the earliest method of preserving flowers. Flowers and foliage are placed on a matte, non-glossy paper such as newspaper, or tissue paper. Then flowers are arranged in a single layer on a non-glossy paper, covering another sheet of dry paper over the top. Then the flowers are pressed with book, heavy boxes or wood and keep in a warm, dry place. After 1-3 weeks, weights and papers are removed pulling out the flowers. They should be crisp and paper-thin, and transparent to light. Though the flowers and foliages become flat after press drying, yet this material can be used for making floral craft items like greeting cards, floral designs and other art creations which may be framed. Pressing flowers is done best with small, flat flowers, such as pansies, candytuft, chrysanthemum, lantana, rose, verbena, euphorbia and leaves like thuja,

Bleaching and Dyeing: The major drawback of dry flower products is that they look dull and lack the brightness of fresh flowers. To overcome this problem, flowers are bleached and dyed for enhancing the visual appeal of the product. Oxidative (Hypochlorite, Chlorite and Peroxide) and reductive bleaching chemicals (Sulphite and Borohydride) are used for bleaching ornamental flowers and foliage. Sodium Chlorite is an excellent bleaching agent because it is relatively selective for lignin without damaging fibre. In reductive bleaches, hydrosulphites (Sodium or Zinc Hydrosulphite) are cheap and have maximum bleaching power. Natural dyes can also be used.

Skeleton Leaves: These are transparent leaves, also called fossil leaves prepared by soaking the fresh leaves in bleached water and then by hand rubbing the soft green flesh from the network of veins. Heavy-textured leaves are the best choices for this method of preservation. These delicate leaves are a perfect accent for all craft projects.

36. HORTICULTURE 16075

Impatiens (Busy Lizzie): A Tender Perennial

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Type	:	Sub shrub grown as a tender perennial
Common name	:	Busy Lizzie
Family	:	Balsaminaceae
Flowering season	:	Late spring to late autumn (April - October)
Mature size / shape	:	25- 60 cm (9- 24 in)

The name Impatience comes from the Latin for impatient, a suitable description of the British yellow balsam that discharges its seeds with great violence when ripe. The famous 19th century naturalist Sir J.D. Hooker, when in his eighties, spent nine years studying the balsam genus and pronounced it to be 'diceitful above all plants, and desparately wicked'- an opinion echoed by many an amateur gardener when faced with the more than 700 species it contains. The confusion is reflected in the numerous classifications still given today to busy Lizzie that can be found listed as a hybrid of *Impatiens sultanii, I. petersiana, I. holstii*, or *I. walleriana*. It was in Zanzibar in 1896 that Hooker found the species he named *I. sultanii* in honour of the sultan of that island.

A very popular house plant, the busy Lizzie will flourish equally well outside when used as a summer bedding plant. It is aptly named in that indoors it will flower steadily from late spring to late autumn (April to October); in the garden its flowering season is curtailed by temperature and weather conditions. The blooms, single or double and about 5cm (2 in) across, are quite delicate and come in a variety of shades ranging from white, through pink and orange, to magenta and scarlet; variegated blooms are also quite common. Many forms have variegated foliage as well, notably the New Guinea hybrids.

Busy Lizzie is a fast grower and its

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appearance is greatly helped by pinching out the main growing tip when the plant is about 25 cm (9 in) high. This induces it to branch out into a more shapely bush, and you will have more flowers on it as well. However, some of the new hybrid varieties, such as the Imp strain are dwarf types that only reach heights of 25 cm (9 in) and so do not need to be pinched out.

Busy Lizzie enjoys a light situation, although if you are growing it indoors avoid placing it on a south- facing windows where it will be in danger of being scorched by direct sunlight. Water it generously during the growing season, with a weekly feed of appropriate fertilizer according to the manufacturer's instructions.

The plants can be propagated equally well from seeds or cuttings. A pot is (13 cm) ideal for a Bussy Lizzie and it only needs to be repotted every year, preferably in the spring (Febuary to April). It will overwinter indoors or in a green house quite happily, so long as the temperature is not allowed to drop below 13ºc (55ºf) and the soil is kept just moist. Don't be alarmed if the plant loses several leaves; they will grow again in the spring. Busy Lizzie does have a tendency to become 'leggy' and rather unattractive after two or three years, and when this happens you must be ruthless take a couple of cuttings and throw it out!

Impatiens sultanii

I. petersiana

I. walleriana

37. HORTICULTURE 16079

Integrated Farming System in Coconut

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INTRODUCTION: Coconut is predominantly cultivated in small and marginal holdings in India and the major coconut growing states are viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. About 98 per cent of the coconut holdings in the country are less than two ha in area and more than 90 per cent of them are less than one hectare in extent. Most of these holdings neither provide gainful employment for the family labour round the year nor generate sufficient in com e to satisfy the family requirement. Coconut palm when grown as a monocrop, does not fully utilize the resources viz., soil, nutrients, moisture and solar radiation available in the garden. There is ample scope to exploit these resources for the integration of crops and animals in coconut garden for enhancing income and employment opportunities. Presently coconut growers are exposed to economic risks and uncertainties owing to the frequent price fluctuations for the produce. In this context, it is neeeliess to emphasize the importance of crop/ enterprise diversification in coconut gardens.

Integrated farming is a common whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food. Coconut based cropping/ farming systems, involving cultivation of compatible crops in the interspaces of coconut and integration with other enterprises like dairy, poultry and aquaculture offer considerable scope for increasing production and enhancing productivity per unit area, time and inputs by more efficient utilization of resources like sunlight, soil, water and labour. Coconut based integrated farming is an ecologically sustainable

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system which helps the farmer to realize more income. Sustainability is the objectivity of the integrated farming system where production process is optimized through efficient utilization of inputs in safeguarding the environment with which it interacts.

Agronomic Feasibility of Coconut based Integrated Farming System

A spacing of 7.5 m x 7.5 m is recommended for planting coconut in the square system. Experimental evidences have shown that a sole crop of coconut, at the recommended spacing of 7.5 m x 7.5 m does not fully utilize the available resources such as land space, aerial space, water and nutrients.

Rooting pattern: Coconut palm like all monocots has a typical adventitious root system. Under favourable conditions, as many as 4000 to 7000 roots are found in the middle-aged palms. About 74 per cent of the roots produced by a palm under good management do not go beyond 2m lateral distance and 82 per cent of the roots were confined to the 31 to 120 cm depth of soil. Recent studies have confirmed that more than 80 per cent of the root activity was confined to a lateral distance of 2 m from the trunk (Fig.1). Thus, in a coconut garden the active root zone of coconut is confined to 25 per cent of the available land area and the remaining area could be profitably exploited for raising subsidiary crops.

Canopy structure and light utilization: The Venetian structure of the coconut crown and the orientation of leaves allow part of the incident solar radiation to pass through the canopy and fall on the ground. The leaves in a coconut palm crown are not randomly distributed, but clumped around few Widely spaced growing points. It is estimated that as much as 56 per cent of the sunlight is transmitted through the canopy eluting the peak hours (1 0-16 hours) in palms aged around 25 years. The diffused sunlight facilitates growing a number of shade tolerant crops in the inter spaces. Thus, canopy structure and light utilization pattern render coconut palm as the tree crop most suited to integration.

Based on the growth habit of the palm and the amount of light transmitted through its canopy, the life span of coconut palm can be divided into three distinct phases from the point of view of intercropping.

i) Planting till full development of canopy (about 8 years): Good transmission initially, but decreasing with age, suitable for growing annuals/biennials.
ii) Young palms (8 to 20 years): Maximum ground coverage and low canopy height poor light availability-not suitable for multiple cropping.
iii) Mature trees (more than 20)'ears): Increase in trunk height; reduction in crown size- light transmission increasing with age - ideal for raising annual and / or perennial crops.

Components in integrated farming system of coconut

S1. No.	Component	Area (ha)/numbers
1	Coconut (WCT)	175 nos
2	Fodder grass (BN CO-3) and guinea grass / Fodder sorghum, fodder maize, (Stylosanthes - annual and perennial fodder cow pea	1.00 ha
3	Black Pepper (Panniyur-1) planted in coconut basin and trailed on the coconut stem	175 nos.
4	Banana (Njali poovan variety) planted on border areas	195 nos.
5	Dairy (Holstein Fries ian and Jersey cross breed cows)	0.02 ha* / 8 nos
6	Poultry (Broiler birds 4-6 batches/ year)	100/ batch
7	Japanese quails	100 layers
8	Biogas plant (3 m 3)	1 no.
9	Awlla unit (4 m ^{2})	3 nos.
10	Aquaculture (Catla, Rohu, Mrigal, Grass carp) -1000 fingerlings in the pond of 27.5 x 22.5 x 1.5 m	0.062 ha
11	Goatery unit	60 sq.m/ (20 + 1)

38. HORTICULTURE 16104

Potential of Chikku Cultivation

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CHIKU is delicious fruit crop of tropical and sub-tropical countries and is cultivated on about 564 hectares with production at 2,018 metric tons. In Pakistan, the mature fruits are also used for making jams as these provide a valuable source of raw material for the manufacture of industrial glucose, pectin and natural fruit jellies. They are also canned as slices.

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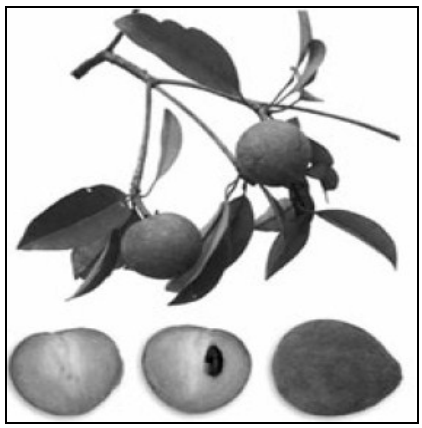
The chiku fruit when fully ripe is delicious to eat. The pulp is sweet and melting. The usual practices are to eat only the pulp. The fruit skin can also be eaten since it is richer than the pulp in nutrient value.



Chiku is rich in protein, fibre and minerals like phosphorus, calcium and iron. The tree bear fruit within three years of planting. The main reasons for its popularity is that there is no danger of pilferage of the ripened in the basket and not on the tree where it remains hard, astringent and rich in latex.

The fruits not peeled show abnormal amounts of tannin contributed by the skin. The moisture range from 69-75.7per cent; ascorbic acid from 8.9 to 41.4mg/100g; total acid 0.09-0.15 per cent, pH from 5-to 5.3; total soluble solids at the ratio of 17.4:23.7; carbohydrates and glucose range from 5.84 to 6.40 per cent.

The fruit has medicinal also as young fruit is boiled and its decoction is used in diarrhoea; an infusion of young fruits and flower relieves pulmonary complaints; decoction of old, yellowed leaves is good for cough, cold and diarrhoea; tea made from bark is also helpful in diarrhoea and dysentery.

Fluid extract of crushed seeds and leaves lowers blood pressure; paste of seeds is applied on stings and bites. The latex is used in filling tooth cavities. A major product of tree is the gummy latex called “chicle”, containing 15 per cent rubber and 38 per cent resin.

Chiku is a tropical fruit and can be grown from sea level up to 1,200 meters. The plant prefers warm and moist weather and can grow both in dry and humid areas. The coastal climate is best suited to this plant.

At higher altitudes, the fruit quality and tree health suffers. Areas with an annual rainfall of 125-250cm are highly suitable. Rain or cloud weather during any part of the year does not do any harm to fruit set. The optimum temperature is between 11°C and 34°C.

The fruits mature in four to six months after flowering. In the tropics, some cultivars bear almost continuously. The main season is from December to March. The trees bear from May to September with the peak of the crop in June and July. The most ideal soils are deep alluvium, sandy loams, red late rites and medium black soils. Sometimes it is planted in dry river beds with alluvial soil. Good drainage is essential. It is highly drought resistant and approaches the date palm in its tolerance of soil salinity.

Pits of the size of 60cm 3 or 100 cm 3 are prepared at a distance of 8-10m both ways depending upon the planting material and the soil. In low rainfall areas and soils with low fertility closer spacing is followed, while in heavy rainfall tracts and fertile soils a wider spacing is recommended. The top 30cm soil is kept separately on one side of the pit, while the remaining is kept on another side. The pits are left for a month or two.

The best time for planting is during early monsoon. Grafts, budded plants or layers are planted one in each pit in the centre and care is taken to ensure that the roots are gently and firmly pressed and stakes are provided to avoid wind damage. The plants are then watered.

Chiku plant can tolerate drought conditions to some extent, yet it responds well to irrigation. Young plants are watered regularly during dry season having long breaks in the monsoon and in winter and summer at an interval of six to 12 days. Young plants are given irrigation once in eight days from October onwards till monsoon starts. Protective irrigation is given during first two seasons.

Newly planted trees need small and frequent feedings to become established. Fertilizers that contain 6-8 per cent nitrogen, 2-4 per cent available phosphoric acid and 6-8 per cent potash give satisfactory results. First year applications should be made every two to three months beginning ¼ pound and gradually increasing to one pound. Thereafter, two to three applications per year are sufficient, in amounts proportionate to the increasing size of the tree.

Chiku is mostly propagated by seeds which remain viable for many years if kept dry. It takes five to eight years to bear. Since seed may not come true, vegetative propagation is desirable. Veneer grafting with seedlings as rootstock is the

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best method. Air layering and rooting of cuttings have not been successful.

In Sindh there are two varieties called oval and round.

Oval: Fruits of this variety are small to medium in size and oval in shape. Pulp is coarse grained and less sweet. It is shy bearing cultivar.

Round: The foliage of this variety is like green and fruits are large but the flesh is gritty and of moderate quality.

Pest and diseases: Generally, chiku tree remains quite healthy with little or no care. Insects and diseases usually don't cause sufficient damage to necessitate control measures. The Woody White Fly can sometimes be a problem. The other leaf spot disease caused by a fungus phaeophleosporaindica is characterized by numerous, small, pinkish to reddish brown spots with whitish centres. The sooty mould is also a fungal disease developing on the honeydew like excretion by scale insects and mealy bugs. This is a common disease and adversely affects the photosynthetic function of leaves and disfigures the fruit.

Chiku improves in quality after harvesting but immature fruits should not be harvested. The maturity can be judged by several external symptoms as mentioned below:

- Fruits at full maturity develop a dull orange or potato colour.
- A mature fruit when scratched lightly shows a yellow streak instead of a green streak which is a sign of immature condition.
- Brown scaly material disappears from the fruit surface as fruits approach full maturity.
- As fruit matures, milky latex content is reduced.
- The dried spine like stigma at the tip of fruit drops or falls off easily when touched.

Chiku tree yields 200 to 450lbs (90 to 180kg). At 30-35 years of age, the tree should produce 2,500 to 3,000 fruits annually. A great deal depends on the cultivar. A 10-yearold 'oval' tree gives 1,158 fruits weighing 184lbs (128.8kg), mature fruit will ripen in 9 to 10 days and rots in two weeks at normal summer temperature and relative humidity.

- Besides poor post-harvest life, soft fruit cannot be shipped in bulk over long distance.
- The crates have to be single layer packed for good results. With two crops a year, there is no reason for its availability year around.

39. HORTICULTURE 16117

Growth Manipulation in Tropical Fruit Crops to Overcome Physiological Constraints

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The productivity as well as the quality of fruit crops is affected to a greater extent due to the physiological and nutritional disorders. Disturbance in the plant metabolic activities resulting from an excess or deficit of environmental variables like temperature, light, aeration and nutritional imbalance result in crop disorders. In fruit crops, the deficiency of micronutrients causes many more disorders than that of macronutrients. The deficiencies of Zn, Mn, Cu, Fe and Boron are common in sweet orange, acid lime, banana, guava and papaya in India. The description of physiological and nutritional disorders in crops include a number of technical terms and it is essential to understand the terms for better identification of symptoms. Some common terms are chlorosis (loss of chlorophyll resulting in loss of green colour leading to pale yellow tissues), decline (onset of general weakness as indicated by loss of vigour, poor growth and low productivity), die-back (collapse of the growing tip affecting the younger leaves), necrosis (death of tissue), scorching (burning of the tissue accompanied with light brown colour resulting from faulty spray, salt injury etc.).

Nevertheless, apart from these, special problems may arise out of usage of a wrong variety to suit the season and soil, problems posed by characteristics of soil, quality of irrigation water, environment induced problems, toxicity of various kinds and pollution problems. The problems (disorders) caused by different factors in any crop are given below

a) The selection of a wrong variety for a particular season lead to continuous vegetative growth (*i.e.* no flowering occurs)
b) The pH and calcium carbonate content of saline and alkaline soils causes either deficiency or excess of micro nutrients as well as macronutrients result in imbalance
c) The pH, EC, TSS and boron content of irrigation water cause nutritional disorders in crops.

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d) The sudden increase or decrease in temperature causes phosphorus deficiency

Physiological Basis of Growth Manipulation

The size and shape of the canopy may be manipulated through physical (pruning and training) and chemical means.

PRUNING: Pruning is a tool to regulate the tree size and shape to achieve a desired architecture of the canopy and also to reduce the foliage density by removing the unproductive branches of a tree. Pruning brings the balance between vegetative and reproductive functions.

Altered physiology: Saidha (1980) observed that, as a result or pruning, the dry matter content in leaf and stem reached the maximum by October – November so that the C/N ratio was the highest during November-December in Neelum, Banglora, Mulgoa cultivars. This seems to be owing to increased photosynthetic efficiency as a result of improved light penetration in the trees. High C/N ratio, however, did not always govern the fruit bud formation but the accumulation of starch at critical period was of special significance for fruit bud formation.

Ribonucleic Acid (RNA): As a result of pruning, the RNA content of leaf, which attained the maximum level at the time of flower bud formation, was significantly higher during the second 'normal' year than in the first 'lean' year. Increased RNA contents coinciding with flower bud formation in Mulgoa, Banglora, Neelum and Banganapalli have also been reported (Suryanarayana, 1975).

Ascorbic acid: The treatments of pruning and thinning or thinning alone increased the ascorbic acid content from September onwards with a varying response in different cultivars (Narayan *et al.,* 2017), however, Narayan *et al.,* (2017) observed that the ascorbic acid content in mango leaves reached a major peak in November coinciding with flower bud formation.

Total phenols: Pruning and thinning or thinning alone increased the total phenolics content as a result of improved light conditions of trees. Phenolic acids have been shown to act as inhibitors similar to abscisic acid to be favourable to flower bud formation in mango (Chacko, 1968). Narayan *et al.,* (2017) also observed that the total phenolics content in the leaves of a flowering shoot was higher than in a vegetative shoot.

Impact of Altered Physiology

- Increased yield and fruit quality
- Avoidance of build-up of micro climate for the disease and pest
- Convenience in carrying out the cultural operations
- Improving access and visibility of fruit during harvest.

Training

Need for training: Training of the perennial trees to the open vase centre is an age old practice to harvest the advantage of the light and ventilation. Basically, the training is a potential tool to manage the canopy architecture of a plant with weak stem like grape vine. Bower system of the training has been found to be the best in tropics throughout the world. Training facilitates channelling its energy distribution from vegetative to reproductive growth.

Impact of Altered Physiology

- Increased productivity and fruit quality
- Gives a desirable shape that maintains its vigour for a long period
- Facilitates requisite leaf exposure and different cultural operations including harvesting and plant protection
- Good protection against hot desiccating winds
- Bunches were saved from damage by birds and sun scorch

Chemical Manipulation

Plant growth substances are chemicals that are central to plant growth and development. They regulate the rate by which the individual part of a plant grows and integrate growth of those parts to form the whole organism and control reproduction. Plant hormones also allow mature plant to respond to changes in their environment.

Altered physiology: Plant growth substances regulates the cell division, elongation and enlargement. Apical dominance is controlled by cytokinin like substances. Assimilation and translocation can also be increased by growth regulating substances. Root system may be promoted or less impeded and hence shoot / root ratio is lowered. The effect of fruit thinning on fruit size is related to the leaf / fruit ratio.

Impact of Altered Physiology

- Increased yield and quality of fruits
- Overcoming apical dominance and prevent abscission
- Early ripening and improved surface colour and delayed senescence
- Prevent seediness (Poovan) and suppress the excessive vegetative growth

Practical application in overcoming the constraints

Crop	Nature of work	Outcome	Reference
Mango	Potassium nitrate from 1 to 8 per cent	Positive impact on the induction of flowering in mango	Dalal *et al.,* 2003
Guava	3 cm pruning of thick shoots from tip and dried branches	Improved fruit yield and quality	Dalal *et al.,* 2004

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Crop	Nature of work	Outcome	Reference
	were removed from bases		
Mango	Foliar spray-urea (2 and 4%)	Improved fruit retention	Bhambid *et al*., 1988
Sweet Orange	Foliar spray - 0.5% ZnSO4 + 15 ppm 2, 4-D + BM (2:2.50)	Reduced fruit drop	Gil *et al.,* 1983
Banana	Soil application 5 g triacontanol /plant	Increased no of hands/bunch and bunch weight	Nagalakshmi *et., al.,* 1989
Pineapple	2 g calcium carbide /plant	Induction of flowering	Sing *et al.,*1974
Mango	Control of fruit drop	2, 4-D during flowering (10 ppm) + 1 month after flowering (30 ppm) +2 months after flowering (10 ppm)	Sarma *et al.,* 1981
Ber	Higher yield and better quality	Pruning during summer on full grown trees by heading back at 8 buds levels of previous year's growth	Harmail Sing *et al.,* 2004
Grapes	Increased weight of cluster and berry size by 75%	Clusters treated with 100 mg GA3 + 20 ppm+ CPPU	Tao *et al.,* 2001

Tripathi and Dhakal (2005) reported that paclobutrazol inducing early flowering at fourth week of December which was 70 days ahead of normal flowering days. Thirugnanavel *et al.,* (2007) revealed that application of GA3 50 ppm in June + cycocel 1000 ppm in September + KN03 2% in October showed better performance in delaying flowering by nearly two months, number of flowers per shoot (7.01), initial fruit set (4.59), fruit retention (3.21 fruit per shoof) number of fruits/tree (224 fruits) and yield (11.15 kg). Paclobutrazol inhibits the biosynthesis of GA and internode elongation which reduces the availability of GA. Bromouracil, 2, 4 D and paclobutrazol in variable doses are effective in inducing flowering in acid lime.

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40. HORTICULTURE 16152

Terrace Farming: A Healthy Breath for Urban Families

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We think that, we are bringing healthy vegetables and fruits from the market, but the fact remains that most of our vegetables and fruits are laced with pesticides and artificial colors. Some like the greens which we are consuming daily are grown in sewage water. So, it may appear like there is no escape, but actually the solution is in our hand and that is 'Terrace Farming'. A garden in which

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crops are grown on terraces, balconies or roofs of buildings called a terrace farming or terrace garden. The kitchen garden has now shifted to the roof due to constraints of space and escalating costs of lands. Terrace gardening is as old as the days of Babylon, but today it has a new meaning in India and other parts of the world. Due to various developments taking place, we started losing agricultural lands. With the pressure of buildings on land and its cost in the urban areas, there is hardly any space to have a garden. So, if one wants to grow vegetables domestically the only alternative is the terrace which provides the ideal space.

Why Terrace Farming in Urban Areas?

Terrace farming brings the varieties of crops in the form of garden which serve as a simple source of joy and a socially engaged lifestyle. It provides an answer to food insecurity and an avenue for cultural expression and citizen involvement. It also enables people to get a taste of the pure enchantment of growing food for themselves and for the community. It is a social and community based gardening which betters the quality of life. The community in contact with the garden will get benefit from the feeling that comes from helping others, commitment to a project and socializing with one another. As a place for experimentation with nature, the garden can be a space for pedagogical and recreational activities that will reinforce scholastic materials or themes from day camps and increase the spirit of team work. Gardening will favour the production of food for a meal-on-wheels program or a food bank or for personal use, which ultimately ensures food security. A roof top garden can improve a building's energy efficiency and increase its value by expanding the usable space. It also helps to diminish expenses related to acquiring food. Roof garden helps in improvement of air quality through the absorption of carbon dioxide and the production of oxygen by plants. The consequent increase in humidity and evaporation will bring down the ambient temperature, biodiversity will attract birds and insects and plants will absorb ambient noise. Use of rain water to irrigate plants will reduce pressure on the municipal water works and can be integrated in a system that uses household waste water.

Considerations for Terrace Farming/Gardens

These gardens can be created on almost all kind of buildings like residential flats, individual houses, commercial hubs, godowns and factories. Roof should water proof which can be done by using different water proofing products (Polymers, Atatic poly propylene etc.) which will ensure that the roof is protected, water-resistant and leakage-free. Unlike any other type of gardening, terrace garden requires detailed plan. It should be proportionate with vegetables, fruits and some ornamentals. Traditionally terrace gardens were limited only in big cities with beautification of flowers and climbers.

Points to be considered for successful terrace farming:

- Finding the right spot - Find a spot on your balcony or terrace that receives a lot of sunlight (at least 4 hours a day)
- Keep some space near the spot - To store your gardening equipment, some compost, natural fertilizer / pesticide, a small trowel, some garden gloves, a spray bottle to water your garden
- Choose your pot wisely - Choose the containers in which you would like to grow your plants. You can re-use old plastic tubes, water bottles, and even trash bags or HDPE plastic bags. Try to re-use what is available rather than buy something new.
- Giving your plant good soil - Using a mixture of coco peat (40%), fertile soil (20%) and vermicompost (40%)
- Seeds and Saplings to plant - Many seeds can be planted as it. Some seeds need to be germinated and then transplanted into its final container.
- Planting time - The best to plant your seeds or saplings is between the new moon and the full moon

Way of Growing Horticultural Crops in Terrace Farming/Garden

Containers/pots - (at least one drainage hole) fill one third bottom of the pot with a material that will create empty spaces like small stones

↓

Covering of material - (with a layer of newspaper)

↓

Pot filling – with mixture of growing media (Cocopeat+ fertilizers + soil)

↓

Planting - One or two seedlings per pot

↓

Aftercare - Staking to support a plants like vines, climbers *etc.*

Suitable crops –The crops for kitchen purpose like coriander, fenugreek, lettuce, tomatoes, legumes and chili *etc.* Even we can grow perennial crops like climbers, drumstick and some fruits like papaya, citrus, banana *etc.* and ornamental flower and crops for aesthetic purpose.

Advantages of terrace farming

- Adds valuable/useable space providing economic benefits.
- Reduce overall heat absorption of buildings and insulate the building against heat and cold
- Convenience of safe, pesticide free, healthy green and fresh vegetables

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- Conducive to a routine of physical exercise, clean air and being close to nature
- Increases amount of oxygen in the air and bring coolness to our eyes
- Energy efficiency year-round.
- Utilization of kitchen waste

Conclusion: The flood of urbanization covering the cities with population beyond their threshold capacity. It reduces the land for cultivation of crops which requires for daily feeding for this increasing population. So, it promotes to cultivate our own farm on roof tops / back yards / balconies. The terrace farming would be beneficial in catering to the needs of the denizens and to maintain good health standards. In concern to food security, cultivation of vegetables in terrace garden can bring the garden to our kitchen and also maintain the aesthetic and nutritional value by growing ornamentals and fruits. Ultimately, we can say that in future 'Terrace Farming' will bring a healthy breath for each and every family of urban areas.

41. HI-TECH AGRICULTURE 16009

Precision Farming: The Production Enhancing Techniques

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Agricultural production system is an outcome of a complex interaction of seed, soil, water and agro-chemicals (including fertilizers). Therefore, proper management of all the inputs is essential for the sustainability of such a complex system. The focus on enhancing the productivity during the Green Revolution coupled with total disregard of proper management of inputs and without considering the ecological impacts, has resulted into environmental degradation. The only alternative left to enhance productivity in a sustainable manner from the limited natural resources at the disposal, without any adverse consequences, is by maximizing the resource input use efficiency. The time has now arrived to exploit all the modern tools available by bringing information technology and agricultural science together for improved economic and environmentally sustainable crop production.

Precision agriculture merges the new technologies borne of the information age with a mature agricultural industry. It is an integrated crop management system that attempts to match the kind and amount of inputs with the actual crop needs for small areas within a farm field. This goal is not new, but new technologies now available allow the concept of precision agriculture to be realized in a practical production setting. Precision Farming is defined as information and technology based farm management system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of the land resource. The goal is not to obtain the same yield everywhere, but rather to manage and distribute inputs on a site specific basis to maximize long term cost/benefit. Precision farming is helping many farmers worldwide to maximize the effectiveness of crop inputs. The issues related to precision agriculture include perceived benefits and also barriers to widespread adoption of precision agriculture management. Today because of increasing input costs and decreasing commodity prices, the farmers are looking for new ways to increase efficiency and cut costs. Precision farming technology would be a viable alternate to improve profitability and productivity.

Benefits of precision farming: Precision farming allows for more efficient use of inputs than does current blanket applications. For example, why waste fertilizer on eroded knolls that don't yield in the best of times? Less fertilizer can also be used in low areas that are already high in fertility, reducing leaching. Not only is precision farming potentially more economical, it should reduce amounts of chemicals released into the environment.

How do you do it?: The idea behind precision farming is to vary fertilizer and pesticide inputs across a field in a predetermined manner. This requires:

1. a map of a field which describes how much of an input to apply in various areas
2. applicators which can vary input rates
3. equipment which allows you to know where you are in a field such as Differential Global Positioning Systems (DGPS).

Stages and Tools of Precision Farming

Precision agriculture is a four-stage process using techniques to observe spatial variability:

Geolocation of Data

Geolocating a field enables the farmer to overlay information gathered from analysis of soils and residual nitrogen, and information on previous crops and soil resistivity.

Geolocation is done in Two Ways

- The field is delineated using an in-vehicle GPS receiver as the farmer drives a tractor

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around the field.

- The field is delineated on a basemap derived from aerial or satellite imagery. The base images must have the right level of resolution and geometric quality to ensure that geolocation is sufficiently accurate.

Characterizing Variability

Intra and inter-field variability may result from a number of factors. These include climatic conditions (hail, drought, rain, etc.), soils (texture, depth, nitrogen levels), cropping practices (no-till farming), weeds and disease. Permanent indicators—chiefly soil indicators—provide farmers with information about the main environmental constants. Point indicators allow them to track a crop's status, *i.e.*, to see whether diseases are developing, if the crop is suffering from water stress, nitrogen stress, or lodging, whether it has been damaged by ice and so on. This information may come from weather stations and other sensors (soil electrical resistivity, detection with the naked eye, satellite imagery, etc.). Soil resistivity measurements combined with soil analysis make it possible to precisely map agro-pedological conditions.

42. PLANT BREEDING AND GENETICS 14095

DUS Testing Guidelines for Maize

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INTRODUCTION: Maize is cultivated widely throughout the world. It is the third most important cereal crop in India after rice and wheat. It accounts for 9 per cent of total food grain production in the country. Nine states viz. Karnataka, A.P., Tamil Nadu, Rajasthan, Maharashtra, Bihar, U.P., M.P. and Gujarat account for 85 per cent of India's maize production and 80 per cent of area under cultivation. Taxonomically, *Zea mays* L. belongs to tribe *Maydeae,* family Poaceae and genus *Zea*. The center of origin of *Zea mays* L. (2n=20) is reported to be Mexico and Central America. The main maize growing countries include U.S.A., China, Brazil, European Union, Ukrain, Argentina, India and Mexico. It is **monoecious** plant generally **protandrous.**

What is PPV&FR Act, 2001

India became signatory to the TRIPs in 1994. Plant variety protection under PPV & FR Act, provides legal protection to the plant varieties either by patents or by an effective *sui generis* system or by any combination. India enacted the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act in 2001 by adopting *sui generis* system (Annonymous, 2013).

Objectives of the PPV&FR Act, 2001

Registerable plant varieties in India

1. New Variety
2. Extant variety
3. Farmers' variety
4. Essentially derived variety (EDV)

Criteria for Protection

A new variety should be registered if it conforms to the criteria of **novelty, distinctness, uniformity and stability**

Benefit of Variety Registration

1. Protection of Breeder's Rights
2. Protection of Researcher's Rights
3. Protection of Farmer's Rights

DUS Testing

According to the 1991 Act of the UPOV Convention, protection can only be granted in respect of a new plant variety after examination of the variety has shown that it is **distinct (D)** from any other variety whose existence is a matter of common knowledge at the time of the filing of the application and that it is sufficiently **uniform (U)** and **stable (S)**. The examination, or "DUS Test," is based mainly on growing tests, carried out by the authority competent for granting plant breeders' rights or by separate institutions, such as public research institutes.

Requirements for DUS Testing

1. Planting material
2. Staff
3. Facilities

Reference Collection

In order to establish distinctness, it is usually necessary to compare the candidate variety with existing varieties. For this purpose, the test centers maintain reference collection of authentic

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samples of seed of existing varieties.

Seed Material Required

Applicants submitting such seed material from a country other than India should make sure that all customs and quarantine requirements stipulated under relevant national legislations and regulations are complied with. The minimum quantity of the seed to be provided by the applicant should be 3000 gram in the case of the candidate variety or hybrid and 1500 gram for each of the parental line of the hybrid. The applicant should also submit along with the seed a certified data on germination test made not more than one month prior to the date of submission (Annonymous, 2007).

Assessment of DUS

Distinctness: Distinctiveness is established by comparing the candidate variety with existing varieties/reference collections

- Consistent Differences
- Clear Differences

Uniformity: For the Assessment of uniformity of inbred lines and single cross hybrids, a population standard of 3 % and an acceptance probability of at least 95 % should be applied. In case of a sample size of 40 plants, 3 off-types are allowed. For visually assessed characteristics the uniformity of the candidate variety is checked against known comparable varieties.

Stability: It is not generally possible during a period of 2-3 years to perform a test of stability which leads to the same certainty as the testing of the distinctness and homogeneity. Generally, when a submitted sample has been shown to be **homogenous during the test**, the material can also be considered stable.

Grouping of varieties: The candidate varieties for DUS testing should be divided into groups to facilitate the assessment of distinctiveness. Characteristics, which are known from experience not to vary, or to vary only slightly within a variety and which in their various states are fairly evenly distributed across all varieties in the collection are suitable for grouping purpose.

The testing organizations / centers use the following characteristics for grouping varieties (Maize).

a) Tassel: Time of anthesis
b) Ear: Time of silk emergence (50% plants)
c) Ear: Anthocyanin colouration of silks
d) Plant: Length
e) Ear: Type of grain

Characteristics and symbols

1. Notes (1 to 9) should be given for each state of expression for different characteristics for the purpose of electronic data processing.
2. Legend:
   a) **(*)** Important for the international harmonization. Included in the variety descriptions, except when the state of expression of a preceding characteristics render this inappropriate.
   b) **(+)** Characteristics the plant parts on which observations to be taken are given in the explanation or in figure(s)
   c) (S) Possible segregation in three way cross and double cross hybrids (Annonymous, 2013).

Conclusion

- India has the largest reservoir of the genetic material and accounts for the second largest skilled population in the world it gives several opportunities to the Indian agricultural research and development.
- PPVFR Act Protects breeder's varieties from unauthorized infringement ensure farmers rights on seeds and encourage growth of seed industries by making seeds of protected varieties available to the farmers.
- To validate these claims distinctness, uniformity and stability (DUS) tests will have to be conducted as per the National Test Guidelines.
- DUS Testing is one of the key features of plant variety protection.
- For easy identification and preservation DUS test are very important.

Future Thrust

- DUS test should be modified according to need, cropping pattern and environmental conditions.
- More emphasis should be given on DUS testing by scientists/technical qualified persons.
- The Institutes/ Research organization engaged in plant breeding should stream line their maintenance breeding programme so to make available pure seed along with the application, which should be used for DUS tests and kept as reference sample for at least 7 years.
- A well conceived programme of training of staff for conduct of DUS tests, data compilation, analysis and its interpretation should be organized.

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43. PLANT BREEDING AND GENETICS 15744

Proteomics: A Tool for Crop Improvement

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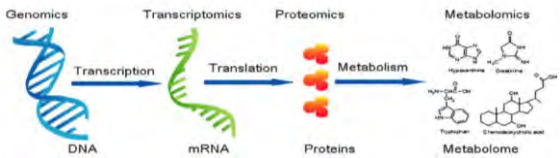
INTRODUCTION: Proteins are the work house of the cell and have important function in both normal and abnormal state. Inorder to understand how proteins interact and regulate various cellular processes it is important to understand their expression behaviour under a wide range of conditions. Proteins are constantly processed within the body in response to external stimuli and undergo post translational modification.

Proteomics is particularly the large-scale study of structure and function of proteins. A proteome is a set of proteins produced in an organism, system, or biological context. The proteome is not constant; it differs from cell to cell and changes over time and with environment. Given genome can give rise to infinite number of proteomes.



Origin of Proteomics

The first proteomics study began in 1975 with the introduction of the two-dimensional gel electrophoresis by P.H.O.'Farrell and J. Klose. The term "proteomics" was first coined in 1997 to make an analogy with genomics, the study of the genes. The word "proteome" is derived from "protein" and "genome" and was coined by Marc Wilkins in 1994.

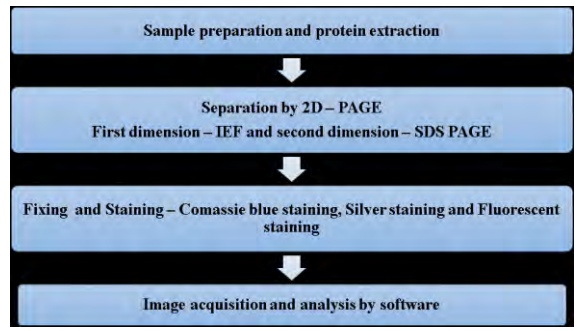
Proteomics undertake investigation of :

- Time and location of protein expression.
- Rate of protein production, degradation and abundance;
- Protein modification eg. post-translational modifications.
- Movement of proteins between subcellular compartments;
- Metabolic pathways involving proteins.
- Interaction between proteins.

Type of Proteomics

1. **Structural Proteomics** – It helps to understand three dimensional shape structure of functional proteins by use of technologies such as X-ray crystallography, NMR spectroscopy etc.
2. **Functional Proteomics** – It explains the protein-protein interaction, protein function and their involvement in different metabolic pathways.
3. **Expression Proteomics** - Expression proteomics is used to study the qualitative and quantitative expression of total proteins under different conditions.

Work flow scheme in proteomics



Application of Proteomics for Crop Improvement-

- Creating a chart of proteome and and its interaction map which can be used to develop plant resistant to various biotic and abiotic stresses.
- Proteomics help to investigate mechanisms involved in biotic and abiotic stress tolerance.
- Analysis of food quality, safety and nutritional values have been more meaningful.
- Proteomic based fungicides are a possibility as target of most drugs are proteins.
- Manufacturing of plant based vaccines can be possible in near future by overexpression of the antigen of interest in plant, no safety concerns are related with plant based vaccines.

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44. PLANT BREEDING AND GENETICS 15999

Antisense RNA Technology: A Mechanism to Inhibit Gene Expression

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INTRODUCTION: Antisense agents are valuable tools to inhibit the expression of a target gene in a sequence-specific manner, and may be used for functional genomics, target validation and therapeutic purposes. This type of technology was first developed by Dr. Hal Weintraub et al. (1980). They were the first to show that aRNA could inhibit gene expressions in mouse cells. Then in 1996 Dr. Meng Chao Yao, showed how aRNA that was incorporated into non-conserved regions of rRNA could also disrupt translation by altering the interaction of mRNA and the rRNA/aRNA chimera. Three types of anti-mRNA strategies can be distinguished. Firstly, the use of single stranded antisense oligonucleotides; secondly, the triggering of RNA cleavage through catalytically active oligonucleotides referred to as ribozymes and thirdly, RNA interference induced by small interfering RNA molecules.

The Principle behind antisense RNA technology

- An antisense nucleic acid sequence base pairs with its complementary sense RNA strand and prevents it from being translated into a protein.
- The complementary nucleic acid sequence can be either a synthetic oligonucleotide, often oligodeoxyribonucleotide (ODN) or longer antisense RNA sequences.

Antisense RNA Inhibition

When the aRNA binds to the complementary mRNA, it forms a double stranded RNA (dsRNA) complex (Figure 1). That is similar to double stranded DNA (dsDNA). The dsRNA complex does not allow normal translation to occur. The exact mechanism by which translation is blocked is unknown.

Several theories include: (i) The dsRNA prevents ribosomes from binding to the sense RNA and translating (Kimball, 2002) (ii) The dsRNA cannot be transported from within the nucleus to the cytosol, which is where translation occurs (Tritton, 1998) (iii) The dsRNA is susceptible to endo-ribonuclease that would otherwise not affect ssRNA but degrade the dsRNA. (Kimball, 2002).

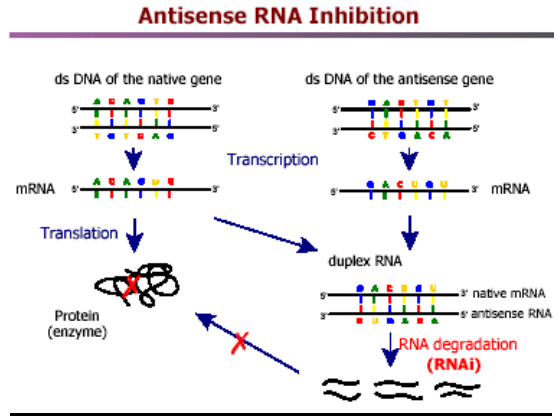

FIGURE 1. Antisense RNA inhibition mechanism.

RNAi: How does it Work

The ability of dsRNA to suppress the expression of gene corresponding to its own sequence is called RNA interference (RNAi). It is also called post-transcriptional gene silencing (PTGS). Since the only RNA found in a cell should be single stranded, the presence of dsRNA signals is an abnormality. The cell has specific enzyme (in *Drosophila* it is called Dicer) that recognizes the dsRNA and chops it up into small fragments (21 – 25 bp).

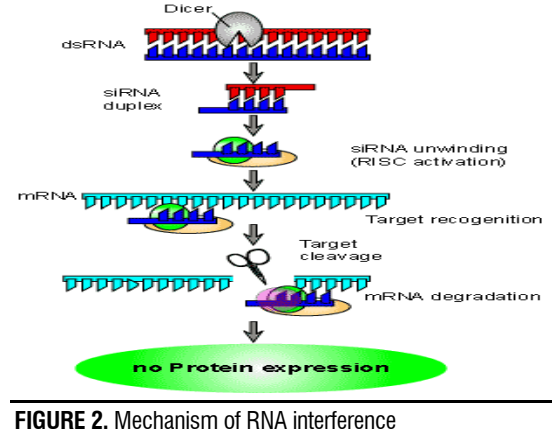

FIGURE 2. Mechanism of RNA interference

Short RNA fragment (called small interfering RNA or siRNA) binds to the RNA induced silencing complex (RISC). The RISC is activated

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(Figure 2) when the siRNA unwinds and the activated complex binds to the corresponding mRNA using the aRNA. The RISC contains an enzyme (called slicer in *Drosophila*) to cleave the bound mRNA and therefore causes gene suppression.

Application

- Control of fruit ripening
- Protect plants from damage by plant viruses
- Antisense in disease research
  - Cancer gene therapy
  - Creating antisense drugs

Problems with Antisense Technology

Although there has been considerable progress in antisense and RNAi system over the past couple of years, various questions regarding delivery, regulation, cellular specificity and others remains to be addressed comprehensively. Antisense technology has not been perfected. It is still difficult to express aRNA only in targeted tissues. Precision gene therapy using aRNA needs to be improved because as it is right now, aRNA sometimes binds to mRNA that is not its target.

Conclusion: Antisense technology (including RNAi) is being employed increasingly as a gene knock down tool in the research laboratories and clinical development. RNAi has enjoyed a recent rapid expansion, but the extent of its applicability and ultimate role will evolve over time. Various companies and researchers have already established key rules in designing these molecules. Regardless there will be still much work to be done to properly understand the molecular process underlying the efficiency and specificity of antisense activity.

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45. PLANT BREEDING AND GENETICS 16023

RNA Dependent DNA Methylation: A New form of Gene Regulation

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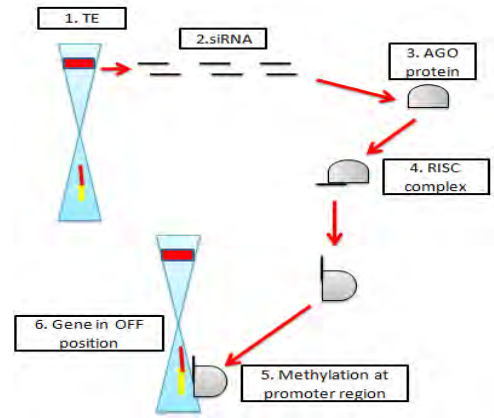
RNA dependent DNA methylation (RdDM) was firstly detected in viroid-infected tobacco plants as RNA-guided epigenetic modification of the genome by Wassenegger *et al.* in 1994. RNA-dependent DNA methylation (RdDM) is a nuclear process in which small interfering RNAs (siRNAs) direct the methylation of DNA sequences that are complementary to the siRNAs. RdDM was originally described in plants but appears to be evolutionary conserved and is also active in fungi, insects and mammals (Law and Jacobsen, 2010). In nature, the process can be triggered by a variety of different conditions like stress induction, transposon mobility, viral infection and other environmental changes. RdDM contributes to regulation of gene in plants. It also involve in evolution of species. It is important mechanism for creation of epigenetic changes.

Basic concept of RDDM for gene expression regulation:

1. Transposable elements in genome will produce siRNA
2. siRNA 24nt size
3. Argonaut protein
4. siRNA bind with Argonaut protein and make RISC complex
5. RISC complex bind with target region promoter site and lead methylation of promoter region
6. Due to methylation at promoter site gene go in off position



RNA Dependent DNA Methylation Pathway in *Arabidopsis thaliana*

RNA Pol IV produce ssRNA from which RDR2 produce dsRNA. DCL3 cut dsRNA in to 24nt specific RNA which transport to cytoplasm. siRNA bind with AGO4 with the help of HSP90 and make

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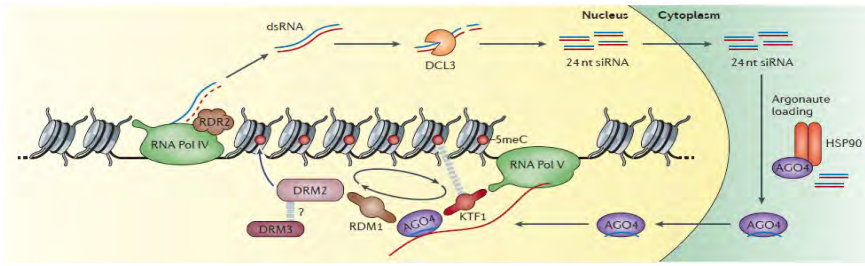
RISC complex. RISC complex transported to nucleus and make complementary with template RNA which produce by RNA Pol V. Then KTF1 and RDM1 make whole complex which lead DNA methylation at target site by DRM2. Sometime DRM3 also take role instead of DRM2.



Components of RdDM Pathway

RdDM pathway components	Full form	Function in RdDM pathway
RDR2	RNA dependent RNA polymerase 2	Make dsRNA from ssRNA
DCL3	Dicer like 3	Cut ds RNA and produce 24nt siRNA
HSP90	Heat shock protein 90	Loading of 24 siRNAs to AGO4
RNA Pol V	RNA polymerase V	mRNA produce from template DNA
KTF1	Kau domain containing transcription factor 1	Act as a adapter protein that binds to transcript generated by Pol V and
		require AGO-4
DRM2	Domains rearranged methyltransferase 2	Carry out methylation of DNA
RDM1	RNA-Directed DNA methylation 1	Binds to methylated ssDNA, fixation of RdDm complex to target region

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46. PLANT BREEDING AND GENETICS 16082

Advanced Backcross Quantitative Trait Locus (AB-QTL) Analysis: A Novel Crop Improvement Approach

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From early ages, humans have always focused on adapting the plants to satisfy their needs. Eventually, crop domestication was the selection process that started being implemented from then onwards. Favorable traits that arose from spontaneous mutation and recombination occur in wild populations and are continually selected at various stages of growth. This domestication has resulted in the transfer of many traits into the cultigens that fit the needs or desires of humans such as increased productivity and better quality. Finally man reached to a position where he noticed the bottlenecks of the domestication *i.e.* reduction in the gene diversity relative to their wild ancestors. Following domestication, the genetic diversity variation in crop plants has continued to be reduced by another force-modern plant breeding as new cultivars were the results from crosses among genetically related modern cultivars. Due to this, genetically more variable, but less productive, primitive ancestors are excluded. The shift of modern germplasm towards the narrow genetic base could result in broad susceptibility to abiotic hazards or newly emerging biotic hazards like insect pests and disease, thereby threatening long-term food and feed security. Growing concerns about genetic vulnerability have stimulated renewed interest in utilizing the more distant gene pools as a source of genetic variation in breeding programs. The wild progenitors and closely related species often contain novel alleles and thereby represent an important source of the genetic variation for crop improvement. In conventional breeding, the phenotype (physical appearance) of the crop is always considered in selection. This approach works well for the traits of interest controlled by one or a few genes, such as simply inherited resistance to diseases and insects. However, the agronomic performance of crop cultivars such as

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yield and quality components is mainly influenced by complex quantitative traits. Also, wild plants in general have smaller fruits; produce fewer seeds that often shatter and other undesirable traits compared to cultivars. Consequently, they appear to be deceptively poor as donors for enhancing yield. Finally, it can be difficult and time consuming to obtain interspecific hybrids and introgress useful traits selectively. The development of molecular markers and molecular linkage maps has made it possible to study the effects of the individual loci that control a quantitatively inherited trait (quantitative trait loci, or QTLs) and to utilize these QTLs for crop improvement. Genetic mapping of major genes and QTLs for many important agricultural traits have allowed the integration of biotechnology with conventional breeding process. Separating QTL discovery and cultivar development into discrete and sequential steps not only increases the time required for new cultivar development, but also reduces the likelihood that the QTL information is used to create a superior crop cultivar. Tanksley and Nelson (1996) proposed the advanced backcross QTL (AB-QTL) analysis as a potential solution by combining the discovery and transfer of valuable QTLs from unadapted germplasm into elite breeding lines into a single process. In the advanced backcross (AB) design, QTL analysis will be delayed until a later generation like the BC_2 or BC_3 generation. The logic behind this approach is that the effect of individual QTLs can be more precisely measured because undesirable effects of wild species on the elite background are reduced since later generation progenies such as BC_2 or BC_3 carry a smaller number of genes from the donor parent. In addition, if epistasis plays a major role in hybrid trait performance, MAS performed in AB progeny may be more effective than in the F_2 because recombination can break the assembly of favorable epistatic gene combinations accumulated by traditional breeding. Because an AB population is skewed toward the recurrent parent genome, favorable epistatic interactions among recurrent parent and tester alleles are less likely to be disrupted. AB-QTL analysis is especially suited for crops in which cultivars are inbred. AB-QTL analysis would be most readily applied to annual crops with relatively short generation times rather than long-generation perennial crops due to the development and exploitation of the necessary advanced backcross populations and near-isogenic lines with QTLs (QTL-NILs). It would be difficult to apply the method to highly heterozygous, out-crossing crops like alfalfa or clonally propagated crops like potato for which inbred lines are not commonly employed in breeding programs. Successful application of the AB-QTL approach in rice breeding can be viewed below mentioned table.

Population(s)	Traits/Genes evaluated	Authors
BC_2 testcross population	12 agronomically important quantitative traits	Xiao *et al.* (1998)
BC_4F_2, BC_4F_3 and NILs	Heading date	Yamamoto *et al.* (2000)
BC_2F_1 and BC_2F_2	Yield, yield components and morphological traits	Thomson *et al.* (2003)
BC_2F_2	Yield and yield component traits	Septiningsih *et al.* (2003a)
BC_2F_2	14 seed quality traits	Septiningsih *et al.* (2003b)
BC_3F_3 and BC_3F_4	Blast resistance	Wu *et al.* (2004)
BC_3F_1 hybrid families	Grain quality and grain morphology	Li *et al.* (2004)
RILs and BC_3F_3	Rice blast disease	Liu *et al.* (2004)
BC_2 testcross progeny	13 agronomic traits pertaining to yield and its components	Marri *et al.* (2005)
$F_{2:3}$ developed from BC_5F_6 line	Agronomic traits	Yoon *et al.* (2006)
BC_3F_4 NILs	Yield-related traits	Xie *et al.* (2008)
A set of 12 BC_2F_6 progenies	Yield and yield components	Cheema *et al.* (2008)
A BC_3F_3 line named BC116	Rice blast disease	Manosalva *et al.* (2009)

47. PLANT BREEDING AND GENETICS 16101

RNA Interference (RNAi): A Novel Approach to Gene Silencing

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RNA Mediated Defence Induction

RNA silencing is a type of gene regulation that, in plants, serves as an antiviral defence. RNA silencing is based on targeting specific sequences of RNA and degrading them. RNA silencing

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occurs in a broad range of eukaryotic organisms, including plants, fungi and animals. While plants use RNA silencing to defend themselves against viruses, the viruses, in turn, encode proteins by which they attempt to suppress the silencing of their RNA. The consensus is that RNA silencing is one of the many interconnected pathways for RNA surveillance and cell defence. RNA silencing was first observed in transgenic plants transformed with viral genes providing "pathogen derived resistance." It was noticed then that sense orientation genes in the transgenic plant interfered with the endogenous genes of the plant. Because of the concurrent suppression of both genes RNA silencing was at first called co-suppression."

RNA silencing, also called as RNA interference (RNAi) is due to a process that occurs after transcription (posttranscriptional gene silencing) of the RNA and involves targeted mRNA degradation. Clues of its existence came from the discovery that plants carrying viral transgenes were resistant to related strains of the virus that replicate in the cytoplasm, which meant that silencing occurs in cytoplasm rather than the nucleus.

RNA Interference (RNAi)

RNA interference (RNAi) is a molecular biology mechanism where the presence of certain fragments of double-stranded RNA (dsRNA) interferes with the expression of a particular gene which shares a sequence with the dsRNA that is homologous to that gene. RNAi is an important tool for the analysis of gene function in plants. This mechanism targets the RNA of the viral genome for degradation, and as the virus contains transcribed plant sequence, homologous host mRNAs are also targeted for destruction. Eukaryotic organisms have developed a mechanism to protect their genomes against RNA molecules that can cause gene silencing. RNA silencing is conserved across kingdoms and is manifested as quelling in fungi, RNA interference (RNAi) in animals, and cosuppression or Post Transcriptional Gene Silencing (PTGS) or Virus Induced Gene Silencing (VIGS) in plants.

Virus Induced Gene Silencing or Post Transcriptional Gene silencing

Virus-induced gene silencing (VIGS) in plants takes place if there is sequence similarity between the virus and either a transgene or an endogenous nuclear gene. From the examples involving viral transgenes, it is known that the mechanism is post-transcriptional and can be targeted, in a sequence-specific manner, against the transgene mRNA as well as the RNA genome of the virus. Because these examples involve cytoplasmic RNA viruses, it was inferred that the mechanism of VIGS involves destabilization of the target mRNAs in the cytoplasm. Post-transcriptional gene silencing also takes place in transgenic plants without virus infection. However, like VIGS, these examples of transgene-induced gene silencing can be targeted against viral RNAs, and it is likely that similar mechanisms are involved. Many of the reported examples of pathogen-derived resistance are probably manifestations of transgene-induced silencing targeted against viral RNA.

These reports that viruses can both initiate and be targets of gene silencing have prompted speculation that the mechanism is part of a defence system in plants against viruses. According to this idea, gene silencing would be activated naturally in virus infected plants and artificially in transgenic plants when the transgene or its RNA is perceived as part of a virus. Consistent with this proposal are examples of virus-induced virus resistance in non-transgenic plants that resemble gene silencing because the mechanism is targeted against RNA in a sequence-specific manner.

Components of Gene Silencing

1. DsRNA: Double stranded RNA longer than 30 nt (Endogenous/exogenous origin). **2. DICER (DCR in animals and DCL in plants):** It is a multidomain enzyme that belongs to the RNase III family which cleaves ds RNA into si RNA and mi RNA, respectively, **3. Small/short-interfering RNAs (siRNAs):** 21-25bp ds RNAs with a 2-nt 3'-overhang that result from cleavage of long dsRNAs or structured ss RNAs. 4. Micro RNAs are 21-23 bp dsRNAs with a 2-nt 3'-overhang that result from cleavage of cell hairpin precursor RNAs (pre miRNAs). **4. Argonaute:** proteins that bind to small RNAs and their targets. 5. **RNA-Induced Silencing Complex (RISC):** Contain several proteins *viz*; Ago2, FMRP & P100 besides siRNAs and binds to target mRNA. Degradation of target mRNA using exo-ribonuclease or loss of gene expression *i.e.* silencing. **6. Slicer:** is an activity of the Ago P1W1 domain that cleaves mRNA in the region of its complementary interaction with siRNA or miRNA in the RISC.

Mechanism of Post Transcriptional Gene Silencing (PTGS) or Virus Induced Gene Silencing (VIGS) in Plants

A viral gene of interest is inserted in the plant DNA (either during natural process of infection or during artificial inoculation with custom made vectors) where it is expressed and produces messenger RNA (mRNA), the viral gene may also be able to do that without being inserted in the plant genome. RNA viruses routinely produce double-stranded RNA (dsRNA) and RNA from some abnormal genes doubles up upon itself and forms aberrant" dsRNA. Both dsRNAs are cleaved by an enzyme called Dicer" into small interfering RNAs about 21—25 nucleotides long. The siRNA

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fragments split into individual ssRNAs and these combine with proteins and produce RNA induced silencing complex (RISC). RISC is activated which is ATP dependent process and unwinds the double stranded siRNAs. This RISC complex captures miRNAs that complement each short RNA sequence using the siRNA as a guide to find the target sequence. RNAs with a nearly perfect match of their sequence with that of small RNA are sliced into useless small fragments with the help of an endo-ribonuclease, which is then degraded by exo-ribonucleases resulting in a loss of expression of the gene. RNAs with less perfect sequence matches cause the RISC complex to block the movement of the ribosomes on the mRNA so that the mRNA is not translated and does not produce a protein, thereby silence that RNA. Some of the double stranded siRNAs may be used as primers by an RNA-dependent RNA polymerase resulting in the formation of another long strand of dsRNA that can continue through the RNAi pathway.

RNA silencing produces exceptionally strong virus resistance in transgenic plants. Such plants have neither detectable accumulation of virus in their inoculated leaves nor can this resistance be overcome. Once RNA silencing of the transgene is established, all RNAs homologous to the transgene, including those from an infecting virus, are degraded.

Systemic Signaling of VIGS

Although RNA silencing is triggered locally, it can spread throughout the plant via a mobile silencing signal. The movement of the silencing signal in the plant parallels that of the virus, moving at first from cell to cell and then entering the phloem and from there spreading out to parenchyma cells again. The parallel movement of the virus and RNA-silencing signal may represent a race between the two, with the out-come of the race being a successful infection if the virus moves faster and becomes established first, or resistance *i.e.* lack of infection, if RNA silencing becomes established first.

Applications of VICGS or PTGS: Functional Genomics - RNA interference can be used as a tool for determining gene function. Proteins and some RNAs are the functional components within a cell, thus the ability to selectively destroy RNA allows researchers to effectively repress gene expression. 2. Reverse genetic analysis - VIGS is an important tool in reverse genetic analysis, to ease and speed up analysis of gene function without the requirement of time- consuming transformation and tissue culture procedures. 3. All genes can be analyzed with VIGS, as researchers can pick a chromosome and systematically knock out genes as they appear sequentially. 4. Study of the genes involved in plant defense against pathogens and in cell development, such as transcription factors, using the VIGS system to facilitate functional analysis of plant genes. 5. Large-scale loss-of-function studies can now be performed using specific vectors and highly efficient cloning systems. 6. Possible next commercial reality — aesthetic benefits *viz;* blue rose flowers development using RNAi technology.

Limitations of VIGS or PTGS: VIGS phenotype is superimposed on, and complicated by chlorosis, leaf distortion and neurosis. Virus is not able to invade every cell, such that cells in which the target gene is not " silenced may obscure VIGS phenotype. Viruses commonly used in VIGS such as TMV. PVX and TGMV don't infect growing points of plant and therefore remain uninformative about genes effecting identity and development of plant tissue. Variation between experiments in proportion of plants showing VIGS phenotype.

48. PLANT BREEDING AND GENETICS 16111

CRISPR: A Genome Editing Tool

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INTRODUCTION: The latest ground-breaking technology for genome editing is based on RNA-guided engineered nucleases, which already hold great promise due to their simplicity, efficiency and versatility.

Clustered Regularly Interspaced Palindromic Repeats (CRISPR/Cas systems) are part of the adaptive immune system of bacteria and archaea, protecting them against invading nucleic acids such as viruses by cleaving the foreign DNA in a sequence-dependent manner.

The most widely used system is the type II clustered regularly interspaced short palindromic repeat (CRISPR)/Cas9 (CRISPR-associated) system from Streptococcus pyogenes.

The CRISPR arrays, including the spacers, are transcribed during subsequent encounters with invasive DNA and are processed into small interfering CRISPR RNAs (crRNAs) approximately 40 nt in length, which combine with the transactivating CRISPR RNA (tracrRNA) to activate and guide the Cas9 nuclease. A prerequisite for cleavage is the presence of a conserved protospacer-adjacent motif (PAM) downstream of the target DNA *i.e.* NGG (or less frequently NAG).

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CRISPER- Clustered Regularly Interspaced Palindromic Repeats Loci in 40% of bacteria and 90% archaea, **CAS 9** - CRISPR associated protein 9 a nuclease, an enzyme specialized for cutting DNA Cas1.Cas10 exist, **g RNA**- guide RNA – a construct/chimera of CRISPR RNA (crRNA) and trans-activating CRISPR RNA (tracrRNA), **PAM**- protospacer adjacent motif with sequence NGG (any, guanine, guanine) specific to Streptococcus pyogenes and 5'-NAG (any, adenine, guanine) PAM tolerated in human cells (only present in viral DNA- for identification)

Advantage of CRISPR/CAS9

- Simplicity, accessibility and versatility.
- Low cost and time saving comperetively other gemone aditing system.
- The CRISPR/Cas9 system does not require any protein engineering steps, making it much more straightforward to test multiple gRNAs for each target gene. Furthermore, only 20 nt in the gRNA sequence need to be changed to confer a different target specificity, which means that cloning is also unnecessary.
- The CRISPR/Cas9 technology is therefore more versatile for genome editing in plants generally but particularly suitable for monocots with high genomic GC content such as rice
- The same strategy can also be used to engineer large genomic deletions or inversions by targeting two widely spaced cleavage sites on the same chromosome mutant gene replaced by healthy copy.

Specificity of CRISPR/Cas9

- Several strategies have been developed to reduce off-target genome editing, the most important of which is the considered design of the gRNA.
- The CRISPR/Cas9 system is also easy to reprogram, so gRNAs can be tested for off-target effects rapidly and inexpensively.
- Optimizing nuclease expression is another way to control specificity because high concentrations of gRNA and Cas9 can promote off-target effects
- Altering the length of the gRNA can also minimize non-target modifications

Applications of Cas9 as a Genome Engineering Platform

A. The Cas9 nuclease cleaves DNA via its RuvC and HNH nuclease domains, each ofwhich nicks a DNA strand to generate blunt-end DSBs. Either catalytic domain can be inactivated to generate nickase mutants that cause single-strand DNA breaks.

B. Two Cas9 nickase complexes with appropriately spaced target sites can mimic targeted DSBs via cooperative nicks, doubling the length of target recognition without sacrificing cleavage efficiency.

C. Expression plasmids encoding the Cas9 gene and a short sgRNA cassette driven by the U6 RNA polymerase III promoter can be directly transfected into cell lines of interest.

D. Purified Cas9 protein and in vitro transcribed sgRNA can be microinjected into fertilized zygotes for rapid generation of transgenic animal models.

E. For somatic genetic modification, high-titer viral vectors encoding CRISPR reagents can be transduced into tissues or cells of interest.

F. Genome-scale functional screening can be facilitated by mass synthesis and delivery of guide RNA libraries.

G. Catalytically dead Cas9 (dCas9) can be converted into a general DNA-binding domain and fused to functional effectors such as transcriptional activators or epigenetic enzymes.

49. PLANT BREEDING AND GENETICS 16120

Coat Protein Mediated Resistance in Plants

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INTRODUCTION: Virus diseases cause serious losses worldwide in Horticultural and Agricultural Crops. Conventional breeding programme to develop resistance is effective but also protracted and expensive. Alternative approaches to reducing the effect of viruses suggested the use of the technique of genetic engineering for virus resistance (Sanford and Johnston, 1985). Transgenic plant resistance by expressing microbial-derived genes encoding a protein in the plant that are recognized by the plant surveillance system and activate the effective immune response. One such microbial-derived gene is the *coat protein genes* of virus.

Coat protein-mediated resistance is used to refer to the resistance caused by the expression of a virus coat protein (CP) gene in the transgenic plant. Expression of CP-gene products in the

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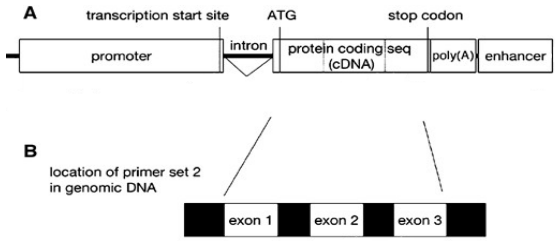
transgenic plant confers resistance to the virus and related virus from which it was derived. Coat protein-mediated resistance is also called as genetically engineered virus resistance, Virus coat protein protection, and genetically engineered cross-protection.

Mechanism of Coat Protein medicated Resistance

Uncoating and coating of the incoming virus particle are done by the proteins present within the cell. In the absence or less quantity of coat protein in the host cell favor uncoating of the virus particle and thereby promoting the viral replication in the host cell leading to the production of more viral particles and disease symptom. As the viral replication proceeds in the host cell, the coat protein quantity also increases this favor the coating of the viral particle by the same protein which had previously uncoated the viral particle.

The transgenic plant for the CP-gene leads to the formation of a large quantity of coat protein in the host cell. The high quantity of coat protein in the cell favor the coating whereby preventing the uncoating of incoming viral particle and prevent viral replication ultimately disease resistance. Transgene-derived coat protein also attaches to the movement protein binding site prior to virus attachment and prevent the long-distance spread of viral particle.

Method of Development



a) **Construction of CP transgene**: Isolation of cloned cDNA that represents the CP open reading frame. Modification of nucleotide sequences that affect the stability or translation of transcript eg. Addition of A/TXX**AUG**XC in the consensus sequences for efficient translational initiation and increased expression of the gene in the plant. Removal of the non-translated region at both 5' and 3' ends of the coding region and low G:C base pair.

b) **Promoter sequence:** Since the RNA virus does not contain promoters. Hence the CP-gene has to attach with a suitable promoter like P35S for the expression of the gene in the transgenic plant.

c) **Termination sequence:** 3'-end of the gene sequences are modified to contain polyadenylation (PolyA) tail confers termination of the transgene in a plant cell.

d) **Transformation of the Plant Cell:** It can be using suitable transformation methods like Agrobacterium mediated, Ballistic gene gun etc.

Examples of coat protein-mediated resistances

1. **Papaya Ringspot virus –** Papaya (Azad et al. 2014).
2. **Alfalfa Mosaic virus –** Alfalfa, Tobacco, and Tomato (Loesch-Fries et al. 1989).
3. **Cucumovirus: Cucumber mosaic virus –** Cucumber (Cuozzo et al. 1988).
4. **Potexvirus: Potato virus X –** Tobacco and Potato (Lawson et al. 1990).
5. **Potyvirus: Potato virus Y –** Potato and Tobacco (Stark and Beachy 1989).
6. **Tobamovirus:** Tobacco mosaic virus – Tobacco (Power et al. 1990).

Conclusion: Although the pathogen derived resistance to plant virus viz, coat-protein mediated resistance is a stable form of virus resistance and leading to the increased productivity in the agricultural and horticultural crops. Several stoppages like policy, environmental, human health issues are preventing the commercial release of these transgenic varieties which are still at the juvenile experimental stage of testing.

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50. PLANT BREEDING AND GENETICS 16150

Transgenic Bt Cotton

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INTRODUCTION: Cotton is one of the major fibre crops of global significance. It is cultivated in tropical and subtropical regions of more than eighty countries of world occupying nearly 33 m ha with an annual production of 19 to 20 million tones of boles. China, U.S.A., India, Pakistan, Afganistan, Australia, Brazil, Greece, Argentina and Egypt are major cotton producing countries. These countries contribute nearly 85% of the global cotton production. In India, cotton is being cultivated in 9.0 m ha and stands first in acreage. The crop is grown in varied agro-climatic situation across nine major states viz. Maharashtra, Gujarat, Madhya Pradesh, Punjab, Haryana, Rajasthan, Andhra Pradesh, Karnataka and Tamil Nadu. The crop is also grown on small area in Orissa, Assam, U.P. and West Bengal. Nearly 60 million people are engaged in cotton production, marketing and processing. The textile industry which utilizes the cotton provides employment to about 16% of the total workforce. Cotton in its various forms also serves as raw material for more than 25 industries.

What is Bt Cotton?

A genotype or individual which is developed by the techniques of genetic engineering is referred to as transgenic. In other words, genetically engineered organisms are called transgenics. A transgenic may be a plant, an animal or a microbe. Transgenic plants contain foreign gene or genetically modified gene of the same species. The foreign gene may be from a distantly related species, closely related species or unrelated species or from micro-organisms such as fungi, bacteria and viruses. Bt cotton refers to transgenic cotton which contains endotoxin protein inducing gene from soil bacterium Bacillus thuringiensis. The first transgenic plant was developed in 1983 in tobacco (Fraley *et al.*,1983) in U.S.A. In cotton, the first transgenic plant was developed in 1987 in U.S.A. by Monsanto, Delta and Pine companies (Benedict and Altman, 2001). Later on, the research work on development of transgenic was intensified all over the globe and several transgenic plants were developed. The transgenic cotton is of two types viz. (1) bollgaurd and (2) roundup ready cotton. The former confers resistance to bollworms and the latter is resistant to herbicides. The area under herbicide resistant transgenic cotton is restricted to USA. However, bollworm resistant Bt transgenic cotton has spread to several countries. Transgenic disease resistant cottons have not yet been developed. In India, a few resistant genes against Fusarium and Verticillium wilts have been isolated and are being transformed into cotton. Chinese scientists have isolated 'GO' gene and have transformed them into cotton which have shown resistance to both the wilts.

What are the Benefits of Bt Cotton?

The introduction of Bt cotton has provided growers with a new tool for managing bollworms in cotton. Numerous benefits of this technology occur to the grower, the global cotton industry, and society on many levels-economic, environmental and social. These benefits include direct benefits, such as reduced pesticide use, improved crop management effectiveness, reduced production costs, improved crop management effectiveness, improved yield and profitability, reduction in farming risk and improvement opportunity to grow cotton in areas of severe pest infestation. Indirect significant benefits of the technology include improved populations of beneficial insects and wildlife in cotton field, reduced pesticides runoff, air pollution and waste from the use insecticides, improved farm worker and neighbour safety, reduction in labour costs and time, reduction in fossil fuel use and improved soil quality. The most significant benefit of biotech cotton to date has been the reduction in insecticidal usage for the control of certain bollworms. Numerous studies, conducted across the United States and in Australia, China, Mexico and Spain, have demonstrated an overall reduction in sprays for Lepidoptera pests. The number of spray reduction ranges from 1.0 to 7.7 sprays per crop season. An average reduction of 3.6 sprays per crop has also been proved by large scale DBT testing of MAHYCO of hybrids in India in 2000-2001 seasons. Seven academies of science from around the world (the Royal Society of London, the U.S. National Academy of Sciences, the Brazilian Academy of Sciences, the Chinese Academy of Sciences, the Indian National Science Academy, the Mexican Academy of Sciences and the Third World Academy of Sciences) issued a report, Transgenic Plants and World Agriculture, in July 2000 spelling out the promise of agriculture biotechnology to alleviate hunger and poverty in the world. The paper urges governments to base

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their decisions regarding biotechnology on sound science and indicates that it will be critical to use the best science to make wise choices with respect to these technologies. It was pointed out that public health regulatory systems need to be put in place in every country to identify and monitor any potential adverse human health effects of transgenic plants, as is the case for any new plant variety. Likewise, environmental concerns must be addressed against the agricultural technologies currently in use that cause environmental problems. Procedures that most nations already have in place to approve the use of new crop plants could serve as the model for a more formal risk-assessment process. Also the report, Genetically Modified Pest-Protected Plants: Science and Regulation, published in April 2000 by the U.S. National Academy of Sciences, found to be valid to the principles that "There is no evidence that unique hazards exist either in the use of recombinant DNA techniques or in the movement of genes between unrelated organisms" and "Assessment of the risks of introducing recombinant DNA engineered organisms into the environment should be based on the nature of the organism and the environment into which it is introduced, not on the method by which it was produced". The initial commercial GE cotton crops are designed primarily to deal with pests. To the extent that they reduce overall pesticide use, they reduce the potential for collateral damage to non-target species, including humans.

FUTURE THRUSTS: The genetic resistance is the cheapest and the most efficient method of protecting crop plants from pests. The Bt transgenic cotton with inbuilt genetic resistance to bollworms will help in protection of natural enemies of insect pests *i.e.* predators and parasites. It will also help in reduction the cost of cultivation by reducing the use of pesticides. Moreover, it will reduce environmental pollution and health hazards caused by pesticidal use. Transgenic cottons with Bt endotoxin protein does reduce expenditure on insecticides and create eco-friendly environment without reduction in yield. The future research work on Bt transgenic cottons needs to be directed towards following thrust areas: 2. Through widespread cultivation of Bt transgenic cotton, the main risk is development of insect resistance against Bt toxin. Hence, multiple sources of resistance should be identified and used in developing bollworm and herbicide resistant Bt transgenic cottons to avoid the risk of developing insect resistance and herbicide resistant weeds. 3. Recently, some transgenic Bt cotton hybrids have been released for commercial cultivation in India. The seed of these transgenic hybrids is very costly. The price of seed is Rs.1600/- for a packet of 450 g. which cannot be afforded by small and marginal farmers. Hence, there is need to provide Bt transgenic seeds at cheaper rate, which can be afforded by small and marginal farmers. 4. Cotton crop also suffers from abiotic stresses such as drought and salinity. There is need to develop Bt transgenic cottons with resistance to drought and salinity conditions. 5. In case of hybrids, the farmer has to purchase fresh seed every year at a very high cost. Hence, efforts should be made to develop Bt transgenic straight cotton varieties, the seed of which can be used by the farmers for 3-4 years. 6. Cotton is a fibre, oil and protein yielding crop. There is need to improve the quality of proteins and oil through genetic engineering besides fibre quality improvement. 7. Besides, Bt gene, several other genes can be used in future for developing resistant genotypes of cotton to various insects. For example, cholesterol oxidaze gene from Streptomycetes fungus can be used for developing boll weevil resistant genotypes. 8. The spider and scorpion venom genes can also be used for developing insect resistant genotypes of cotton. 9. The Helicoverpa armigera stunt virus contains three genes which attack midgut of Heliothis and ceases its feeding.

51. POST-HARVEST MANAGEMENT 16110

Non-Destructive Methods for Quality Analysis of Fruits

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Nowadays, people pay more and more attention to their health; fruit consumption is increasing due to not only their good taste and appearance, but also the health benefits from their vital components such as phenolics, polysaccharides, proteins, vitamins and minerals. Increasing consumer demand for high quality fruits has need to develop and adopt advanced technologies in post-harvest in terms of growing demand for quality products.

What is Quality?

Quality means degree of superiority or excellence. A combination of characteristics attributes and properties that gives the value to human and enjoyments. Quality can be judge by five senses such as touch, sight, smell, taste and hearing. There are mainly two component of quality *i.e.* internal and external quality. Appearance, flavor,

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texture, nutritive value, and defect factors are generally recognized as the five quality factors of fruits.

What is Non Destructive Method?

Today, measuring the quantity and quality of agricultural products without any injuries has a special position in post-harvesting and processing of agricultural products. In this regard, various non-destructive methods *i.e.* means quality evaluation of fruits without damaging fruit sample have been developed to detect internal properties of crops which many of them come to the practical application as used in the grading system. These methods are replacing traditional ones which were too expensive, unreliable, difficult and exhausting. On the other hand, the power of human visual perception is too limited because of the human narrow band of the electromagnetic spectrum which cause the human decision with errors and even impossible about identifying the quality factors such as flavour in fruits, the amount of nutrients, texture and internal injuries, near about all physico-chemical properties and defects are judged by these methods.

Why Nondestructive Methods?

The first and most important reason for using nondestructive method is export rejection. If growers cannot fulfill the quarantine needs and meet their quality requirement, the export consignment may reject. From consignment randomly a sample of fruit is taken to estimate the quality of batch, but the sample may not ensure the quality of whole batch. Other reasons are sample not destroyed, quick and almost instantaneous, simultaneously determination of many parameters, online application for bulk handling etc.

Non Destructive Methods –

In recent years, on one hand, nondestructive methods of fruit quality assessment have get momentum; on the other hand, considerable assay have been made to expand these nondestructive methods. Most of these methods are based on optical, vibrational, transmission, an electrical etc. characteristic, which is subsequently correlated with various physicochemical quality parameters.

1. **Near Infrared Spectroscopy –** This method is no longer new; as it started in early 1970, just after some reports from America. The use of near-infrared spectroscopy as a rapid and often nondestructive technique for measuring the composition of biological materials has been demonstrated for many commodities. NIR as a nondestructive method for quality evaluation was started for the determination of sugar content in intact peaches, Satsuma orange and similar other soluble solids. Similarly, a nondestructive optical method for determining the internal quality such as sucrose content, sorbitol content, etc. It also use for grading citrus. Now various NIR spectrometers are available and are being used commercially. Some modifications in these available spectrometers, especially for holding the intact samples, are reported. It is based on electromagnetic radiation between visible wavelength and near infrared wavelength.
2. **X-ray and computerized tomography (CT) -** X-ray imaging is an established technique to detect strongly attenuating materials and has been applied to a number of inspection applications within the agricultural and food industries. It is use for detection of bruises, water core and internal browning of apples, injury in papaya, maturity of peaches, freeze damage, dry sections and granulation in oranges, split pit in peaches and changes of peach internal structure during ripening.
3. **Ultrasonics and Acoustic Technology -** Ultrasonic vibrations are above the audible frequencies (> 20 kHz). These waves can be transmitted, reflected as they interact with material. Wave propagation velocity, attenuation and reflection are important parameters used to evaluate the tissue properties of fruits. Through this technique ripening, firmness, maturity and other internal quality of fruits judged.
4. **Magnetic Resonance Imaging -** The nuclear magnetic resonance technique, often referred as magnetic resonance imaging (MRI) involves resonant magnetic energy absorption by nuclei placed in an alternating magnetic field. The amount of energy absorbed by the nuclei is directly proportional to the number of a particular nucleus in the sample such as the protons in water or oil. There are many applications of NMR in agriculture. The simplest among them is the determination of seeds in orange, hallow heart, invisible bruises and translucency in over ripe pineapple, internal defects such as pits, dry regions, insect bodies air filled cavities etc., moisture and oil content in avocado.
5. **Fluorescence technique -** Fluorescence refers to the property of light emitted by molecules of a particle when they are excited by photons. Short wavelength light such as UV light is used. The main application concern chlorophyll inflorescence.
   Eg. The chlorophyll fluorescence yield decrease with the ripening of papaya fruits. The instrument used named as portable fluorimeter. Also used to monitor grape maturation specially monitoring anthocynin accumulation.
6. **Electronic Nose -** An Electronic Nose, also called an Artificial Olfactory System, is a

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machine that is designed to detect and discriminate among complex odors using sensor arrays. The sensor array consists of broadly tuned sensors that are treated with a variety of odor-sensitive biological or chemical materials.

During ripening, fruits release volatiles in their surrounding atmosphere. On that basis maturity of fruits, monitoring fermentation process etc. can be judge. E-nose technique is simple, rapid and appears to be useful for discriminating fruits. It can detect chemicals in concentrations so small that people could not smell them. It can also detect chemicals that people find "odorless" and toxic in nature. It doesn't suffer from "odor fatigue," the human tendency to grow insensitive to smells that start small and increase gradually.

7. **Multispectral and Hyperspectral Imaging -** Although digital color cameras (RGB) have been designed to acquire the same red, green, and blue bands captured by the human eye, the extraction of quality aspects corresponding to small contrasts in the images (bruises, ripeness stages, etc.) remains very challenging. These very small differences might be detected with more advanced image processing algorithms; however, the computation costs are very often too high for use in the food industry. Instead of trying to detect these very small differences, it might be more efficient to enhance the contrast. Multi- and hyperspectral imaging aims to combine the spectral information content and discriminating power of point spectroscopy with the spatial information content of machine vision. In multispectral imaging, images are acquired at a small number of wavebands (5--10), whereas many more wavebands are included in hyperspectral imaging.

Future Tendencies

- The future lies in the fusion of different methods to provide systems that gives more global information on each fruit.
- Integration of such methods should ensure consumer purchase quality product.
- There is a need for a concerted effort by various Indian research institutes for accelerated development of low cost non-destructive methods for quality evaluation of major fruits of India in order to have major share in the world market.

Conclusion

- NDT provides constitutional variation of the fruits. These are now available for many quality attributes.
- Their accurate quantification, leading to better characterization, improved quality and safety evaluation results.
- It is gaining a good momentum in the global horticulture industry. As these methods are instantaneous and can simultaneously determine many parameters, could be used for bulk handling of produce.

52. SEED SCIENCE AND TECHNOLOGY 15997

Seed Dormancy

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Seed dormancy is defined as a state in which seeds are prevented from germinating even under environmental conditions normally favourable for germination. These conditions are a complex combination of water, light, temperature, gasses, mechanical restrictions, seed coats, and hormone structures.

Classification of Dormancy

A. Innate dormancy / primary dormancy: It is the state of the seed itself or dormancy induced in the seeds at the time of dispersal from the mother plant *i.e.,* the dormancy may be induced before maturity, during maturity and after maturity but before seed is dispersed from mother plant.

B. Secondary dormancy: Secondary dormancy can take place only in a matured and imbibed seed by certain environmental conditions, which are unfavourable to germination. (*e.g.*) Spring wheat and winter barley, the secondary dormancy could be imposed by

1. Exposure of dry barely seed to temperature between 50 and 90^{0}C
2. Storage of winter barely for seven days in high moisture containers at 20^{0}C
3. Storage of spring wheat for one day at high moisture content in airtight containers at 50^{0}C
4. Placement of seed under water and in darkness for 1 to 3 days at 2^{0}C

Induction of secondary dormancy was possible one and half months after physiological maturity. Secondary dormancy in spring wheat could not be broken by two weeks of storage.

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However, it was completely broken by treatment with 0.1% GA_3, 0.5 to 1.0% ethanol, low temperature stratifications, removal of pericarp and storage at 20°C.

Secondary Dormancy Mechanism

- Imposition of blocks of crucial points in the metabolic sequence that leads to germination
- An unfavourable balance of growth promoting versus growth inhibiting primary dormancy (coat imposed dormancy)

In many species seed dormancy is imposed by the structures surrounding the embryo (seed coat), which may include glumes, palea and lemma (grasses, the pericarp, perisperm and endosperm). The embryo in these cases is non-dormant one.

Primary dormancy is further classified into endogenous and exogenous.

Exogenous dormancy is due to the seed coat factor either due to presence of inhibitors or hard seed nature. It is further classified into,

a) **Physical** – Dormancy is due to the hard seed coat which prevents the entry of water and sometimes gaseous exchange is also prevented. *e.g.* Hard seeds of pulses, acacias. prosopis, sapota etc.,
b) **Chemical** – Presence of some inhibitors in the seeds coat which prevents the germination
c) **Mechanical** – restriction of the growth of protruding radicle due to structure. (*e.g.*) inadequate space in the seeds of *Terminalia* sp.

Endogenous dormancy – Dormancy due to embryo. May be the presence of inhibitors, immature embryo or combination of both. It is further classified into

a) **Morphological** – Due to immature embryo, which is not able to putforth germination even under favourable conditions. (*e.g.*) Apple
b) **Physiological** – Due to arrest of the metabolic activity in the seeds due to presence of some inhibitors like ABA, coumarines, phenols etc.,
c) **Morphophysiological** – Combination of immature embryo with inhibitors.

Secondary Dormancy

Whose germination is inhibited, fail to recover even when the inhibitory factor is removed. Adoptive mechanism to pass the adverse environmental condition.

Types of Secondary dormancy

a) **Thermo** – Dormancy due to temperature
b) **Skoto** – Light; Photo – Quality of light and Osmotic – stress or high osmotic stress prevents germination

According to Harper (1977) dormancy may be classified into following,

1. Nature of origin
   a) Innate
   b) Induced
   c) Enforced
1. Time of origin
   a) Primary
   b) Secondary
1. Location of dormancy
   a) Exogenous
   b) Endogenous
   c) Combined

Advantages of Dormancy

1. Storage life of seed is prolonged
2. Seed can pass through adverse situation
3. Prevents the *in situ* germination.

Disadvantages

1. Long periods of time needed to overcome dormancy (for uniform germination)
2. Contributes to longevity of weed seed.
3. While raising a crop it is very difficult to maintain the population in the field with dormant seed lot

53. SEED SCIENCE AND TECHNOLOGY 16051

Genetics of Seed Longevity: An Overview

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INTRODUCTION: Seed deterioration can be defined as "deteriorative changes occurring with time that increase the seed's vulnerability to external challenges and decrease the ability of the seed to survive." The seed longevity record is ~2000 years dated by radiocarbon dating and is hold by date palm (*Phoenix dactylifera* L.). Seed longevity is an important trait in the context of ex-situ conservation and it is clear that the management of seed banks would benefit from understanding of the factors which determine both inter- and intraspecific variation in this trait (Nagel and Borner, 2010). The rate of seed aging mainly determined by environmental and genetic factors and also by physical, chemical and molecular factors.

What Causes Seed Deterioration?

A new consensus is emerging regarding a common cause of seed deterioration and perhaps

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the most frequently cited is the production of free radicals that causes profound damage within a cell. The mtDNA is more prone to free radical attack than nuclear DNA and is attributed to: (1) mitochondria are the principal site of oxygen utilization that results in a greater level of free radical production. (2) mtDNA being naked, whereas nuclear DNA is protected by special proteins called histones. (3) Very fewer repair enzymes exist around mtDNA than nuclear DNA. Every percentage increase in moisture during storage, coupled with a raise in temperature, lowers the integrity of the nuclear DNA and the performance of the embryo at germination. The genetic basis of seed longevity is unclear. However, there are several groups of mutants that have altered seed longevity. Mutations in the key regulators of seed maturation lead to rapid loss of viability upon storage, as has been shown for leafy cotyledon1 (lec1) and abscisic acid intensitive3 (abi3) mutants (Sugliani *et al.*, 2009). The testa-defective mutants, including transparent testa (tt) and aberrant testa shape (ats; Debeaujon *et al.*, 2000), display considerably reduced seed longevity.

Role of DNA Repair and Telomere in Seed Longevity

As seeds aged or in poorly germinating old seeds, frequent chromosomal aberrations were commonly found at first metaphase or anaphase (Navashin, 1933). These aberrations reflect the overall loss of DNA integrity in the dry seed and the lowered ability to repair DNA on imbibition. It is knew that in almost all eukaryotes there are highly conserved special reiterated tandem short oligonucleotide sequences (5'-$(TTTAGGG)_n$-3'), the telomeres, that cap and protect the ends of chromosomes. These DNA termini (telomere) prevent the end of chromatids from being recognized as DNA breaks and so to stop them being repaired and rejoined into aberrant non-linear chromosome abnormalities observed at first cell divisions of aged seeds. Bucholc and Buchowicz (1992) showed that telomere lost from high-molecular-weight DNA on storage are restored to chromosomal DNA within few hours (3-6 hr) of imbibition, that is before the initiation or completion of S-phase. However, increased telomerase activity in other plant tissue has been associated with the S-phase of the cell cycle (Tamura *et al.*, 1999) and so it may be that telomerase is neither reactivated nor newly synthesized until the first S phase germination. Extra-chromosomal telomere containing mini-fragments or mini circles of DNA may therefore play a critical role in the regaining of telomere multiples at the very early stages before S-phase, which is considered as very crucial in seed longevity.

Genetic Variability, Molecular Markers/QTLs and Candidate Genes for Seed Longevity

Genetic variability for seed longevity observed in various crops (soybean, corn etc.) and also varies within crops among the varieties which is attributed to various seed traits (seed germination, seed vigour, seed composition etc.). Therefore, the genetic variability exist among aged seeds of different crops/varieties/inbred lines etc. could be used for association studies with seed germination. Revilla *et al.*, 2009 identified genes related to germination and seed longevity in aged seeds using the sweet corn inbred line P39 and the field corn inbred line EP44. They also compared the bulks of living and dead seeds after 20 and 22 years of storage by using simple sequence repeats (SSRs) and, when the bulks differed for a marker, the individual grains were genotyped and this differences between dead and living seeds could be explained by residual variability, spontaneous mutation, or ageing. They also noticed larger variability for chromosome 7 than for other chromosomes, and for distal than for proximal markers, suggesting some relationships between position in the genome and viability in aged seed. This variability was significantly higher for distal markers than for proximal markers across all chromosomes, which is in agreement with the theory that associates telomere stability and longevity (Monaghan and Haussmann, 2006). This result suggests that at least part of the variability could actually be explained by degradation of DNA due to ageing. Therefore, genetic variability among aged seeds of inbreds/varieties was useful for preliminary association analysis to identify candidate genes. The polymorphic SSRs between living and dead seeds were found in six known genes, including pathogenesis-related protein 2, superoxide dismutase 4, catalase 3, opaque endosperm 2, and metallothionein1 that were related to germination, along with golden plant 2. In addition, five novel candidate genes have been identified; three of them could be involved in resistance to diseases, one in detoxification of electrophillic compounds and another in transcription regulation.

Genetic markers for improved seed longevity would be useful to allow breeders to incorporate this trait into seeds, as conventional ageing tests are generally too slow to be useful in selection. Thus such early indicators (markers) of seed deterioration would also be valuable to enable seed companies to harvest, process, store, ship, market, and replenish seed stock costs effectively. To date, there are no reliable indirect genetic markers for seed longevity, though a number of candidate genes have been reported to influence longevity (Sattler *et al.*, 2004; Bentsink *et al.*, 2006; Prieto-Dapena *et al.*, 2006). However, number of quantitative trait loci (QTLs) controlling seed longevity identified in different crops (Table1).

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TABLE 1. Quantitative trait loci (QTLs) controlling seed longevity in different crops

Crop	QTLs/chromosomes associated with seed longevity	Author or reference
Rice	QTLs were identified on seven of the 12 chromosomes, although only one of these—on chromosome 9—appeared repeatedly. With respect to homoeology, chromosome 1 of rice is comparable with wheat group 3, 2 with group 6, 3 with group 1, 4 with group 2 and 9, 11 and 12 with group 5 chromosomes of wheat.	(Kurata *et al*. 1994; Salse *et al*. 2008).
Rice	12 QTLs for seed longevity on chromosome 7 and 9	Sasaki, 2008
Wheat	The major longevity QTL QLng.ipk-2A mapped to a region of chromosome 2AS that also carries several pathogen defence response genes; in particular, the QTL is flanked by Per2 (peroxidase) and Wip (wound-induced protein) (Li *et al*. 1999). The minor QTL QLng.ipk-3B mapped to a region of chromosome 3B also implicated in the yield components grains per ear and thousand grain weight.	Rehman *et al*., 2011
Barley	Chromosomes 2H, 5H and 7H	(Nagel *et al*. 2009).
Maize	QTLs controlling seed viability loss were identified	Casarini *et al*., 2004
Lettuce	Multiple longevity-associated QTLs were identified. A major QTL on chromosome 4 was responsible for almost 23% of the phenotypic variation in viability with improved longevity conferred by the Salinas allele.	Schwember and Bradford, 2010

Marker Assisted Selection (MAS) for Seed Longevity A Case Study

Miura *et al*., 2004 identified QTLs for low temperature germinability and seed longevity in rice using backcross inbred lines (BILs) derived from a cross between a *japonica* variety Nipponbare and an *indica* variety Kasalath in order to facilitate MAS of these traits and to confirm the efficiency of backcross breeding to introduce accelerated coleoptile growth into japonica elite varieties from foreign varieties. Three putative QTLs for seed longevity, qLG-2, qLG-4 and qLG-9, were detected on chromosomes 2, 4 and 9, respectively. The QTL qLG-9, with a large effect on seed longevity was detected and explained 59.5% of total phenotypic variation in BILs. The Kasalath allele in the case of qLG-9 will be useful for improving seed longevity in rice. Further, MAS may helpful to select plants with QTL/marker (qLG-9) because the phenotyping for seed longevity is not easy due to variable environmental conditions during seed development, seed processing and storage.

Conclusion: The genetics of seed longevity is still at an early stage. An improved understanding will require the analysis of variation for the trait across a more diverse range of germplasm and environments (different storage conditions). The identification of favourable alleles offers perspectives for the prediction of seed longevity in germplasm collections. Further work identifying the genes associated with these QTLs and developing molecular markers for them may enable breeding for improved seed longevity or assist in elucidating mechanisms responsible for seed deterioration during storage. If these mechanisms could be understood, we might someday be able to greatly increase the seed longevity of agriculturally important species and varieties, thereby enhancing our ability to preserve plant genetic resources for generations to come.

54. PLANT PATHOLOGY 15713

Forecasting of Occurrence of Diseases and Pests based on Weather Conditions in Agriculture

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Forecasting allows the prediction of probable outbreaks or increase in the intensity of the diseases and pests, hence helps to determine when or where particular management practices should be applied. Forecasting based on weather factors during a plant disease or pest epidemic is more difficult as there is a need for the continuous monitoring of several different factors (temperature, relative humidity, leaf wetness, rain, wind, and cloudiness) at various locations.

However, several types of electronic sensors have been developed that produce electrical outputs recorded easily by computerized data loggers. Such computerized sensors are now

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prevalent in many countries and have improved studies of weather in relation to disease greatly and have facilitated the acceptance and use of predictive systems for disease control on the farm. To develop a plant disease or pest forecast, one must take into account several characteristics of the particular pathogen, pest, host, and environment.

Development of disease or pest may be predicted by assessing the amount of the initial inoculums and economic threshold level (ETL) respectively. For example, in case of late blight of potato and tomato (*Phytophthora infestans*), cool temperatures between 10 and 24°C and the relative humidity over 75% for at least 48 hours or at least 90% for 10 hours each day for 8 days, then infection will take place and a late blight outbreak can be expected from 2 to 3 weeks later.

Hence according to diseases, computerized predictive systems have been developed *viz.,* BLITECAST for late blight, FAST (for forecasting *Alternaria solani* on tomato), TOMCAST for tomato early blight, *Septoria* leaf spot, and anthracnose and PLAM for peanut leaf spot. From this information weather severity values are calculated, infection and disease severity values are predicted, and recommendations are issued to growers as to when to begin spraying.

Several leaf spots, such as those caused by the fungi *Cercospora* on peanuts and celery and *Exserohilum* (*Helminthosporium*) *turcicum* on corn, can be predicted by taking into account the number of spores trapped daily, the temperature, and the duration of periods with relative humidity near 100%. An infection period is predicted if high (95–100%) relative humidity lasts for more than 10 hours, and growers are then urged to apply chemical sprays immediately.

In case of pest forecasting there are mainly two models (Day- Degree model and Phenology model). Degree day (DD) is way of measuring of insect growth and development in response to daily temperature and phenology model is driven by many weather factors. Forecasting models are available for many pests like codling fly of apple, diamond back moth (crucifers), Colorado potato beetle, tomato fruit borer and many others. Hence disease or pest forecasting is extremely useful to farmers in practical management of economically important diseases and pests.

55. PLANT PATHOLOGY 16017

Priming for Enhanced Defense against Plant Pathogens

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Priming of Defense

Priming is a mechanism which leads to a physiological state that enables plants to respond more rapidly and or more robustly after exposure to biotic or abiotic stress. The "primed" state has been related to increased, more efficient activation of the defense response and enhanced resistance to challenging stress. This increased alertness correlates with no or minimal gene induction. The primed state results from the improved perception and or amplification of defense response-inducing signals, rather than from the direct activation of these defense responses (Conrath, 2009).

Plant Defense Response

The plants were protected by inducible defense mechanisms in which the signal molecules salicylic acid, jasmonic acid and ethylene often play crucial roles. Elucidation of signalling pathways controlling induced disease resistance through plant-pathogen interactions. The capacity of a plant to develop a broad-spectrum, systemic acquired resistance (SAR) after primary infection with a necrotizing pathogen is well known and its signal transduction pathway extensively studied. Plants of which the roots have been colonized by specific strains of non-pathogenic fluorescent *Pseudomonas* spp. develop a phenotypically similar form of protection that is called rhizobacteria-mediated induced systemic resistance (ISR). In contrast to pathogen-induced SAR, which is regulated by salicylic acid, rhizobacteria-mediated ISR is controlled by a signalling pathway in which the phytohormones jasmonic acid and ethylene play key roles.

There are basically two ways of defense response are mediated against plant pathogens.

- Biological and chemical mediated defense
- R gene mediated defense

Biological and Chemical Mediated Defense Response

Biologically-induced disease resistance occurs after root colonization by selected strains of non-pathogenic *Pseudomonas* spp. This type of resistance is generally called rhizobacteria-induced systemic resistance. ISR has been demonstrated in different plant species against several pathogens under conditions where the rhizobacteria and the pathogen remained spatially separated (Pieterse *et al.*, 2002). The expression of rhizobacteria-mediated ISR was shown to be

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independent of the presence of SA or enhanced *PR*-gene expression. Phenotypically, rhizobacteria-mediated ISR resembles pathogen-induced SAR. Although the terms SAR and ISR are synonymous (Hammerschmidt, 2009), for convenience we distinguish between pathogen- and rhizobacteria-induced resistance by using the term SAR for the pathogen-induced type and ISR for the rhizobacteria-induced type of resistance. The non-protein amino acid β-aminobutyric acid (BABA) appears to have a different mode of action. Like ISR, it induces resistance without the expression of *PR*-genes. However, BABA can induce resistance to *H. parasitica* in *Arabidopsis* independent of SA, JA or ET, through a signaling pathway that requires abscisic adid (ABA) and involves priming for callose depositon (Ton *et al.* 2005). On the other hand, BABA-induced resistance against the bacterial pathogen *Pst* DC3000 and the fungal pathogen *B. cinerea* is SA dependent (Zimmerli *et al.* 2001). A large variety of chemicals have been shown to activate the SAR response. Benzothiadiazole (BTH), 2, 6-dichloroisonicotinic acid (INA), and SA induce the same set of *PR* genes comparable to biologically-induced SAR. Using parsley cells as a model, SAR induction by the commercially available plant activator BION and the biological agent Milsana, as well as a large group of related chemicals was demonstrated.

R Gene Mediated Defense Response

Plant *R* genes encode proteins that resemble signal transduction components and fall into at least six classes (Martin *et al.*, 2003). The largest class encodes an amino-terminal coiled-coil (CC) or TIR (Toll–interleukin receptor homology) domain, fused to a central nucleotide binding- site (NBS) domain, and a carboxy-terminal region that contains leucine-rich repeats (LRR). In *Arabidopsis*, over 150 NBS–LRR genes are believed to be involved in disease resistance. Recognitional specificity resides in the LRR domain, and potentially in the TIR domain (Jones, 2001). A second major *R*-gene class encodes proteins with extracellular LRR and receptor-like kinases (Brueggeman *et al.*, 2002) In *Arabidopsis*, there are several hundred of these genes, but except for three (*Cf*, *Ve*, and *RPP27*) most are not involved in disease resistance. Therefore, initial specific recognition between plant proteins and fungal elicitor molecules can be mediated through the NBS–LRR proteins, LRR receptor- like protein kinases, and through recognition (direct or indirect) of pathogen avirulence (effector) molecules. There are prospects for the use of *R* genes in transgenic plants to enhance resistance to fungal pathogens. For example, the *Rpg1* gene from barley (Horvath *et al.*, 2003) and the tomato *Cf9* gene (Hennin *et al.*, 2001) as well as *Ve1* and *Ve2* genes (Kawchuk *et al.*, 2001) provided enhanced resistance against stem rust in barley (caused by *Puccinia graminis* f. sp. *tritici*), *Leptosphaeria* in canola, and verticillium wilt in potato (caused by *Verticillium dahliae*), In addition, the *Arabidopsis R* genes *PPW8.1* and *RPW8.2* conferred enhanced resistance against powdery mildew infection in transgenic tobacco (Xiao *et al.*, 2003), while the flax rust resistance gene *L* provided resistance to *Cercospora* and *Phytophthora* in transgenic tobacco (Frost *et al.*, 2004).

TABLE 1. Transgene for plant pathogens resistance

Transgene	Source	Target species	Parhogen	Reference
Vst I [Stilbene (resveratrol) synthase]	*Vitis Vinifera*	*Nicotiana Tabacum*	*Botrytis Cinerea*	Hain et al. (1993)
Aglul, RCH10	Alfalfa, Rice	*Nicotiana Tabacum*	*Cercospora Nicotiane*	Zhu *et al.* (1994)
PR-3(I)	*Rice*	*Rice*	*Rhizoctonia solani*	Lin *et al.* (1995)
Aglul, RCH10	Alfalfa, Rice	Alfalfa	*Pbytopbthora megasperma f.sp. medicaginis* (Pmm)	Masoud et al., 1996
PR-3(I)	Rice	Cucumber	*Botrytis cinerea*	Tabei et al. (1998)
Vst I (Stilbene (resveratrol) synthase) pss (pinosylvin synthase)	*Vitis vinifera, pinus sylvestris*	*Hordeum vulgare, Triticum aestivum*	*Botrytis cinerea; Puccinia recondita f.sp. tritici & Stagonospora (Septoria) nodorum*	Leckband and Lorz (1998); Serebriakova et al. (2005)
RCC2	Rice	Grape vine	*Uncinula necator, Elisinoe ampelina*	Yamamoto *et al.* (2000)
Synthetic D4EI	*Cecropia* (insect)	*Nicotiana tabacum*	*Colletotrichum destructivum*	Cay *et al.* (2000)
AiiA	*Bacillus*	*Solanum tuberosum*	*Pectobacterium (Erwinia) carotovora*	Dong *et al.* (2001)
RC7 cbitinase PR-3	*Oryza sativa*	*Oryza sativa*	*Rbizoctonia solani.*	Datta *et al.* (2001)
Gf-2.8 (oxalateoxidase)	*Triticum aestivum*	*Glycine max*	*Sclerotinia sclerotiorum*	Cober *et al.* (2003)
CrylAb (Bt toxin)	*Bacillus thuringiensis*	*Zea mays*	*Fusarium spp*	Clements *et al.* (2003); Hammond *et al.* (2004)

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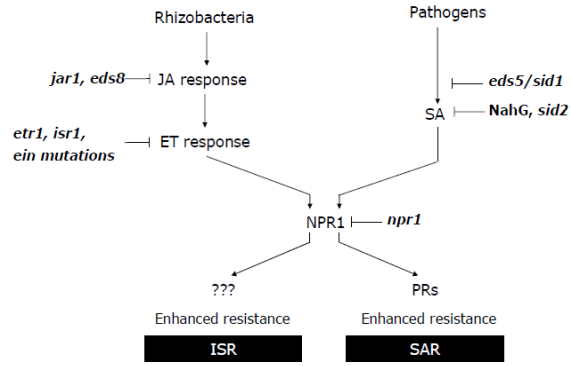
Transgene	Source	Target species	Parhogen	Reference
Gf-2.8 (oxalate oxidase)	*Triticum aestivum*	*Populus euramerica na*	*Septoria musiva*	Liang et al. (2004)
Rcbit	*Rice*	*Pigeon pea*		Kumar *et al.* (2004)
9f-2.8 (oxalate oxidase) & TaPERO (peroxidase)	*Triticum aestivum*	*Triticum aestivum*	*Blumeria graminis f.sp. tritici*	Altpeter *et al.* (2005)
Chit	French Bean	Cotton	*Verticillium dahliae*	Masoud *et al.* (2005)
Chill (chitinase) Tip (PR-4)	*Oryza sativa*	*Oryza sativa*	*Rhizoctonia solani*	Kalpana *et al.* (2006)
NPRI	*Arabidopsis thaliana*	*Triticum aestivum*	*Fusarium graminearum*	Makandar et al. (2006)
KP4	*Virus infecting Ustilago maydis*	*Triticum aestivum*	*Tilletia caries*	Schlaich *et al.* (2006)
Gfzbd101	*Clonostachys rosea*	*Zea mays*	*Fusarium graminearum*	Lgawa *et al.* (2007)
Synthetic D4EI	*Cecropia (insect)*	*Gossypium hirsutum*	*Thielaviopsis basicola*	Rajasekaran *et al.* (2007)
Chi 18 (chitinase)	*Solanum tuberosum*	*Raphanus sativus* Linn	*Rhizoctonia solani*	Yang *et al.* (2009)

Mechanisms of Priming Defense

1. Systemic acquired resistance: The local infection by a necrotizing pathogen leading to an HR, the enhanced state of resistance extends systemically into the uninfected plant parts. During the onset of SAR, a locally altered transcriptional response precedes the hypersensitive reaction and a second wave of transcriptional reprogramming, not apparent in a virulent attack, marks the transition from basal to induced resistance. The induction of SAR is accompanied by local and systemic accumulation of endogenous levels of the plant hormone SA, followed by *PR*-gene expression (Metraux *et al.* 1990). The importance of the accumulation of SA for the expression of SAR was demonstrated by using transgenic NahG plants. These plants express the bacterial salicylate hydroxylase *nahG* gene, making them incapable of accumulating SA. NahG plants do not show a SAR response (Ryals *et al.* 1996). Exogenous application of SA, or one of its functional analogs BTH or INA, leads to the full expression of SAR.

2. Induced systemic resistance: Plants produce exudates and lysates at their root surface, where rhizobacteria are attracted in large numbers (Walker *et al.*, 2003). Selected strains of non-pathogenic rhizobacteria are named plant growth-promoting rhizobacteria (PGPR), because they possess the capability to stimulate plant growth (Pieterse *et al.*, 2003). *Pseudomonas* spp. is among the most effective PGPR. Moreover, they have been shown to be responsible for the reduced activity of soil-borne pathogens in disease-suppressive soils (Duff *et al.*, 2003). This type of biological control can be the result of competition for nutrients, siderophore-mediated competition for iron, antibiosis or the production of lytic enzymes (Van loon and Bakker, 2003).



Priming of Defense by Natural Compounds

Many natural compounds have been claimed to be plant growth promoters, plant activators or plant defense inducers, among other names. A large portion of them has already been related to priming, including oligosaccharides, glycosides, amides, vitamins, carboxylic acids and aromatic compounds. In general, natural compounds tend to be better tolerated by plants than most of the synthetic compounds tested, but there is still concern about toxicity (Noutoshi *et al.*, 2012). Most mimic pathogen interaction by acting as (endogenous or exogenous) elicitors, and are able to induce or prime defense in a concentration-dependent manner. A wide range of cellular responses has been reported to be potentiated by these compounds, including alterations in ion transport across the plasma membrane, synthesis and secretion of antimicrobial secondary metabolites (phytoalexins), cell wall phenolics and lignin-like polymers, and activation of various defense genes (Conrath, 2009).

Conclusion: The well primed defense activities are highly tolerate to biotic and abiotic stress like, plant pathogens, pest high temperature, soil salinity, cold and high wind by seed priming with synthetic chemicals, growth regulators, PGPR and Transgenic approaches are to induce a vital role in defense modulation in plant dependent with environment.

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56. PLANT PATHOLOGY 16032

Mechanism of Bacterial Wilt Disease Development

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INTRODUCTION: Bacterial wilt was described by Erwin Frink Smith as *Bacillus solanacearum* in potato, eggplant & tobacco at 1896 and later in tobacco at 1908. In 1948, the genera was renamed as *Psuedomonas solanacearum* and was also temporary reclassified in the genera *Phytomonas* & *Xanthomonas.* Later in 1992, it was then re-classified under *Burkholderia solanacearum* and in 1995, it was placed under genera *Ralstonia solanacearum.* The taxonomic classification of *R. solanacearum* comes under division: gracillicutes, class: beta proteobacteria, order: burkholdariales, family: ralstoniaceae, genus: *Ralstonia* and species: *solanacearum, pickettii* & *syrzii etc.*

The diversity of *R. solanacearum* has been classified as **"species complex"** affecting 200 plant species belonging to 53 botanical families. On the basis of host range, *Ralstonia* has been claasified into 5 races. Race 1 affects chilli, tomato, tobacco, potato, marigold, sunflower & groundnut occurring in Europia countries, whereas, race 2 affecting *Musa* sp. & *Heliconia* sp. was found in south america & phillipines. Race 3 affects capsicum, tomato, potato, eggplant & geranium was found in USA & Canada, while, race 4 afffecting ginger was found in asia and race 5 affecting solely *Morus* sp. was found in china. Traditionally, 6 biovars have been classified on the basis of pathogen's ability to utilize and/or oxidise several hexose alcohols & disaccharides (1, 2, 2T, 3, 4 & 5). *Ralstonia* has been divided into 4 phylotypes in which phylotype I consists of biovar 3, 4 & 5 (asia), whereas, phyloptype II consists of biovar 1, 2, 2T & race 2 (America). Phylotype III consists of biovar 1 & 2T (Africa) and phylotype IV consists of heterogenous groups of biovar 1, 2 2T (Indonesia, Australia & Japan).

Mechanism of Bacterial Wilt Development

Ralstonia solanacearum is a soil borne, rod shaped (0.5-0.7 X 1.5-2.5 μm), gram-negative bacterium producing **fluidal or mucoid** colonies with characteristic whorls at centre. In presence of suitable host, bacterium invades root tissue *via* chemotaxis by root exudates and open wounds or natural openings, thus colonizing xylem and reach to aerial parts of plant, and, accumulating large number of bacterial population in xylem vessels resulting in development of symptoms. External symptoms includes yellowing, wilting, stunting & downward bending of leaves & over production of adventitious roots leading to leaf epinasty. Formation of narrow dark stripes at infected vascular vessels has also been observed. Internal symptoms includes progressive discolouration of vascular bundles specially xylem vessles at early stage of infection leading to necrosis & slimy viscous ooze from transverse section of stems. The pathogen survive in soil for long period of time till it gets hosts & colonizes xylem and then returns to soil to live as saprophytes.

Virulence Factors

Mechanism of pathogenesis involves certain virulence factors *viz.,* Extracellular Polysaccharides, Lipopolysaccharide & Lectins, Protein appendages: Flagella & Pili (Fimbrae), Plant cell wall degrading enzymes (CWDEs), Hrp/Hrc Gene cluster & T3SS and Secreted proteins & effectors, which contributes to incidence, rate of severity, symptoms, enhancing pathogen's ability to colonize host tissue systemically (>10^8 cfu/g tissue), appearance of disease symptoms as well as extensive colonization. Model strains on which studies have been conducted were strain K60 (phylotype II, biovar 1), strain AW & strain GM1000 (phylotype 1, biovar 3) of tomato.

Extracellular polysaccharides EPS 1 have been considered as major virulence factor which is long (>10^6 Da) polymer with trimeric repeating units *viz.,* NAG, DGA & tri-DG, encoded by 16-kb *eps* operon EPS biosynthetic pathway. It is usually observed as fluidal or mucoid colonies in virulence wild type strains and responsible for modulating disease severity at later stages of infection, colonizing xylem vessels and interfere fluid movement of plant leading to hydrostatic overpressure & wilting. Bacterial lipopolysaccharides present at outer membrane of gram negative bacterium consists of Lipid-A, core polysaccharide & O-antigen polysaccharide. O-antigen consisting of repeating unit of rhamnose, N-acetylglucosamine & Xylose in 4:1:1 ratio contributes to virulence at early stages of infection. EPS minimize recognition of pili/LPS (pathogenicity of bacterium) & lectin (plants) leading to hypersensitive response and activation of plant defense system. Protein appendages such as lopotrichus flagella of *Ralstonia* also contributes to virulence at cell densities 10^7 & 10^9 cells/ml in the form of flagella based motility encode by *flic* flagellin structural gene. Type-4 pili encoded by *TfP gene* composed of *PilC* protein is responsible for twitching motility, autoaggregation, biofilm formation, hence,

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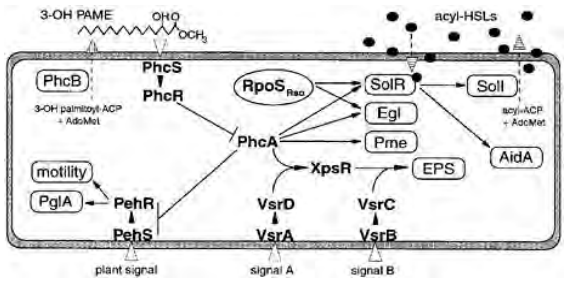
contributing to virulence. *R. solanacearum* has been reported to produce 6 plant cell wall degrading enzymes secreted by Type-2 secretion system *viz.,* **Egl (β-1,4-endoglucanase), ChbA (Exoglucanase; β-1,4-cellobiohydrolase), PehA/ Pgl A (Endopolygalacturonase), PehB & PehC (Exopolygalacturonase) & Pme (Pectin methylesterase).** The function of these CWDEs are to hydrolyze plant cell wall components to obtain nutrient & energy at early stage of infection leading to host colonization and virulence. Transition of CWDEs & extracellular proteins through inner & outer membrane takes place *via Sec-dependent general export pathway* & Type II secretion system (T2SS) respectively. In addition, strain K60 & strain GMI1000 & AW has reported to produce **Schizokinen (Dihydroxamate Siderophore) & Staphyloferrin B (Polycarboxylate Siderophore)** as low molecular extracellular iron scavenging system for iron bioavailability to pathogen for its virulent nature.

Regulated Production of Virulence Factors



PhC:LysR-type transcriptiona regulator is responsible for controlled production & expression of many virulence genes, also knows as phenotypic conversion system. In strain AW, *PhC* is responsible for positive regulation of EPS1, EgL, Eme peoduction & acyl-homoserine lactone quorum sensing as well as negative regulation of PehA, staphyloferin B siderophore, type-4 pili, flagellar motility *etc. PhcA* is a small molecule of methyltransferases which synthesizes 3-OH Palmitic acid methyl ester (accumulate by bacteria in extracellular environment) to which responds regulatory systems such as *PhcS & PhcR*. PAME stimulates *PhcS* to phosphoralate *PhcR* regulator which increases the level of *PhcA*. Increase in the level of *PhcA* leads to increase in virulence at succesfully colonized xylem vessesls. *PhcA* further stimulates the expression of *Egl & XpsR* enhancing levels of *VsrD & VsrA* factors responsible for promoting rapid multiplication, growth &colonization of Ralstonia in plant cells.

Hrp genes are clustered on 23-kb region of megaplasmid encoding components of **T3SS** & effector proteins & translocating it in cell plant cell cytoplasm. T3SS consists of extracellular pili, Hrp pili encodes *hrC* genes (hrp conserved genes) at core secretion system, where HrCC ATPase located at cytoplasm & HrCC secretin cause pore formation at outer membrane. The function of T3SS are attachment & penetration of pathogen to plant cell wall, translocation of effector protein into cytoplasm, facilitation of nutrient release & suppression of plant defence system. In *R. solanacearum, Hrp Pili* composed of *HrpY* protein which is essential for secretion of effector proteins *viz., POPA* (HR-like response), *POPF1* (Virulence), *POPB* (nuclear localization signal) & *POPP1* (*Avr* determinant towards resistant plants).

57. PLANT PATHOLOGY 16057

Pseudomonas Spp. Beyond Biocontrol Agent

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INTRODUCTION: *Pseudomonas* is a genus of aerobic Gammaproteobacteria, belonging to the family *Pseudomonadaceae* containing about 191 validly described species (Euzéby, 1997). Members of the genus display these defining characteristics: Rod-shaped, gram-negative, one or more polar flagella, providing motility, aerobic, ubiquitous and non-spore forming. (Krieg, 1984).

Pseudomonas is non-pathogenic saprophytes that colonize soil, water and plant surface environments. *Pseudomonas* can suppress plant diseases by production of number of secondary metabolites including antibiotics, siderophores and hydrogen cyanide. This microbe has the unique ability to enter the plant vascular system, reach the various parts of the plant system and act as a systemic bio-control agent against various fungal and bacterial diseases. Competitive exclusion of pathogens as the result of rapid colonization of the rhizosphere by *Pseudomonas fluorescens* may also be an important factor in disease control.

Species of *Pseudomonas* grow well at 28–30°C, which is more appropriate for most of the species. *Pseudomonas* strains have increased root and shoot elongation in various crops (Glick *et al.,* 1997). These bacteria also exhibit other traits beneficial to plants, such as production of

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phytohormones, antibiotics, siderophores, vitamins, antifungal substances, and hydrogen cyanide (Rodriguez and Fraga 1999).

Why Growers Prefer *Pseudomonas*?

- The *Pseudomonas* spp. can be easily formulated into long shelf life products, rapidly colonize the growing media under suitable conditions.
- *Pseudomonas* spp. is a strong competitor in the Rhizosphere and Phyllosphere generally has a good chance of establishment even when there are pre-existing healthy populations of other microbial species.
- Effective to control the different diseases in different crops.
- *Pseudomonas* not only controls the disease but also enhance the plant growth.
- It increases crop yield also.
- It helps in solubilizing various elements and makes it easily available to the plant.
- Along with biocontrol it also induces disease resistance in plants.
- Several species of *Pseudomonas* work as a bioremediation agent against various pollution hazards.
- This is main activities of *Pseudomonas* spp. beyond biocontrol agent.

Pseudomonas as other than bio-control agent to improve plant health and production

1. Plant growth promoting activities
2. Nutrients solubilization
3. 3) Induce resistance
4. 4) Bioremediation

1) Plant growth promoting activities

- Microorganisms has vital role in agriculture in order to promote the exchange of plant nutrients and reduce application of chemical fertilizers as much as possible.
- PGPR enhance plant productivity by a range of mechanisms. These beneficial effects of PGPR can be either direct or indirect.
- Direct promotion of growth by PGPR occurs when the rhizobacteria produce metabolites that promote plant growth such as auxins (Asghar *et al.,* 2002), Cytokinins (Arkhipova *et al.,* 2005) and Gibberellins (Gutierrez-Manero *et al.,* 2001; Joo *et al.,* 2004) as well as through the solubilization of phosphate minerals (Freitas *et al.,*1997).
- Indirect growth promotion occurs through the elimination of pathogens by the production of cyanide (Owen and Zlor, 2001) and siderophores (Tailor *et al.,* 2012).

2) Nutrients solubilization

- Plants need several macro and micro nutrients for their growth and reproduction. These nutrients supplemented through inorganic or organic forms are taken up by the plant roots along with water. Bacteria also play an important role in mobilizing nutrients requisite by the plants to some extent.
- Phosphate solubilizing microbes plays an important role in plant nutrition through increase in phosphate uptake by plants and used as biofertilizers of agricultural crops.
- Several genera of rhizobacteria belonging to *Pseudomonas* spp. *and Bacillus* spp. are reported to solubilize zinc.
- Thus, identification of efficient microbial strains capable of solubilizing minerals quickly can conserve our existing resources and avoid environmental pollution hazards caused by heavy application of chemical fertilizers.
- Plants require at least 16 macro- and micro-nutrients for their growth and for yield production. The absence or deficiency of each nutrient in soil can adversely affect plant performance.
- Nutrients may be present in the soil; however, their chemical properties can make them unavailable for plant use. Hence, different methods have been tested and proved to be effective on the enhancement of soil nutrient availability.

3) Induce resistance

- Plants actively respond to a variety of chemical stimuli produced by soil- and plant-associated microbes. Such stimuli can either induce or condition plant host defenses through biochemical changes that enhance resistance against subsequent infection by a variety of pathogens.
- Induction of host defenses can be local and/or systemic in nature, depending on the type, source, and amount of stimuli.
- Recently, phytopathologists have begun to characterize the determinants and pathways of induced resistance stimulated by biological control agents and other non-pathogenic microbes.
- The first of these pathways, termed systemic acquired resistance (SAR), is mediated by salicylic acid (SA), a compound which is frequently produced following pathogen infection and typically leads to the expression of pathogenesis-related (PR) proteins.
- A number of strains of root-colonizing microbes have been identified as potential elicitors of plant host defenses.

4) Bioremediation

What is Bioremediation?

- **Bioremediation** is the use of microorganism metabolism to degrade or remove waste materials contaminants (sewage, domestic and industrial effluents) into non-toxic or less toxic materials by natural biological

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processes.

Advantages

- Bioremediation is a natural process.
- It is cost effective.
- Toxic chemicals are destroyed or removed from environment and not just merely separated.
- Low capital expenditure.
- Less energy is required as compared to other technologies.
- Less manual supervision.

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58. PLANT PATHOLOGY 16066

Ganoderma Wilt Disease: Havoc to Arecanut Cultivation in Assam

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The arecanut palm (*Areca catechu* L.) is one of the most important plantation crops in Assam grown in an area of 70,542 ha with an annual production of 64,948 metric tonnes and a productivity of 921 kg chali/ha. It is commonly known as betelnut or supari and used in various religious and social ceremonies. Assam occupies third position in area and production next to Karnataka and Kerala. Although, India is the largest producer of arecanut its productivity is very low, 1214kg/ha. Besides, arecanut cultivation is beset with recurring problems due to reduced productivity, delayed commercial yield, soil fertility depletion, small holding size, price fluctuation and pests and diseases. Among the various minor and major diseases, basal stem rot caused by *Ganoderma lucidum* (Curtis Ex. Fr.) Karst is the most dreaded since it causes damage to the product as well as the crop. It is a slow decline disease with a history of more than 100 years. It has not only affected the productivity but has also wiped out areca plantations in certain localities. This disease first appeared in the coastal areas of Thanjavur district of TamilNadu after cyclones of 1952 and 1955 and hence the names Thanjavur wilt. The disease has also been reported from Tamil Nadu, Kerala and Assam, Bengal and Nicobar Island. Survey conducted by CPCRI, RC, Kahikuchi in different district of Assam viz., Kamrup, Darrang, Goalpara, Nagaon, Morigaon, Kokrajhar, Bongaigaon and Barpeta revealed that the disease incidence ranged from 1.00-65.00 per cent. The disease is severe in neglected, ill drained and overcrowded gardens.

Symptoms and Disease Development

1. Palms in the age group of 10–30 years are easily attacked by the pathogen. The fungus first infects the root system and during the very early stage of infection no external

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disease symptoms are clearly visible.

2. Symptoms first appear as exudation of reddish brown viscous fluid from the basal portions of the stem in coconut palm. The bleeding patches begin from the base and extend upwards as the disease progresses and discoloration in the stem can be seen up to the height of bleeding.
3. The most usual symptoms in the crown are leaflets of outermost whorls exhibit wilting symptoms, and yellowing, withering and drooping of the outer fronds, which remain hanging around the trunk for several months before shedding.
4. The younger leaves remain green for some time and later turn yellowish brown. The new fronds produced become successively smaller and yellowish in colour, which do not unfold properly.
5. As the disease progresses, normal development of flowers and bunches is arrested leading to button shedding and nuts become barren.
6. The characteristic symptom of the disease is extensive discoloration and rotting of root systems, which leads to tissue disintegration and the stele turns brown. The roots become watery with a typical smell of alcohol. More often, the formation of new root produced is progressively reduced.
7. In the advanced stages of infection, the fungus produces fruiting bodies (sporophores) which may or may not develop before foliar symptoms appear. Sporophores may develop at the trunk base and the appearance of sporophores is most diagnostic of the disease. The sporophores initially appear as small, white buttons of fungal tissues that develop rapidly into the familiar bracket-shaped mature sporophore. The young sporophore is white or yellow, whereas the mature sporophore upper surface can be light to dark brown, with a light margin and a shiny lacquered finish. The undersurface is whitish in color and has numerous minute pores. Ganoderma is a soil-borne pathogen and it survives well in the soil for a long time. The formation of chlamydospores during adverse conditions helps survival of pathogen and chlamydospores become more resistant to environmental factors than basidiospores and could be responsible for dissemination of the disease.

Predisposing Factors

1. The disease is generally observed in sandy or sandy loam soils in coastal areas where arecanut is grown under rainfed conditions and also in neglected plantations.
2. Soils with poor drainage and water stagnation during rainy seasons were found to favor the disease.
3. Irrigation water and rain water help in the spread of the fungus from one field to others.
4. The disease incidence is more between the months of March and August.
5. The spread of disease is mainly through root contact (root graft) between diseased and healthy palms.

Management

Cultural method

1. The clean clearing technique gives a lower disease incidence (14%) by comparison with other replanting techniques. Remove and destroy all affected palms.
2. Use of uninfected soil in polybags to grow seedlings,
3. Eradication of all sources of Ganoderma in the field by adopting clean cultivation or field sanitation.
4. Green manure crops must be raised and ploughed in-situ at the time of flowering. In sandy soil, organic matter status of the soil has to be improved. For this, green manure crops may be raised and ploughed in situ or well decomposed farm yard manure at 50 kg per palm has to be applied every year.

Biological method

- Apply *Pseudomonas fluorescens* (Pf1) @ 200g/palm + *Trichoderma viride* @ 200g/palm/year.
- Apply 200g Phosphobacter and 200 g Azotobactor mixed with 50kg of FYM/palm.
- Apply FYM 50kg + neem cake 5 Kg once in 6 months along with fertilizers.
- T. harzianum applied at the rate of 50 g per palm along with 5 kg of neem cake or 50 kg of green leaves or 50 kg of farmyard manure reduced BSR disease
- Calcium nitrate application increases the population of Trichoderma. harzianum and other antagonistic fungi in the soil.

Chemical method

- Isolation of trench around the tree, 4 feet away from the base of the trunk. Apply Sulphur dust inside the trench.
- The bleeding patches in the stem may be chiseled and protected with tridemorph (5% calxin) and subsequently with hot coal tar.
- Aureofungin-sol 2 g +1 g Copper Sulphate in 100ml water or 2 ml of Tridemorph in 100 ml water applied as root feeding. (The active absorbing root of pencil thickness must be selected and a slanting and a slanting cut is made. The solution to be taken in a polythene bag or bottle and the cut end of the root should be dipped in the solution).
- Trunk injection / root feeding with Calixin 3 ml/tree.

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- Forty litres of 1% Bordeaux mixture should be applied as soil drench around the trunk in a radius of 1.5m at quarterly intervals three times a year and repeating after 2–3 years.

59. PLANT PATHOLOGY 16155

The Genetic Basis of Host Resistance to Pathogens

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Pathogens are ubiquitous and have a significant impact on their hosts' fitness and survival. While the detrimental effects that pathogens have on their hosts is clear, the genetic interaction between a host and pathogen is much less certain. Understanding the fundamental genetic mechanisms of host-parasite interactions has great importance in crop breeding and more importantly evolutionary and population biology and furthermore will give insight into areas of human medicine.

Studies into the genetics of host-pathogen interactions date back to 1940's, though prior to recent advances in molecular techniques, the extent to which the genetics of host-parasite interactions could be investigated was severely limited. However, several models were developed to describe the genetic basis of host resistance to pathogens. Genetic variation for host resistance has been found in many organisms (*e.g.* plants, invertebrates). The presence of genetic variation in fitness traits such as host resistance is not predicted by the theory of natural

The Genetic Basis of Host-Pathogen Interactions

Many ideas have been documented in an attempt to explain the genetic basis of host resistance to pathogens. Three views feature strongly throughout the literature. These are; the gene-for-gene model, the matching-allele model and the quantitative view of resistance.

The Gene-for-Gene Model

The gene-for-gene model refers to a specific genetic interaction between a host and its pathogen. It states that a resistance gene (*R* gene) in the host and an avirulence gene (*Avr* gene) in the pathogen must be present for the host to be resistant. *R* genes in the host recognize *Avr* genes in the pathogen and a defense response is activated preventing the establishment of the pathogen in the host. Flor was the first to discover and present this matching specificity between host and pathogen genes. His work in selective crop breeding with Flax lead to the rather unintentional detection of this interaction between this plant and its fungal pathogen, Flax Rust. He showed that for every gene in the plant that conditioned resistance, a corresponding and complementary gene in the pathogen that conditioned avirulence existed. Since the initial proposal of this gene-for-gene idea evidence for its presence has been presented for over 25 different plant host-pathogen pairs. However, this proposed gene-for-gene interaction between host and pathogen is controversial. Evidence for this interaction has almost exclusively been found in plants and more specifically agricultural crops. (Mehdy, M.C., 1994)

The Underlying Molecular Mechanism of Gene for-Gene Resistance in Hosts

Hosts require *R* genes to recognize invading pathogens. In order for successful recognition by the host, *Avr* genes need to be present in the invading pathogen. On recognition of the invading pathogen by the host a complex early defense response is activated. This is called the hypersensitive response and involves two phases:

Phase 1: An increase in extra cellular pH and potassium ions and an influx of calcium and hydrogen ions into the cell is triggered by the *R* gene following the recognition of the *Avr* pathogen gene. This results in necrosis and the formation of lesions which contain antimicrobial compounds which enable restriction of the growth of the pathogen.

Phase 2: Reactive oxygen species including super oxides, hydrogen peroxides and hydroxyl radicals are produced by cells undergoing the hypersensitive reaction. These chemicals act to kill the invading pathogen before it spreads to neighboring cells. Overproduction of lignin related materials and the induction of certain pathogen related (PR) proteins also occur as part of this defense response.

Matching-Allele Model

Another view termed the matching-allele model has been presented to explain the genetics underlying host resistance. This model suggests each host allele confers resistance to one parasite allele. Resistance in the host occurs when its genotype and that of its pathogen match exactly. For successful infection by the pathogen to occur the genotype of the host and pathogen must not match. In contrast to the gene-for-gene model, which predicts that parasite host range will vary greatly, the matching-allele model predicts that all parasites can attack the same number of hosts.

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Whereas the gene-for-gene model has been important in the understanding of host pathogen interactions in plants, the matching-allele model is favored by zoologists. A matching-allele interaction has been documented in both studies with invertebrates and vertebrates. However, overall there is little experimental support for this alternative genetic scenario. Although the gene-for-gene model and the matching allele model have been considered independent in much of the literature it has been suggested that they are in fact two ends of a continuum. Assessment of allele-frequency dynamics along this continuum revealed that the variance of allele frequencies under a gene-for-gene system can strongly approach those predicted by matching-allele models if the costs of virulence and resistance are great. In light of such findings there may be doubt as to how the two models can be discriminated between given certain data and it is possible that results of past studies based on allele frequency variance may be misinterpreted and fitted to the wrong model. Rather than considering both models as being equally likely to explain the results, it may be that if the results fit what could be the outcome of the gene-for-gene model the matching-allele model will not be considered. The consideration of both models in explaining empirical data is necessary given their convergence under certain conditions.

Quantitative Trait Loci Mapping

The loci controlling quantitative traits such as resistance are called quantitative trait loci (QTL). Quantitative genetics are used to identify QTL. To map QTL, DNA markers found throughout the genome are tested to see how likely it is that they are associated with a QTL. For each DNA marker, individuals being tested are split into classes according to the marker genotype. Comparison of mean and variance parameters among the classes are then undertaken. If there is a significant difference between classes this suggests that a relationship between the DNA marker and trait of interest is present. It is therefore likely that the DNA marker is linked to QTL (Orlandi, E.W., (1992).

Conclusions: Three models have been developed and used to explain the genetic basis of resistance: gene-for-gene, matching-allele and a quantitative resistance. Nonetheless there is still a large degree of uncertainty regarding the true genetic basis of host resistance. The gene-for-gene model was the first view of host resistance to be introduced and evidence suggests it may be outdated and have limited applicability. The matching-allele model lacks experimental support and is less prominent in the literature. Quantitative resistance is the idea largely favored by most recent investigations using modern molecular practices. Most fitness traits result from the action of more than one gene. Therefore quantitative resistance seems to be the most realistic interpretation of the genetic underlying hosts' resistance to pathogens

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60. PLANT PATHOLOGY 16157

Quarantine Regulations and the Impact of Modern Detection Methods

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Plant quarantine is a biosecurity measure designed to reduce or prevent the introduction and spread of economically important pests of plants or plant products that are not yet present in an area or that are present but do not widely occur and are under official control. Plant quarantine regulations can be implemented nationally at the border and regionally within a country. All countries have a sovereign right to impose plant quarantine policies and regulations to protect production and market access for plant industries and to protect the natural environment. Detection methods for pests in quarantine and certification program include visual inspection, isolations onto growth media, bioassays, microscopy, serology and molecular methods such as polymerase chain reaction (PCR), reverse transcription-PCR (RT-PCR), quantitative-PCR (q-PCR) and nucleic acid blot assays. However, it is important that, no single method is completely reliable for pathogen detection (Laxmi *et al.*, 2014).

Although current diagnostic techniques provide opportunities for pathogen detection, further challenge for plant quarantine is the ability to determine the cause of a disease especially those which are unfamiliar or unusual or for

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which a pathogen is not known. Under such situations next generation sequencing (NGS) technology could play a significant role, because they have the ability to identify all known and most importantly, unknown agents in a timely fashion (Martin *et al.*, 2016).

Thirumalaisamy *et al.* (2011) developed species specific primers from rDNA-ITS region (ITS KB F and ITS KB R) and 2.3kb mtDNA fragment of *Tilletia indica* (causing karnal bunt) mtDNA KB F and mtDNA KB R for detection and identification of closely related species of *T. indica* from wheat seed lots. The PCR amplification of teliospore DNA using species specific primers *i.e.,* ITS KB F, ITS KB R and mtDNA KB F, mtDNA KB R amplified 570bp and 885bp amplicon of *T. indica*, respectively. Comparative study of both sets of species specific primers revealed that, ITS primers had higher sensitivity, uniform amplification with single resolvable band than the mtDNA sequence based primers.

Chalam *et al.* (2014) carried out quarantine processing of 4,836 germplasm accessions of different legume crops imported from different countries including CGIAR centres, which revealed the presence of 29 viruses through visual inspection, growing on test, electron microscopy and enzyme-linked immunosorbent assay. Among 29 viruses, eight viruses are not reported from India and 14 viruses are known to occur in India on other crops but not on the hosts on which they were intercepted, hence these 22 viruses are of quarantine significance for India.

Bag *et al.* (2015) identified the etiological agent associated with stem pitting in nectarine trees by metagenomic analysis using NGS approach in post entry quarantine. cDNA library was constructed by extracting double stranded RNA, subjected to RT PCR and sequenced using illumina platform. Sequence reads were assembled and BLAST analysis was carried out which indicated the presence of novel *Luetovirus*. This indicates, metagenomic analysis by NGS approach is an essential tool to diagnose the pathogen.

The implementation of effective quarantine detection technique acts as an important tool for identification of pests. Currently, most of the diagnostic laboratories and inspection agencies are using molecular methods than conventional methods for detection and identification of pathogen. Novel approaches (microarray, DNA barcoding and NGS technology *etc.*) being embraced in plant pathology and is likely to be used in the future as a fast, accurate and routine diagnostic tool for plant quarantine and certification.

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61. DISEASE MANAGEMENT 15897

Post-Harvest Diseases of Cocoa

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1. Frosty Pod ROT (*Moniliophthora roreri*)

Disease symptoms

- The fungus infects only actively growing pod tissues, especially young pods.
- The time from infection to the appearance of symptoms is about 1-3 months.
- The most outstanding symptom is the white fungal mat on the pod surface.
- This devastating disease will start an infection at the surface of cocoa pods which can penetrate through the pods during its first ninety days of development and growth.
- The symptoms can be seen as swelling and followed by a cream colored formation of discoloration outside the pods.

Management: Maintain canopy height and structure - annual pruning (usually once in the dry season) helps control brooms. Recognise early symptoms and management practices to ensure yield and improve natural resistance from trees

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(shade management, weeding, chupon removal and fertilization). Fortnightly removal of infected pods during the epidemic season to prevent from sporulation and reduce inoculum pressure. Spraying: from peak of flowering then perhaps 3 months (up to 6 applications of fungicides) for pod protection. Applications of protectant fungicides, especially copper, are known to reduce disease incidence and increase yield: chlorthalonil is more toxic. Good application methods for chemical and biological control agents are essential. In the long term: it is important not to spread infected material from one region to another. Resistant varieties may become available, but potentially useful genotypes are very limited.

2. Phytophthora Pod Rot

Disease symptoms

- The infection starts at any surface of an immature pod while most of the infection can be seen at the tip of a cocoa pod. The fungus that produces infections turns the surface of a cocoa pod into a firm and chocolate brown lesion.
- The seeds inside each of the pod are not contaminated after initial infection but the harvest can result to yield loss.
- In other cases of black pod infections the result is a black and mummifies cocoa pods.
- It also causes blight to the young stem and leaves of cacao seedling in the nurseries.
- The pathogen that causes black pod comes from the soil, spore from infected pods, and infected stem, leaves, and roots.

Management: Poor aeration within the crop canopy may encourage the disease, so thinning the canopy can help to reduce disease. Fungicides will only work well in combination with appropriate good tree height and canopy management facilitates pod inspections. Remove soil on cocoa trunks, this eliminates two sources of disease: spores carried in infested soil and those carried by the ants themselves. Apply appropriate fungicides using correct application methods. Copper compounds and metalaxyl are widely available fungicides that are effective. The hyperparasite *Trichoderma asperellum* appears to be the most promising biological control agent found to date. Cankers have been successfully treated by trunk injection of potassium phosphonate.

3. Pod Rot of Cocoa (*Lasiodiplodia theobromae*)

Disease symptoms

- In cocoa pod rot the infected tissue shows brown necrosis with dark brown powdery spore masses.
- Such infected tissues show greyish-black mycelia.
- The fungus is most important as a cause of postharvest food decay.
- It also causes damage in cocoa in the form of dieback disease.

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62. DISEASE MANAGEMENT 16076

Post-Harvest Diseases Management in Citrus

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Postharvest physiological disorders are a consequence of environment, handling, treatments, and storage conditions to which fruits are subjected. In particular, losses of citrus fruits stored for several months or shipped for long distances are a consequence of the low temperatures required for cold storage. Fungal pathogens are considered the main cause of citrus diseases, severely affecting postharvest management. Pre-harvest infections include Grey mould (*Botrytis cinerea* Pers.), Anthracnose (*Colletotrichum gloeosporioides* Penz.), whilst postharvest infections include Green mould (*Penicillium digitatum* Sacc.), Blue mould (*P. italicum* Weh.) and Sour rot (*Geotrichum candidum* Link).

Sooty Mold - A sooty black coating develops on leaves and twigs and sometimes on the fruit also. The root-cause of the disease is the infestation of tree with aphids and scale insects. The intensity and extent of this sooty growth is proportional to the intensity of insect infestation. The fungus grows on the honey dew secretion of insects. Ants may help in the spread of insects and fungus. Though the fungus does not affect the tree directly it may reduce the amount of sun light falling on the leaves. The trees present a sickly appearance and the fruits reduced in size

Management - Spraying the plant with fish oil resin soap or crude oil emulsion and starch (250g: 250g: 450 l water) will control the insect as well as remove the entire surface grown fungus mat, which will come off as flakes in due course. - Dusting sulphur will also be helpful in the control of sooty mold.

Green Mould - Green mold is the most important post-harvest diseases on citrus. This disease is ubiquitous to all citrus growing regions in India. Conidia of the fungus are airborne and large numbers are produced by the fungus on the surface of infected fruit. The fungus is able to enter the fruit through wounds. Therefore, the disease can occur on fruit on the tree, in the packinghouse, in transit, in storage and in the marketplace. A white mold is first seen growing on the peel. The mold later turns green because of the large number of green spores produced. Decayed fruit becomes soft and shrinks. Softening of damaged tissue. White fungal growth, which progressively turns blue or green as spores develop on fruit. Post harvest fungicides (Imazalil) can arrest spore development resulting in white only fungal growth.

Management - Careful handling reduces damage to rind. Good hygiene and sorting reduces spore load and infection rates. Sanitation destroys spores in re-circulating water and packing line equipment. Post harvest fungicides should be applied within 24h of harvest. Lower storage temperatures slow down fungal development.

Blue Mold - Blue mold originates primarily from infection of wounds such as punctures, bruises and limb rubs on the fruit. Blue mold can also originate from infection at the stem of fruit. Stem-end blue mold is commonly seen on d'Anjou pears, but it also occurs on apples such as Red Delicious. Calyx-end blue mold occurs on Red Delicious apples but is usually associated with fruit that are drenched prior to storage.

Management - Orchard sanitation to remove decayed fruit and organic debris on the orchard floor helps reduce inoculum levels of *Penicillium* spp. in the orchard. Good harvest and handling management to minimize punctures and bruises on the fruit helps prevent the fruit from infection at wounds by *P. expansum* and other *Penicillium* species. Thiabendazole is commonly used as either a pre storage drench treatment or a line spray to control blue mold. TBZ is effective to control gray mold but is not effective to control TBZ-resistant *Penicillium*. Two new postharvest fungicides, fludioxonil (Scholar) and pyrimethanil. Can be used as drenches, dips or line sprays and have been reported to be effective to control from wound infections.

Anthracnose - Leaves display more or less circular spots of light tan colour with a prominent purple margin. The center of these spots gradually

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turns greyish and, in the later phases of the infection, it may show tiny dispersed black flecks. Tissues injured by environmental factors (such as insect damage or otherwise inflicted lesions) are more susceptible to the colonization by the anthracnose fungus. Fruits that have previously been injured by other agents like sunburn, chemical burn, pest damage, bruising, or un favourable storage conditions, are particularly prone to develop anthracnose. Fruit symptoms are firm and dry, brown to black spots of 1,5 mm or slightly greater diameter. The spore masses growing on the lesions are usually brown to black, but under humid conditions, they can turn pink to salmon.

Management - Always consider an integrated approach with preventive measures together with biological treatments if available. Fungicides containing a zoxystrobin or chlorothalonil can be sprayed regularly to lower the risk of infection. Seed treatment with these compounds can also be envisaged. Finally, post-harvest fungicides together with a food-grade wax can be applied to reduce the incidence on fruits bound to be shipped to overseas markets.

63. BIOCONTROL 16034

Botanical Insecticides: A Tool to Protect Environament

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Several pressures have accelerated the search for more environmentally and toxicologically safe and more selective and efficacious pesticides. Most commercially successful pesticides have been discovered by screening compounds synthesized in the laboratory for pesticidal properties. The average number of compounds that must be screened to discover a commercially viable pesticide has increased dramatically, so that new discovery strategies must be considered. Increased emphasis on reduced-tillage agriculture will make adequate control of weeds more dependent on chemical control. New herbicides will be needed to fully meet this challenge. The increasing incidence of pesticide resistance is also fueling the need for new pesticides. Furthermore, most synthetic chemicals that have been commercialized as herbicides are halogenated hydrocarbons with relatively long environmental half-lives and more suspect toxicological properties than most natural compounds. Thus, natural compounds have increasingly become the focus of those interested in discovery of pesticides. Tens of thousands of secondary products of plants have been indentified and there are estimates that hundreds of thousands of these compounds exist. There is growing evidence that most of these compounds are involved in the interaction of plants with other species-primarily the defense of the plant from plant pests. Thus, these secondary compounds represent a large reservoir of chemical structures with biological activity. This resource is largely untapped for use as pesticides. This review will provide an overview of those compounds from plants that have been utilized for pest control, examples of some compounds with pesticidal potential, and a discussion of considerations in development of natural plant compounds for pesticidal use.

Botanical Insecticides

1. Nicotinoids

General Properties: It is an alkaloid derived from certain members of the plant family Solanaceae. Commercially, nicotine and the closely related nornicotine are obtained from the leaves of Nicotiana tabacum and Nicotiana rustica. Anabasine occurs in Anabasis aphylla, a member of the Chenopodiaceae in Central Asia and Africa and is used commercially as an insecticide in Russia.

Nicotine is marketed under the name Black Leaf 40® as an aqueous solution of the dibasic salt nicotine sulfate. Toxicity The free base of nicotine has been used as a contact spray and has also been used as a stomach poison in the form of nicotine tannate. The use of nicotine is restricted to home gardens and greenhouses. It is especially effective as an insecticide against small, soft bodied insects such as aphids, thrips, white flies and some species of mites. Its use is generally restricted because of narrow insecticidal spectrum, low residual activity, and very high mammalian toxicity. In addition, nicotine is metabolized and excreted fairly fast in insects. The major route of metabolism in all organisms studied is formation of the 5-keto derivative of nicotine, cotinine. The reaction is catalyzed by the microsomal mono oxygenases through an intermediate hydroxylation product.

Mode of Action: Nicotinoids can be described as nervous system toxins, specifically acting at the synapses and affecting A Ch-mediated excitatory

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transmission. However, unlike the OP's and carbamates, nicotine does not effect acetylcholine esterase but instead acts on the Ach receptor.

2. Rotenoids

General Properties: Another group of plant derived insecticides derived from roots of certain genera of the plant family Leguminoseae. These are 6 active principles of the genus Derris (rotenone being the most active) from Malaya and the East Indies. Rotenone is used in the form of ground roots, resins, or as a crystalline material which is extracted by solvents, such as chloroform. Toxicity Rotenoids are also effective fish toxins and have been used by native fisherman.

Mode of Action: Rotenone is unique among the insecticides discussed thus far in that it is the only compound that is not a neurotoxin. Rotenone is very slow acting and has a depressant effect rather that excitatory as seen with most of the neurotoxic insecticides.

The toxicity of rotenone is believed to be associated with its ability to inhibit respiratory metabolism. More precisely, rotenone interferes with the electron-transport process between reduced diphosphopyridine nucleotide (NADH) and cylochrome b.

3. Pyrethrins

Physical and Chemical Properties: There are four principal active ingredients in pyrethrum flowers, known as pyrethrins I and II and cinerins I and II. All four components are esters comprised of an acid containing a three-carbon-ring joined to an alcohol containing a five-carbon ring. The proportions of each component may vary with the strain of flowers, conditions of culture and methods of extraction.

Pyrethrums are highly unstable in the presence of light, moisture and air. Whole flowers decompose more slowly than ground flowers or dust. Stored powders lose about 20% of their potency in 1 year. This instability has limited their use as stomach and contact poisons. Anti-oxidants are often included in formulations to increase stable.

64. BIOCONTROL 16124

Plant Disease Management by *Pseudomonas fluorescens*

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INTRODUCTION: The indiscriminate and extensive use of pesticides in recent years has posed a serious problem of pollution in the eco-system and development of resistance in the pathogens. Therefore, biocontrol agent in general and *Pseudomonas fluorescens* in particular have gained importance as a component of Integrated Pest Management for sustainable agriculture.

Significance of *P. fluorescens* Rhizobacteria

Pseudomonas fluorescens belongs to plant Growth Promoting Rhizobacteria (PGPR) that plays a major role in the plant growth promotion, induced systemic resistance, biological control of pathogens, *etc*. Moreover, it is inexpensive and environmentally safe.

Important Genera of *Pseudomonas*

Important genera of Pseudomonas are P. fluorescens, P. putida, P. aeruginosa P. alcaligens, P. aureofaciens and P. cepacia.

Mode of Action

1. Siderophore production: Siderophores are extra cellular, low-molecular weight compounds with a very high affinity for ferric iron. As siderophore sequester the limited supply of iron in the rhizosphere, they limit its availability to pathogens and ultimately suppress their growth.

2. Antibiotics production: Many secondary metabolites of *Pseudomonas fluorescens* act as antibiotics against plant pathogens. *P. fluorescens* strain Pf-5 produces two antifungal compounds, pyoluteorin and pyrrolnitrin which are fungistatic, inhibiting spore germination and lysis of fungal mycelia.

3. Induce systemic resistance: Induction of resistance by *P. fluorescens* is mainly through the production of phytoalexins, increased lignifications and production of PR-proteins in inoculated plants.

Biological Control of Plant Diseases

I. Fungal diseases: Seed treatment with PGPR strains significantly reduced lesion number and diameter of cucumber anthracnose, Root rot of cotton (*R. solani)* reduced to 10 and 24 % when seeds treated with isolates FP-43 and FP-47 of *P. fluorescens,* respectively. *Pseudomonas* strain FPC- 32 and FPO – 4 showed antibiosis against collar rot of peanut caused by *A. niger* and improved the seed germination, plant growth and yield. Combination of *T. viride* and *P. fluorescens* proved best for better seed germination (86.3%) as well as in reduction of wilt incidence in coriander.

Isolates NH-51 and SBI-42 of *P. fluorescens* gave about 90 per cent inhibition of *Pythium*

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graminicola causing seedling rot of sugarcane. However, isolates NH-51 and TAS-72 gave maximum germination (82 & 85% respectively) and complete control of red rot under glass house condition. PDBC-AB-30 isolate of *P. fluorescens* was found effective against *B. cinerea M. phaseolina, R. solani* and *F. oxysporum* with inhibition zones ranging from 38 to 67 mm. Similarly, *Pf*-1was most effective with an inhibition zone of 11.6 mm against *M. phaseolina.* However, application of P*f* 1 as seed treatment and soil application gave good reduction in root rot incidence, moderate nodulation and maximum kernel yield in peanut.

Among the antagonists, *P. fluorescens* inhibited maximum (67.22%) mycelial growth of *Sclerotium rolfsii* followed by *B. subtilis* (55.56%). *Psuedomonas fluorescens* isolate 10 @ 10 gm/kg was found effective in reducing *S. oryzae* seed infection, increased seed germination and seedling vigour. Strains NRC-1 and NRC-3 of *P. fluorescens* effectively reduced the mycelium growth of *P. capsici* and *R. solani* causing basal stem rot and root rot of tomato. In PF-2 strain of *P. fluorescens,* growth inhibition was more in PAF medium (72.6%) than in PDA medium (52.1%). However, strain *Pf*-9 and *Pf*-13 was most effective in reducing the bakane disease of rice.

II. Bacterial diseases: A significantly lower population of *E. carotovora* was recorded on roots of potato treated with *P. fluorescens* than untreated control. The seed treatment with *P. fluorescens* strain 26 gave maximum germination and minimum seedling infection in cotton infected with *Xanthomoas axonopodis* pv. *malvacearum*.

III. Nematode diseases: Culture filtrate of *P. fluorescens* caused maximum reduction in cyst (90.4%) and juvenile (89.0%) population in black gram. Similarly, application of *P. fluorescens* talc formulation ($15x10^8$cfu/gm) @ 10 and 20 kg/ha (47.7 and 62.6 %) reduced potato cyst nematode parasitization, respectively. Soil application of *P. fluorescens* @ 6 gm + carbofuran 3 G @ 1.3g a.i./m^2 in nursery significantly reduced rice root nematode population in soil as well as in root. However, under field conditions seed treatment @ 20 gm/kg significantly reduced the nematode population having higher bacterial colonization. Seed treatment with *P. fluorescens* strain *Pf*-1 having $6x10^8$ cfu/ml significantly decreased in the reniform nematode penetration. Seed treatment with *P. fluorescens* strain *Pf*-1 and soil application of neem cake and crab shell was effective in reducing the nematode population in soil as well as in root.

Conclusion: The *Pseuodomonas fluorescens* Rhizobacteria has been found a potential bioagent for management of different crop diseases viz., sheath blight of paddy, collar rot of groundnut, damping off of tomato, etc. caused by fungal pathogens; soft rot of potato, bacterial blight of rice caused by bacteria; nematode and viral diseases. However, it needs to be used judiciously as various strains of *Pseudomonas* are known to have host preference. The bacteria can also be used in combination with fungal bioagents, nematicides, and amendments; therefore it is one of the promising components in integrated crop management leading to the suppression of soil borne as well as certain foliar pathogens.

Future thrust

- Further investigation is desirable on host preference.
- Identification of efficient strains of *P. fluorescens* for disease suppression under various soil conditions.
- Suitable agronomic practices needs to be evolved for enhancing growth and development of *P. fluorescens.*
- Genetic manipulation of the bacteria for expression of desirable characteristics.
- Development of transgenic plants of beneficial genes from *P. fluorescens*.

65. ENTOMOLOGY 15535

Secretory (Endocrine) System: Structure and Functions of Neuro-Secretory Organs

(Neuro-Secretory Cells of Brain, Corpora Cardiaca, Corpora Allata, Pro-Thoracic Glands and Ring Glands)

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- The endocrine organs and hormones together referred as endocrine system in insects.
- The endocrine organs produce *hormones* which travel usually in blood to various organs of the body coordinating their activities.
- The endocrine system is thus complimentary to the nervous system.
- *Endocrine system* helps to maintain homeostasis, coordinate behavior, and regulate growth, development, and other physiological activities.

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- A *hormone* is a chemical signal sent from cells in one part of an organism to cells in another part (or parts) of the same individual. Hormones are often regarded as *chemical messengers*. Although typically *produced in very small quantities*, hormones may cause profound changes in their target cells. Their effect may be stimulatory or inhibitory. In some cases, a single hormone may have multiple targets and cause different effects in each target.

Endocrine Organs are of Two Types

- Neurosecretory cells in the central nervous system, and specialized endocrine glands. The neurosecretary cells are modified motorneurons.
- Both types of organs produce hormones which are generally released directly or indirectly via storage organs (neurohaemal organs), into blood, but in some instances the hormones produced by neurosecretaory cells are conveyed to the target organs along the axons of the cells.
- Nervous stmuli commonly lead to the release of the hormones.

Endocrine Organs in Insects

- The endocrine organs of insects are of two types; *neurosecretary cells* (mainly within the central nervous system) and the *specialized endocrine glands* (such as corpora cardiac, corpora allata and prothoracic glands).

Neurosecretory Cells

- The neurosecretary cells normally occur in the ganglia of the CNS.
- They generally resemble typical bipolar nerve cells, but are characterized by showing cytological evidence of secretion.
- The neurosecretary cels are modified motorneurons.
- The secretion is granular, synthesized in cell bodies and pass down to axons.
- It is possible that the visible secretion is only a carrier (possibly a lage protein), to which the smaller hormone molecule is attached.
- When hormone is finally released it becomes separated from the carrier (protein) and is then free into blood.
- The endocrine activity of neurosecretary cells may take one of two forms: the cells may either produce hormones which act directly on effector organs, or they may act on other endocrine organs, which in turn, are stimulated to produce hormones.

Neurosecretory Cells of the Brain

- The neurosecretory cells are found in clusters, both medially and laterally in the insect's brain.
- Axons from these cells can be traced along tiny nerves that run to the corpora cardiaca and corpora allata.
- Typically there are two groups of neurosecretory cells on each side of the brain.
- One group is in the pars intercerebralis, near the midline, are called median neurosecretary cells. The axons from these cells pass backwards through the brain and some or all of them cross over to the opposite side, emerging from the brain as a nerve which runs back to the corpus cardiacum. Most of the fibres end here, but few pass through the corpus cardiacum to the corpus allatum, and in the locust, to the foregut and ingluvial ganglion.
- The second group of cells (lateral neurosecretory cells) is variable in position, but usually between the optic lobe and corpora pedunculata. From these cells, a second axon also extends to the corpus allatum.
- The products of the neurosecretory cells of the brain (Brain Hormone) pass along the axons, usually to the corpora cardiac or allata. Here they may be stored or released.
- The secretions of the neurosecretory cells in the pars intercerebralis (median NS cells) promote the functioning of the prothoracic glands (PTG), stimulate protein synthesis and possibly control water loss, oocyte development and activity.

Neurosecretory Cells of other Ganglia

- Large number of neurosecretory cells occurs in the ventral ganglia of the nerve cord.
- In *bombyx* there is more number of NS cells in the ventral ganglia than brain.
- Different cell types are widely distributed in different ganglia.
- The secretory products are liberated into blood via neurohaemal organs on the peripheral nerves.
- *The functions of these cells in general are not known*, but in some cases they are known to be concerned with water regulation.

Corpora Cardiaca

- The corpora cardiaca are a pair of organs often closely associated with aorta.
- These are absent in collembolan.
- Each organ contains endings of axons from NS cells in the brain and other axons passing through to the corpora allata.
- The corpora cardiac *store and release hormones from NS cells of the brain*, to which they are connected by one or two pairs of nerves.
- In addition, the intrinsic secretory cells produce hormones which are concerned with the regulation of the heartbeat and have other physiological effects.

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Corpora Allata

- The corpora allata are glandular bodies, usually one on either side of oesophagus.
- They are fused to a single organ in diptera.
- Each is connected with corpus cardiacum of the same side by a nerve which carries fibres from NS cells of the Brian.
- In addition, a fine nerve connects each corpus allatum with suboesophageal ganglion.
- The corpora allata produce Juvenile Hormone (JH) which regulate metamorphosis and yolk deposition in eggs. Changes in the volume of corpora allata or in the sizes of the cells within gland are not necessarily correlated with JH activity in the haemolymph.

Prothoracic Glands (PTG)

- The prothoracic, or thoracic, glands are a pair of diffuse glands at the back of the head or in the thorax.
- Each gland has a rich tracheal supply and often nerve supply.
- The glands show cycles of development associated with secretion. At rest, the nuclei are small and oval, but in active gland, they become enlarged and lobulated and the cell has more extensive and deeply staining cytoplasm. During active phase, the number of mitochondria increase and endoplasmic reticulum becomes more extensive. This reflects the production of enzumes engaged in synthesis of ecdysone.
- The prothoracic glands produce moulting hormone, ecdysone, and except in thysanura, which moult as adults, the prothoracic glands breakdown soon after the final moult to adult.

Ring Gland

- In the larvae of cyclorrhaphous Diptera, the ring gland surrounds the aorta just above the brain.
- It is formed from corpora allata, corpora cardiac and prothoracic glands, all fused together.
- The ring gland is connected to the brain by a pair of nerves.

Role and Function of Hormones

- When an immature insect has grown sufficiently to require a larger exoskeleton, sensory input from the body activates certain neurosecretory cells in the brain.
- These neurons respond by secreting *brain hormone which triggers the corpora cardiaca to release their store of prothoracicotropic hormone* (PTTH) into the circulatory system.
- This sudden "pulse" of *PTTH stimulates the prothoracic glands to secrete molting hormone* (ecdysteroids). Molting hormone affects many cells throughout the body, but its principle function is to stimulate a series of physiological events (collectively known as apolysis) that lead to synthesis of a new exoskeleton.
- During this process (apolysis), the new exoskeleton forms as a soft, wrinkled layer *underneath* the hard parts (exocuticle plus epicuticle) of the old exoskeleton. The duration of apolysis ranges from days to weeks, depending on the species and its characteristic growth rate. Once new exoskeleton has formed, the insect is ready to shed what's left of its old exoskeleton. At this stage, the insect is said to be pharate, meaning that the body is covered by two layers of exoskeleton.

66. ENTOMOLOGY 15570

Neurobiology of Monarch Butterfly (*Danaus plexippus* L) Migration

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The annual migration of the eastern North American monarch butterfly (*Danaus plexippus* L) is a visually spectacular phenomenon in terms of both the number of butterflies and the mass of butterflies congregated at their overwintering sites in Mexico. Not only is the monarch migration a visual splendor, it is also a biological treasure trove. To successfully reach their goal, migratory animals likely to use a map for a sense of position and compasses for directional information. The migratory monarch butterfly is a model species to study the neurobiological basis of long-distance animal migration (Reppert *et al.,* 2016). The main orientation mechanism uses a time-compensated sun compass during both the migration south and the remigration north. Daylight cues, such as the sun itself and polarized light are processed through both eyes and integrated through intricate

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circuitry in the brain central complex, the presumed site of the sun compass. The compass sense that migrant butterfly use to orient in the southerly direction throughout the day over the course of their migration (Reppert *et al.,* 2016). Migrating monarch butterfly antennae have circadian clocks that are directly entrained by light independent from the brain with molecular clockwork identical to that found in brain clocks and these clocks actually provide the primary timing component of the sun compass orientation mechanism (Merlin *et al.,* 2009).

Monarchs butterflies use an earth-strength, light-dependent, inclination-based and magnetic compass during the course of migration. Flight simulator studies showed that fall migrants can use the inclination angle of the earth magnetic field to obtain directional information, which they use to guide their latitudinal movement during the fall migration (Guerra *et al.,* 2009). The cryptochrome (CRY) proteins in neural pathways are relevant for migration and circadian behaviour. A CRY 2 in neural pathway connect the pars lateralis (PL) clocks or the pars intercerbralis (PI) to the central body region of the central complex (CC) for regulating circadian behaviours *viz.,* daily flight activity, metabolic rhythms and the sleepwake cycle (Zhu *et al.,* 2008). Monarchs have specialized photoreceptors in the dorsal rim area of the eye that can detect skylight cues. These cues passed through the optic lobe and two specialized regions of the lateral accessory lobes (LALs) information from both eyes is integrated in the central complex of brain. The CC is an array of neurons possesses tunings that provide a topographical representation of the solar azimuth (Heinze and Reppert, 2013).

In response to environmental factors (temperature and photoperiod), physiological process like insulin signaling could be reduced through a decrease in the production or secretion of insulin-like peptides and decrease in the expression of associated receptors, which would reduce JH biosynthesis in the corpora cardiac-corpora allata complex, leading to both reproductive shutdown and reduced aging in migrant monarchs (Herman and Tatar, 2001). Migrating monarch butterfly use a time-compensated sun compass to navigate from eastern North America to their overwintering grounds in central Mexico. The circadian clock plays a critical role in monarch butterfly migration by providing the timing component to time compensated sun compass orientation. A novel molecular clock mechanism in monarchs by focusing on the functions of two cryptochrome proteins. The monarch clock may be the prototype of a clock mechanism shared by other invertebrates that express both CRY proteins and its elucidation will help crack the code of sun compass orientation.

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67. ENTOMOLOGY 15663

Entomopathogenic Nematodes as Biological Control

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Nematodes that parasitize insects, known as entomopathogenic nematodes (EPNs), have been described from 23 nematode families. Of all of the nematodes studied for biological control of insects, the Steinernematidae and Heterorhabditidae have received the most attention because they possess many of the attributes of effective biological control agents and have been utilized as classical, conservational, and augmentative biological control agents. The vast majority of applied research has focused on their potential as inundatively applied augmentative biological control agents. Extensive research over the past three decades has demonstrated both their successes and failures for control of insect pests of crops, ornamental, and lawn and turf.

Life Cycle

The infective juvenile stage (IJ) is the only free

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living stage of entomopathogenic nematodes. The juvenile stage penetrates the host insect via the spiracles, mouth, anus, or in some species through intersegmental membranes of the cuticle and then enters into the haemocoel. Both *Heterorhabditis* and *Steinernema* are mutualistically associated with bacteria of the genera *Photorhabdus* and *Xenorhabdus*, respectively. The juvenile stage release cells of their symbiotic bacteria from their intestines into the hemocoel. The bacteria multiply in the insect hemolymph and the infected host usually dies within 24 to 48 hours. After the death of the host, nematodes continue to feed on the host tissue, mature and reproduce. The progeny nematodes develop through four juvenile stages to the adult. Depending on the available resources one or more generations may occur within the host cadaver and a large number of infective juveniles are eventually released into environment to infect other hosts and continue their life cycle.

Mode of Action

Entomopathogenic nematodes are a nematode-bacterium complex. In this association, the nematode is dependent upon the bacterium for quickly killing its insect hosts, creating a suitable environment for its development by producing antibiotics that suppress competing secondary microorganisms and transforming the host tissues into a food source. The bacterium requires nematode for protection from the external environment, penetration into the hosts haemocoel and inhibition of the hosts antibacterial proteins.

Searching Behavior

Entomopathogenic nematodes use two search strategies: ambushers or cruisers Ambushers such as *Steinernema carpocapsae* have an energy-conserving approach and lie-in-wait to attack mobile insects (nictitating) in the upper soil. Cruisers like *Steinernema glaseri* and *Heterorhabditis bacteriophora* are highly active and generally subterranean, moving significant distances using volatile cues and other methods to find their host underground. Therefore, they are effective against less mobile pests such as white grubs (Scarab beetles). Some nematode species such as *Steinernema feltiae* and *Steinernema riobrave* use an intermediate foraging strategy (combination of ambush and cruiser type) to find their host.

TABLE 1: List of EPN species and the targeted pests of various crops

EPN species	Targeted pest(s)
Steinernema glaseri	White grubs (scarabs, especially Japanese beetle, *Popillia* sp.), banana root borers
Steinernema kraussei	Black vine weevil, *Otiorhynchus sulcatus*
Steinernema carpocapsae	Turfgrass pests- billbugs, cutworms, armyworms, sod webworms, chinch bugs. Orchard, ornamental and vegetable pests- banana moths, codling moths, cranberry girdlers, dogwood borers and other clearwing borer species, black vine weevils, peach tree borers, shore flies (*Scatella* sp.)
Heterorhabditis indica	Fungus gnats, root mealybugs, grubs
Heterorhabditis marelatus	White grubs (scarabs), cutworms, black vine weevils
Heterorhabditis zealandica	Scarab grubs

Advantages of Entomopathogenic Nematodes

Entomopathogenic nematodes have certain advantages over chemicals as control agents. Nematodes are non-polluting and thus environmentally safe and acceptable, Infective juveniles can be applied with conventional equipment and they are compatible with most pesticides. They find their hosts either actively or passively and in cryptic habitats and sometimes in soil, they have proven superior' to chemicals in controlling the target insect. They are not well-suited for foliar application, since, they are sensitive to desiccation and ultraviolet radiation. The nematodes usually reproduce in the insect host and thus provide new infective juveniles to search for additional host insects. The effective host range of a given species or strain is usually rather narrow, thus they do not cause indiscriminate mortality. The narrow host range means that one must select the appropriate nematode just as one must select the appropriate chemical insecticide to control the target insect.

68. ENTOMOLOGY 15886

DNA Barcoding in Insects: A Novel Way to Explore

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INTRODUCTION: Until now, biological specimens were identified using morphological features like the shape, size, and color of body parts. In some cases, a trained technician could

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make routine identifications using morphological "keys" (step-by-step instructions of what to look for), but in most cases, an experienced professional taxonomist is needed. If a specimen is damaged or is in an immature stage of development, even specialists may be unable to make identifications. Barcoding solves these problems because even non-specialists can obtain barcodes from tiny amounts of tissue. This is not to say that traditional taxonomy has become less important.

History: In 2003, Paul Hebert, a researcher at the University of Guelph in Ontario, Canada, proposed "DNA barcoding" as a way to identify species. Barcoding uses a very short genetic sequence from a standard part of the genome the way a supermarket scanner distinguishes products using the black stripes of the Universal Product Code (UPC). Two items may look very similar to the untrained eye, but in both cases the barcodes are distinct. DNA barcoding can serve a dual purpose as a new tool in the taxonomist's toolbox supplementing their knowledge as well as be an innovative device for non-experts who need to make a quick identification.

The Need of the Hour

Morphology, the shape, and structure of plants and animals have enabled scientists to designate some 1.7 million species, a remarkable feat, and morphology remains the foundation of Linnaean-type taxonomic diagnosis. Relying on morphology alone to describe life's diversity has limits; however, the nuances that distinguish closely allied species are so complex that most taxonomists specialize in one group of closely related organisms. As a result, a multitude of taxonomic experts is needed to identify specimens from a single biodiversity survey. Finding appropriate experts and distributing specimens can be time-consuming and expensive.

How does it Work?

The first step is finding a short piece of the DNA that could produce identifications, one that is long enough to contain in a formation that would distinguish species but short enough to be fast and efficient to use. A particular gene segment is used as the standard reference for animal species. This segment is part of a gene housed in mitochondria energy-producing subunits of cells, which are inherited from the mother. The gene selected gives rise to an enzyme called cytochrome *c* oxidase subunit 1, Or CO1 for short. And although it is a tiny fraction of the DNA inside each cell, it captures enough variation to tell most species apart. COI is proving highly effective in identifying birds, butterflies, fish, flies and many other animal groups. COI is not an effective barcode region in plants because it evolves too slowly, but two gene regions in the chloroplast, matK and rbcL, have been approved as the barcode regions for plants.

Mitochondrial DNA has proved especially suitable because sequence differences among species are much more numerous than in the DNA of a cell's nucleus. Thus, short segments of mitochondrial DNA are more likely to parse separate species. In addition, mitochondrial DNA is more abundant than nuclear DNA and therefore easier to recover, especially from small or partially degraded samples.

DNA Hub

Now that we have found a barcode, the next step is to compile a reference library of this segment from specimens whose identity is already firmly established. By comparing barcode DNA from some creature against these "voucher specimens," researchers can determine whether the organism is a member of a known species or is a new find. The mechanics of creating the library are simple: someone obtains DNA from a tissue sample, determines the base-pair sequence of the barcode segment, and enters the information into a barcode database. The acquisition of specimens is more complex. The extent of variation within each species, though low, nonetheless suggests that at least 10 individuals per species should be analyzed to register this diversity.

Even though the world's museums hold more than 1.5 billion specimens, most were not prepared with DNA recovery in mind, and many are simply too old to yield full barcode sequences. For older museum specimens that serve as original references for taxonomic names, amplifying a mini barcode of 100 to 200 base pairs, a size that can often be recovered from old or damaged DNA, will usually provide enough information to demonstrate membership in the same species as younger specimens with full barcodes. To aid construction of the barcode library, researchers at many institutions have begun assembling large tissue banks stored under conditions that preserve DNA. Some of the major libraries are listed hereunder:

1. **iBOL -** The International Barcode Life Project (iBOL)
2. **CBOL -** The Consortium for the Barcode of Life (CBOL)

Practical Applications

- Species identification in a wide range of animal taxa, including butterflies and moths, birds, mayflies, spiders, fishes, ants, Crustacea, gastropods, mosquitoes, and wasps.
- Rapid acquisition of molecular data and less cumbersome.
- A handy tool when conventional methods fail to distinguish between immature and adult insects.
- Clear cut molecular discrimination in insects which are difficult to visualize.

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- Can even recognize partially damaged or fragmented specimens.
- Can be a key player in conservation studies and also in analysis involving umpteen numbers of studies.
- Improve large surveys aiming at unknown species detection and identification of pathogenic species with medical, ecological and agronomical significance.

Conclusion: The fact remains, however, that formal descriptions of new species can take years to complete. The generation of sequence data is thus running far ahead of official species descriptions. Barcoding can be a new ushered technology, which can create a map of DNA diversity that will serve as a framework for the subsequent detailed study. DNA barcoding can be a rapid, relatively inexpensive first step in species discovery. It could facilitate the identification of the unexplored species within a short span of time which could bring about greater breakthroughs in biodiversity.

69. ENTOMOLOGY 15943

Biology and Management of Khapra Beetle

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Khapra beetle (*Trogoderma granarium*), is a dermestid also called as du grain in French, Khaprakafer in German. This beetle is a Indian origin mostly confined to north India. It is one of the most destructive pests of stored wheat grain and its products. It breaks or powders more grain than it consumes. Losses of 5% in weight and 33% damaged grain. It has a quarantine importance and one among 100 worst invasive species. It acts as a primary and secondary pest, confine to upper layers heaps. It survive even in low oxygen and low moisture conditions and resistant to temperature humidity, starvation and insecticides. It can go diapause even up to three years.

Spread: Adults and larvae are known to seek out cracks and crevices in sacks, crates, rail cars, ship and trucks. Transportation of infested materials such as bagged cereal grains or seeds.

Distribution: Countries infested with Khapra beetle are Afghanistan, Bangladesh, Egypt, India, Iran, Iraq, Israel, Myanmar, Nigeria, Pakistan, Saudi Arabia, Sri Lanka, Sudan, Syria, Turkey, and the United Arab Emirates. Beetle has failed to establish in America due to stringent quarantine policies.

Host range: The khapra beetle is now found in all continents where grain and grain products are stored. They prefer whole grain and cereal products such as **wheat, barley, and rice, oats, rye, corn, dried blood, dried milk, fishmeal, ground nuts**,

Biology: Eggs are laid on grains or crevices, which are cylindrical 0.7 mm X 0.25 mm length and 0.02 mg weight, milky white pale yellowish in colour. **Grub** are dark brown with hairy bands on each segment and tuft forming a tail of long hairs. **Pupas** were found on surface of grain or overlapping edges of bags. **Adult** are reddish brown, convex oval in shape and no distinct division of head, thorax and abdomen.

Nature of damage: *T. granarium* larvae most serious stored seed pest feeds on embryo and later consume the entire kernel. Infested seeds are fill with frass, cast skins of larvae and excreta, which results in deterioration of quality of grain. Wheat, maize and sorghum grains, significant decreases in crude fat, total carbohydrates, sugars, protein, starch content, vitamins thiamin, riboflavin, niacin, total lipids. Increases in the levels of uric acid, moisture, crude fiber and adults are harmless.

Damage symptoms: Moulted skins are seen in grains results in low market value. Larval skins cast by the beetles may cause skin irritation in people handling heavily infested grains

Khapra Beetle Management

1. **Godown/warehouse sanitation:** Floors, walls, ceilings, windows, and screens should be properly cleaned and maintained. Cracks have to be sealed so as not to provide hiding places of entry. A new cargo should not be stored with the remains of the previous cargo. Never store products in used bags or new bags without washing.
2. Pusa bin storage structure is used for grain storage
3. All warehouses have to be treated with Malathion+Nuvan 2ml/litre of water on the floors and walls periodically as prophylactic measure.
4. Three Aluminium phosphate tablets are used for fumigation of one tonne grains.

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70. ENTOMOLOGY 15952

Migration of Monarch Butterflies

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Millions of monarch butterflies leave their summer breeding grounds in the northeastern U.S. and Canada and travel upwards of 3,000 miles to reach overwintering grounds in southwestern Mexico. But unlike birds or wildebeest that also embark on epic migrations, these individual butterflies will never return. Why won't they make it all the way back? How do they know where to go in the first place?

How does Monarch Butterfly Migration Work?

As the days get shorter and the temperatures drop off, monarchs begin to abandon breeding and feeding territories in search of a safe place to spend the winter. For monarchs, that overwintering ground is found high up on just a few mountains in central Mexico. Once there, the monarchs huddle together by the millions on the branches of oyamel fir trees. These trees, also known as sacred firs, create a microclimate that protects the insects. "The tree canopy and ecosystem provide a blanket effect for the monarchs, so the temperatures don't go too high or too low. After waiting out the winter, these individuals head part of the way back north to warmer climes such as Texas, where they mate and lay eggs on milkweed plants. In just a few days, the eggs hatch into brilliantly striped caterpillars of black, gold, and white. These monarch larvae consume vast amounts of milkweed before forming a chrysalis and transforming into adult butterflies. At this point in the cycle, the new butterflies take to the skies again and fly another few hundred miles north before finding another patch of milkweed and repeating the process.

It might take the monarchs as many as four to five generations to complete the journey all the way back up to Canada. "Interestingly, the waves of monarchs heading north will complete their entire life cycles in just five to seven weeks each. But when fall rolls around again, a special 'super generation' of monarchs that can live up to eight months will make use of air currents to wing all the way back to Mexico—a seemingly impossible feat for such a delicate-looking insect. This makes the migrating monarchs so unique as they are the same species but for some reason live much longer."

Why do Monarchs Migrate, and how do they Know Where to go?

This part is still very much up for debate, but there are a couple of theories.

One explanation might be that when monarchs march north, they are essentially following the bloom of their primary food source 'milkweed plants'. And then when winter comes and those plants die back, the animals retreat to a place with conditions that protect them from the weather.

Another idea involves their immune systems. "Migration also allows monarchs to escape habitats where parasites have accumulated at the end of the summer. Adult butterflies infected with a protozoan parasite called *Ophryocystis elektroscirrha*, or OE, can't fly as well in lab tests and travel shorter distances in the wild. We think that migration weeds out the most heavily infected monarchs, removing them from the populations. As for how the monarchs know where to go, a study published in 2016 suggests that the critters navigate based on their relative position to the sun. But scientists are still ironing out exactly how this works.

Why are Monarch Butterflies Important?

While monarchs may seem small and insignificant, the creatures play a crucial role in the ecosystems they inhabit

- As adults, monarch butterflies visit countless numbers of wildflowers each year as they seek out nutrient-rich nectar. In doing so, the monarchs transfer pollen from one plant to another and assist in those species' reproduction
- Orioles and grosbeaks in particular make a feast of monarchs over the winter, and ants, wasps, flies, and spiders have been known to prey on the caterpillars when they get the chance

What Threats do Migrating Monarchs Face?

Because migratory monarchs have such a wide range, they also have many threats. These include declining milkweed populations across their range in the U.S. and Canada, parasites and diseases and even a growing demand for avocados sourced from Mexico.

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71. ENTOMOLOGY 16006

Tomato Pin Worm: A Bane to Tomato Farmers in Tamil Nadu

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INTRODUCTION: South American tomato moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) also known as the tomato leaf miner is an oligophagous invasive pest associated with solanaceous crops. Tomato is the primary host of *T. absoluta*, but it has been reported on other secondary hosts like egg plant (*Solanum melongena* L.), potato (*Solanum tuberosum* L.), pepper (*Capsicum annuum*), sweet pepper (*S. muricatum* L.) and tobacco (*Nicotiana tabacum* L.).

In India, T. absoluta was **first reported by Sridhar *et al.*, (2014)** and recently spreading rapidly in southern states of the country (Anitha Kumari ***et*** *al.,* 2015; Kalleshwaraswamy *et al.*, 2015; Shashank *et al.*, 2015). *T. absoluta* causes reduction in yield and fruit quality causing up to 100% loss in both greenhouses and open field conditions (Sridhar *et al.*, 2014; NAPPO, 2012). Different parts of tomato plants like leaves, stems, buds, calyces, young and ripe fruits are damaged by feeding of *T. absoluta*. The natural incidence of *T. absoluta* under field conditions on all the host plants considered in the present study *i.e.*, tomato, potato and egg plant with varying degree of damage incidence.

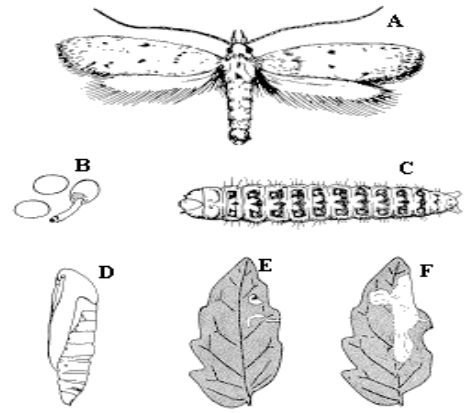
In fact, horticulture production (268.9 million tonnes, or mt) surpassed foodgrain output (257 mt) for the first time in 2012-13. In the case of tomato, production has grown two-and-a-half times to 18.7 mt in 2013-14 from 7.4 mt in 2001-02.

Tuta Absoluta

It all started in October 2014 when scientists at a Pune research station under the Indian Council of Agricultural Research (ICAR) observed an unknown pest in their tomato trial fields. A team of taxonomists and entomologists from the Indian Agricultural Research Institute (IARI), Delhi, and ICAR, Pune, conducted surveys in nine tomato-growing districts near Pune and found the pest infestation in all. Specimens were taken to Delhi, and after DNA bar-coding, it was confirmed that the tiny moth-like pest was indeed the South American *Tuta absoluta* (tomato leafminer).

A nationwide alert was issued by ICAR in January this year for the pest, known to be responsible for 80-100% of yield and fruit quality losses under greenhouse and field conditions. The pest skeletalises the leaves of the plant, and feeds on stems and buds, leaving line-like bore marks on the fruit.

From South America to India: *Tuta absoluta*, which not only affects tomatoes but also others from the solanaceous family of vegetables such as potatoes, eggplant and capsicum, became one of the most virulent pests in South America in the 1960s.



Tomato pinworm. A. Adult, B. Eggs and new larva, C. Larva, D. Pupa, E. Early damage, F. Later damage.

Later, it was detected in Spain in 2006, and since then has rapidly spread to other European countries, infested North African and Mediterranean countries including Bahrain, Iraq, Israel, Jordan, Turkey, Yemen, Syria and even Japan. It was found in Iran in late 2010, and it is suspected that the pest has infested crops in Pakistan, too.

Tomato Production in India

Tomato is one of the most important vegetable crops in India. India is the second largest producer, accounting for 11.2% of the world production and the second largest in terms of acreage accounting for 18.27%. Its production has increased by almost 36 times, from a mere 0.54 Mt in 1961 to about 18.2 Mt in 2014. The South

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American tomato moth, *Tuta absoluta* is a quarantine pest was detected **first time in Maharastra,** India in late 2014 and then in Karnataka.

Junnar Taluk of Pune district, during **October 2014** and **in Kolar and Bengaluru districts of Karnataka in January, 2015** the incidence was found by a team of taxonomists and entomologists from the Indian Agricultural Research Institute (IARI), Delhi, and ICAR, through **DNA bar** coding the species was conformed.

A **nationwide alert** was issued by ICAR for the pest, known to be responsible for **80-100%** of yield and fruit quality losses under greenhouse and field conditions.

Tomato Production in Tamil Nadu: During 2015 -2016, tomato area and the production in Tamil Nadu is estimated to be 0.24 lakh hectares with a production of 3.05 lakh tonnes as against 0.25 lakh hectares with 3.28 lakh tonnes respectively for the year 2014-15, as per NHB estimates.

First Report in Tamil Nadu: In Dharmapuri district and the occurrence of *T. absoluta* was first noticed in Karimangalam block in the tomato **hybrid Sivam**. The widely cultivated tomato hybrids Sivam and Sagar were equally susceptible to the SATM with 20-32 per cent leaf damage and 28 - 53 per cent fruit damage.

Conclusion: Now it is evident that *T. absoluta*is establishing in tomato in India. The origin and mode of introduction is not known. Intensive spread and dissemination of tomato leaf miner should be correlated with fruit importation and commercialization (Potting, 2009). One of the possible pathways for a long distance dissemination of *T. absoluta* could be through a packaging material (boxes) coming from infested countries (EPPO, 2010). Being an r-selected and multivoltine species (Pereyra and Sánchez, 2006) and due to its rapid population growth, potential dispersal through environment and expressed resistance to insecticides (Desneux*et al.,* 2010), this pest has been classified as the most serious threat for tomato production worldwide.

The current report is alarming because 1) its developmental cycles depend on environmental conditions, 39.8 days at 19.7°C and 23.8 days at 27.1°C (Barrientos *et al.,* 1998) which are very much present in major tomato growing areas of India to facilitate the pest to complete 10 to 15 generations per year; 2) Existence of suitable solanaceous host plants in central and southern India makes establishment and spread of transient populations possible; 3) In addition to crop plants, solanaceous weeds could serve as host reservoirs which do exist in India; and 4) Difficulty in adaptation of area wide management programmes due to numerous small holdings.

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72. ENTOMOLOGY 16016

Synergism of Insecticides

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Synergism is an increase in the bioactivity of two compounds to produce an effect greater than the one expected from a single algebric summation of the effects of two compounds individually administered. This may also be called activation. It is derived from Greek word "Sunergos" meaning "working together". Generally, in synergism the synergist compound is non toxic while a word potentiation is also used wherein the compound used for increasing the total toxicity is also toxic one. Synergism was first used in pharmacology for presenting the unusual combined effect of drugs and was defined by Macht (1929) as "The phenomenon exhibited by the combination of two or more drugs in which the pharmacodynamic effect produced by the mixture is not a simple summation of the effects produced by the two or more individual components". Such combinations produce a pharmacological effect of an unexplained nature in that the effect of one of the components may be greatly heightened or potentiated by the other. Bliss (1939) was largely responsible for introducing the statistical calculation of independent action, similar action, and synergism.

Types of Synergism

1. Negative synergism: If two materials *i.e.* one toxic material and other modifier applied together elicit lower response than that expected from the sum of two individuals is known as negative synergism and antagonism.
   a) **Antagonist:** A substance, that has the opposite effect, *i.e.*, that which reduces the toxicity of an insecticide. *E.g.*

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Piperonyl butoxide used with Malathion, Piperonyl cyclonene used with Malathion, Parathion mixed with Malathion, Parathion mixed with Azinphosmethyl and Demeton mixed with Trichlorofon.

b) **Autosynergism:** A compound which synergize its own toxicity. This would involve forging a "synergophore" and "toxophore" in to the same molecule in such a way that the former does not interfere with the action of the later. *E.g.* 2- and 3-(2 prophynyloxy) phenyl, N-methyl carbamate have demonstrated autosynergistic properties.

2. **Quasi-synergism:** Increase in the toxicity through the increase in cuticular penetration. Synergists which enhance penetration, transport or accessibility of insecticides without any inhibition of detoxifying system. *E.g.* Carbaryl-Thanite synergism Tween ® 20, Tween ® 80
3. **Pseudo-synergism:** Increase in the efficiency of insecticides by stabilizing the droplet size of their sprays. Ensuring better and persistent contact of insecticides with the insect body. *E.g.* Oleic oil -Pyrethroids synergism
4. **Analogue synergism:** The analogue synergists have structural resemblance to the insecticide. The non-toxic compound competes with a toxic compound for the same site on the detoxifying enzyme system and reduces the amount of detoxification of toxic compound. The potential value of such a compound was diecovered early in carbamate history when dimetilan enhanced the toxicity of carbaryl to German cockroaches and houseflies. However, this was. In reality, potentiation, because dimetilan when applied alone was toxic to the insects. Phenyl dibutylcarbamate enhances the toxicity of isolan and carbaryl.
5. **Target site synergism:** When two compounds interact with the different sites of the target. Combination of an aryl N-methyl carbamate with an N-propyl carbamate overcomes the aryl N- methyl carbamate resistance in rice green leaf hopper. Resistance due to modified AchE insensitive to n-methyl carbamates and the N- propyl carbamates are more inhibitory to the modified AchE. Both components of the combination interact with the preferred inhibition sites.

Advantages of Synergism

- Small quantity of insecticides would be required for field application if synergist is mixed with, which result in considerable reduction in the environmental pollution caused by a particular insecticide.
- Many tolerant and resistant insect strains can effectively be controlled on the addition of the synergist with insecticide. It was observed that resistant houseflies which were able to tolerate individual treatment of 100 μg of carbamate were killed by 1μg of insecticide when piperonyl butoxide (5μg) was added.

Quantification of Synergism

$$\text{SR ratio} = \frac{LC_{50}/LD_{50} \text{ of insecticide alone}}{LC_{50}/LD_{50} \text{ Of insecticide + synergist}}$$

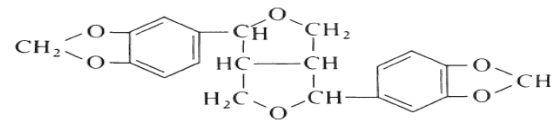
≥1.05	=	synergism
0 – 0.95	=	antagonism
0.95 – 1.05	=	additive action

Synergist

A synergist may be defined as any chemical which in itself is not toxic to insects as dosage used, but when combine with an insecticide, greatly enhance the toxicity of the insecticides.

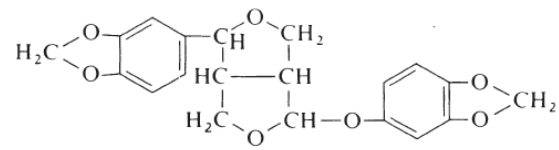
It helps in penetration and stabilization of insecticides, and prevents the detoxification of insecticides. The synergists were initially developed for use with pyrethrum a botanical insecticide, but have since been observed to synergize some of organochlorines, organophophates and carbamates. Synergists should be non toxic in nature. Synergists result in a plus, neutral, or negative effect when added to insecticides. The plus response is synergism while negative response is known as antagonism. *E.g.* Sesamin, sesamoline, piperonylbutoxide and sesamax.

- Sesamin: It is one of the active principles of sesame oil, which has long been known to synergize the action of pyrethrin. It is a crystalline oleoresin, and its structure was determined by Haller *et al.* (1942).



SESAMIN

- Sesamolin: Sesamolin is another active principle of sesame oil. It is a noncrystalline residue and is more effective than sesamin as a synergist with pyrethrin.



SESAMOLIN

- **Piperonylbutoxide**: Perhaps the most widely used synthetic pyrethrin synergist is piperonylbutoxide. Its effectiveness is cited as around a tenfold increase in pyrethrin toxicity when it is mixed with pyrethrin in the ratio of 10:1. Its solubility in petroleum oils and in Freon ® is acceptable enough for the

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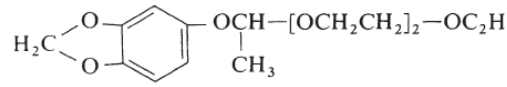
preparation of aerosols. Its acute oral LD_{50} to rats is 7500-12,800 mg/kg.

- **Sesamex (Sesoxane):** It is a wide-spectrum synergist which acts not only with pyrethrin but also with carbamates, some organophosphates, and chlorinated hydrocarbon insecticides. Its synergistic action with allethrin is better than that of piperonylbutoxide.



ACETALDEHYDE 2-(2-ETHOXYETHOXY)ETHYL 3,4-METHYLENE-DIOXYPHENYL ACETAL

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73. ENTOMOLOGY 16031

Effects of Mobile Radiations on Honey Bees

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In the present day situations the usage of the mobile phones and other electronic gadgets has been increasing enormously. The mobile phone radiations are the major cause of the electro pollution in the environment. The electromagnetic radiation (EMR) emitted from the cell phones is very harmful on human beings, plants, animals, micro-organisms in whole ecosystem. Mobile phone uses EMR in the microwave range (450-2100 MHz). In 2011, International Agency for Research on Cancer (IARC) classified mobile phone radiations on Group 2B- possibly carcinogenic (Wikipedia, 2016).

Albert Einstein has stated that man cannot live for more than four years if honey bees are extinct.

Honey Bee Populations affected by Mobile Radiation

The honey bees populations are also affected because of the EMR. Many researches were conducted to suggest that cell phone radiations are affecting honey bees very badly and have revealed that there is direct relationship between decline in honey bee populations and electromagnetic radiations (Dalio, 2015).

A sharp decline has also been noticed in commercial bee population in Kerala posing a serious threat to honey bees, hitting apiculture (the cultivation of bees on a commercial scale for the production of honey) as it has the highest density of mobile towers. When honey bee colonies were exposed with radiation, the honeycomb weight and area were reduced and returning time of honey bees increased compared to similar non-exposed colonies (Girish, 2010). The massive amount of radiation produced by mobile phones and towers is frying the navigational skills of honey bees and preventing them from returning back to their hives (Sahib, 2011). The radiations lead to low egg laying capacity in queens (Greenberg *et. al.*, 1981) or exposure of queen bees to cell phone radiation stimulates to produce only drones (Brandes and Frish, 1986). EMFs from telecommunication infrastructure interfere with bees biological clocks that enable them to compensate properly for the sun's movements, as a result of which, may fly in the wrong direction when attempting to return to the hive (Rubin *et. al.,* 2006).

Studies conducted by Nashaat *et al.,* in 2013 reveals that the honey bees in their normal state produced sounds at lower frequencies around 450 Hz, and with lower intensity of normalized amplitude. But, when they were disturbed by mobile phones, they produced sounds with higher frequencies that reached 1.5 KHz and with higher intensity reaching 0.7 Normalized amplitude and this may be the reason behind their decline.

It is clear that the Colony Collapse Disorder (CCD) is mainly due to electro-pollution by increasing mobile phone tower radiations. The mobile phones have great benefits in spite of all the harmful effect and hence complete ban on their usage is not acceptable. But its usage has to be minimized in order to conserve the honey bees.

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74. ENTOMOLOGY 16097

Crop Protection against Insects through RNA Interference

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Plant breeders and biotechnologists are using different approaches to develop insect/pest resistant varieties. Although classical breeders have been developed various insect/pest resistant cultivars, however, this approach is tedious and time consuming as complexity increases with some added traits. The practice of using pesticides to control pests has become a common approach around the world, but having dramatic health and environmental effects its use seems to be very limited in coming years. Among transgenic approaches to control specific insect/pest, Bt-based toxins proved effective and replaced chemical insecticides in many crops. Most of the commercially used biotechnological approaches to control insect/pests on crops are subjected to expression of *Bt* insecticidal proteins which help in the permeabilization of gut epithelial cell's membrane in susceptible insects. However, this approach is limited for some specific crops to manage some specific pests, and there is also a threat that some insects can develop resistance against *Bt*. After the successful induction of transgene-encoded RNAi in plants, biotechnologists speculated about crop protection from insects through genetic-engineering to exhibit dsRNAs target insect genes.

RNAi offers robust and more selective pathway for battling with various destructive insect/pests that cause significant economic losses. It is a new strategy about plant-mediated herbivorous insects RNAi, which describes the suppression of a critical insect-gene through insect feeding on plant engineered to develop a specific dsRNA that can prompt dissection of gene functions in these insects. The herbivorous insect RNAi efficiency can be stimulated by ingestion of transgenic dsRNA producing plants that is gene-specific and proved effective against like cotton bollworms (*Helicoverpa armigera*) damage. A gene 'CYP6AE14' was identified in *Helicoverpa armigera* as shown in Fig. 1. This identified gene expressed in the insect midgut was correlated with larva growth when food contains gossypol. Therefore, after feeding on plant material exhibiting dsRNA specific to gene 'CYP6AE14', the effect of the transcript decreased in midgut and larva growth also retarded. The gene silencing of 'glutathione-S-transferase' (GST1) can trigger RNAi process when herbivorous insects feed on plant material expressing dsRNA. When dsRNA was injected in whitefly body cavity, RNAi was induced that knocked-down the genes expression to 70% in midgut as well as salivary glands of whitefly. RNAi-mediated death of whitefly via oral dissemination of dsRNA, targets ADP/ATP, translocase, a-tubulin, ribosomal protein L9 actin ortholog and v-ATPaseA genes responsible for insects mortality.

Interference in expression of the targeted genes results various phenotype disturbances *viz.* stunted growth, moulting defects, and insect mortality. In western corn rootworm (WCR) ingestion of dsRNAs provided in diet can trigger the RNAi which result in stunted larva growth and their death (Fig. 1). They further revealed that transgenic corn plants which are engineered for WCR dsRNAs expression exhibited a substantial reduction in insect damage that suggests RNAi pathway is effective and can be exploited further to control coleopteran insects. This mechanism was also practiced in *Acyrthosiphon pisum* for silencing of a gene C002 expressed in insect salivary glands that proved lethal for pea aphids. Rack-1 and MpC002, expressed in salivary glands and gut tissues of *Myzus persicae* (green peach aphid) and reported that knock-down of these genes reduced aphid proliferation.

RNAi has also been exploited in plants to develop resistance against nematodes and this approach has appeared as a novel tool to control plant parasitic nematodes. dsRNAs can be produced through engineered plants that have the ability to silence target genes in nematode body. The delivery of dsRNAs from plant to nematode occurs by the ingestion process of plant cytoplasm and after its injection into the nematode body accelerate the RNAi that results in inactivation of targeted genes through dsRNA. Nevertheless, to target host genes destined for interaction, efficient regulation of dsRNA triggers expression is a prerequisite that will reduce the negative effects on plant growth and development and it also necessitate identification of nematode-responsive promoters. In plant-parasitic nematodes, it is important to understand the RNAi mechanism for loss-of-function nematode phenotypes through effective gene silencing.

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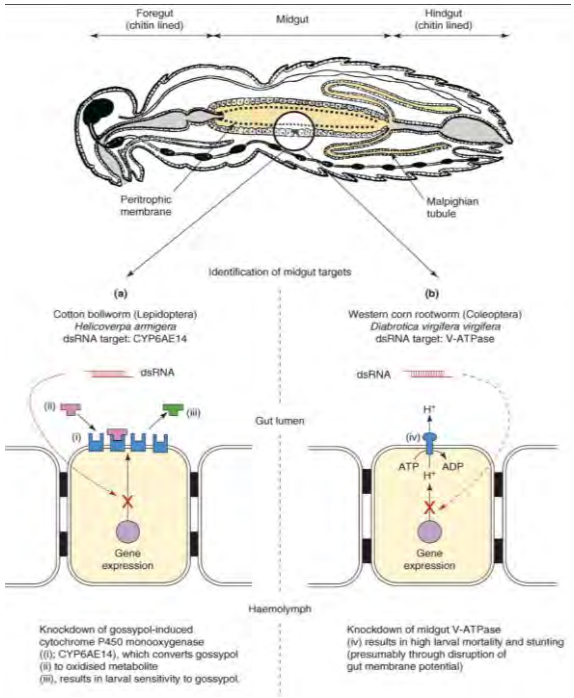

FIG. 1: Overview of RNAi approaches for insect-resistant transgenic plants.

Transgenic plants producing RNAi triggers expression of nematode targets proved more effective against root knot nematode compared with cyst nematode. It has been reported that in vitro ingestion of 16D10 dsRNA gene results the target parasitism gene silencing in root knot nematodes and reduced nematode lethality, whereas, in *Arabidopsis*, in vivo expression of 16D10 dsRNA gene also increase the resistance against four species of root knot nematodes. Since, there is no single natural resistant gene known against root knot nematodes, expression of dsRNA to silence target genes for disruption of the parasitism effect significantly proved a sustainable approach for robust RKN resistant cultivars. RNAi permits the molecular determinants regarding parasitism and also can make it possible to identify novel specified targets vital for survival of nematodes and thus leads to the development of efficient control methods.

Plants armed with dsRNA prevent the insect/pests damages, as the transgenic cultivars that produced dsRNAs can target certain genes in insect tissues to reveal dominance in gene expression and caused their mortality. A robust RNAi pathway proved to be effective against different insects and pests which have open new pathways for crop protection by developing insect resistant cultivars of commercially important plants. Nevertheless, the success of the RNAi approach to control notorious insect/pests is mainly co-related with the wise screening system for target gene selection and an appropriate delivery mechanism.

Double-stranded RNA (dsRNA) produced in planta can lead to targeted gene silencing in Lepidoptera and Coleoptera pest species. dsRNAs corresponding to specific insect targets are expressed in planta and are cleaved by endogenous plant Dicer enzymes to produce short interfering RNAs (siRNAs) of around 21 nucleotides. Large dsRNA and siRNA cleavage products are expressed throughout plant tissues and are orally delivered to insect herbivores feeding on transgenic plant material. For gene-silencing to initiate in targeted insect pests, large dsRNAs and siRNAs must persist in the insect gut, and sufficient quantities must be present for uptake into cells in contact with RNAs (the exact uptake mechanism in target insects remains unknown). Approach (a): a gut-specific cytochrome monooxygenase, CYP6AE14, has been identified (i) whose expression correlates with larval growth on diets containing gossypol (ii), a cotton secondary metabolite. CYP6AE14 is presumably involved in detoxification of gossypol (iii) because specific knockdown of this gene product by dsRNAs delivered in artificial diet and by transgenic plant material increases larval sensitivity to gossypol. Approach (b): a related study used a screening approach to identify a lethal phenotype in Diabrotica virgifera virgifera when midgut V-type ATPase A (V-ATPase) (iv) was downregulated by dsRNAs delivered in artificial diet feeding trials and transgenic corn. Although no direct evidence was presented for the deleterious effects observed in larvae, it is tempting to speculate that knockdown of V-type ATPase A results in disruption of electrochemical gradient across the gut epithelia, which results in high larval mortality.

75. ENTOMOLOGY 16134

Rodents and their Nature of Damage

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INTRODUCTION: Rodents are omnivorous and feed on grains, vegetables, fruits, meat and other products in the houses or in the field. They are responsible to causes enormous losses to crops

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and stored grains. Besides feeding on these products they destroy a substantial quantity by spillage and contamination with their droppings, urine, body hair etc. The Rodentia make up over 40% of mammal species and represent the largest order of mammals, comprising some 2277 species in 30 extant families that include 481 genera (Wilson and Reeder, 2005). A further 12 families and 300 genera are known only from fossils. Their principal unifying feature is the possession of one pair of incisors above and below and the use of these for gnawing. The name of the order is derived from the Latin *rodere*, meaning to gnaw. The rodent fauna of the Indian sub-continent is represented by 46 genera and 128 species (Roonwal 1987). Of these 18 species are commensal and agricultural pests. Some species are widely distributed while others are locally important. There are some examples like

Indian gerbil (Tatera indica)
The soft-furred field rat (*Rattus meltada)*
House, roof or black rat (*Rattus rattus)*
Indian field mouse (*Mus booduga)*
The larger bandicoot rat (*Bandicota indica)*
The lesser bandicoot rat *(Bandicota bengalensis)*

Damages and Economic Losses

Losses: The problems caused by rodents in stores are wide ranging. Attempts to quantify losses inevitably fail to do anything but confirm the variability of the problem and the difficulty of measuring losses caused by mobile species in dynamic environments.

Broadly, losses may be attributed to the following:

- Direct consumption of food;
- Food contamination and damage;
- Structural damage;
- Disease transmission;
- Source of reinfestation of adjoining areas
- Costs associated with control operations

Direct Consumption of Food: Rodents eat food intended directly for human consumption or for consumption by domesticated livestock. The impact of direct consumption may be relatively limited in developed countries, but can be a major problem in countries where food is scarce and alternative supplies may not be found in time to prevent hardship for the human population. On average, rodents need to consume about 10% of their body weight each day, but consumption will vary with the size and species of rodent, and with the prevailing climatic conditions.

Damage and Contamination of Food: Rodents damage and contaminate far more food than they consume. Through their gnawing activity, they damage the packaging and storage facilities used to store and transport the food. Food is lost through spillage and wastage, and is also thrown away as unsuitable for human consumption. Rodents contaminate food principally through their droppings, hair and urine. Commensal rat species like *R. rattus* and *R. norvegicus* produce about 40 droppings a day each; thus, a relatively small infestation of ten rats would produce some 146,000 droppings a year.

Structural Damage: Food is not the only material that is susceptible to rodent gnawing and activity. Sacking, packaging and building structures are damaged and will be costly to repair or replace. Damage to roofing, walls, insulation, foundations and doors of buildings reduces the efficiency and security of the storage facility. Damage to a roof allows water to enter the building, whereas damage to walls, doors, foundations and floors not only weakens the structure of the facility, but also increases the likelihood of further infestation of the facility, allowing in more rodents and frequently increasing the level of rodent damage. Effective control of insect pests by fumigation is also prevented if a structure is not gas tight.

Rodents as a Carrier of Diseases

Rodents have always been associated with diseases. This no doubt is because of the association, over the centuries, of rats with bubonic plague and the 'Black Death', which was one of the deadliest pandemics in human history. They act as a carrier of diseases like Plague, Amoebic dysentery, Diarrhoeal disease, Pasteurellosis, Haemorrhagic fever.

Source of Infestation: By their very nature, stores present the potential to support significant rodent populations from which some rodent emigration will take place. Where the units are situated close to human habitation or field crop production, the potential exists for the transmission of disease and field crop damage. The control of peripheral infestations is unlikely to be effective while the focus of the infestation remains. Conversely, of course, these peripheral sites may have been the source of the original infestation.

Costs of Control: The costs of maintaining a rodent-free storage environment must be borne in mind when discussing the total costs of rodent infestation. In the UK, farmers are often required to pay for rodent monitoring and prophylactic control in order to satisfy the requirements of their main market (supermarkets).

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76. INTEGRATED INSECT PEST MANAGEMENT 16113

Insect Folivory: A Behavioural Defense Mechanism in Herbivores against Plants

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Leaves are the most important photosynthetic organs of plants which are heavily protected from enemy attack by noxious poisons, sticky glues, volatile compounds released to attract distant parasitoids and predators, domatia of ants and fed sugar bribes. In spite of these folivores are faced with the challenge of identifying suitable food, constitutive defenses and preventing inducible responses and omnipresent array of natural enemies. Insect folivores feed selectively on plant species which are low in defense. Some ingest a mixture of plant species to avoid excessive consumption of any poison, to acquire a suitable nutrient mix, or to obtain toxins that protect against enemies. Other species form galls that provide quality food and a safe environment. Many folivores build shelters mow trichomes and prickles or cultivate and consume fungi on leaves thus utilizing plant resources that otherwise would be unavailable. The following behavioural approaches are used by folivores to fight against plant defenses.

1. Vein Cutting and Trenching

Over 110 species in 17 families of caterpillars, beetles, katydids, and sawflies sever leaf veins or cut trenches before beginning to feed. Vein-cutting insects sever individual leaf veins with their mandibles, often repeatedly with a series of cuts that progress toward the periphery of the leaf. Trenching insects, in contrast, use their mandibles to make a continuous line of cuts that extend partially or entirely through the leaf blade and isolate a portion of the leaf.

1.1. Plants with canal-borne exudates: Canal-cutting insects are found predominantly on plants that emit exudates from elongate secretory canals. Some plants possess laticifers which are living cells that contain latex, other plants such as conifers and dipterocarps possess ducts which are elongate intercellular spaces filled with resins and oils. Cabbage loopers, *Trichoplusia ni* (Noctuidae) cut comparable trenches in plants with laticifers and exuding phloem sap. When an insect bites into a leaf, fluid flows from high pressure within the canals to low pressure at the breach. Exudate is emitted immediately at the wound directly onto the mouthparts of the herbivore. The exudates contain noxious compounds and enzymes that are known to deter or poison herbivores. These noxious substances are emitted in a viscous fluid that typically coagulates, thus sealing the wound and threatening prospective herbivores with the risk of entrapment. Both dietary specialists and generalists have been observed with legs stuck together, mouthparts glued shut, and/or heads fatally stuck to the leaf. Likewise, canal cutting in turn functions to disable the secretory canals. Both vein cuts and trenches reduce exudation beyond the cuts, where the insect invariably feeds.

Generalist plusiine caterpillars cut trenches almost exclusively in plant species that emit exudates from canal systems. Canal architectures are easily deduced by damaging leaves with standard wounds and recording effects on exudation. Most canal-cutting herbivores exhibit either vein cutting or trenching, some species employ both behaviors. \

1.2. Plants Lacking Canal-Borne Exudates: Vein cutting and trenching insects occur also on plants lacking secretory canals. Canal cuts on plants lacking secretory canals serve a variety of functions such as facilitating leaf handling and creating a leaf roll or other shelter that protects folivores against natural enemies and inclement weather. The insects may also gain other benefits such as improving leaf nutrition and decreasing toughness, maintaining water balance, providing shade to protect against light-activated compounds, blocking the movement of signaling molecules and defensive compounds, suppressing the release of plant volatiles and altering leaf water content. Generalist folivores that feed on plants both with and without secretory canals typically exhibit canal cutting only on species that emit exudate from secretory canals *e.g.* soybean semiloopers, *Chrysodeixis includens* **2. Girdling**

Girdling animals chew a furrow that completely encircles a petiole, stem or trunk *e.g.* soybean girdle beetle, *Oberopsis brevis* that make two girdle on stem and oviposit near lower girdle in stems. Sap-sucking insects such as the three-cornered alfalfa hopper (*Spissistilus festinus*) that produce a circle of punctures around a stem, then feed above and within the girdle on tissues enriched in sugars and amino acids. Girdles and furrows by *Oedemasia* and other notodontids may function to expose vascular tissues and allow the larvae to apply salivary fluids directly to these transport vessels in leaves, presumably to reduce plant defensive responses. Folivores on plants that emit exudates also sometimes girdle petioles or

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flower stalks. *Epilachna* beetles on zucchini, occasionally cut a girdle that spirals around the petiole. The girdle presumably isolates and depressurizes secretory canals in the entire leaf, similar to furrows and constrictions in petioles and flower stalks.

2. Leaf Clipping

Forty species in 12 families of caterpillars and sawflies clip leaf petioles after partially consuming leaves. Leaf clipping occurs primarily on trees, most or all of which lack laticifers and ducts. When the leaf fragment is removed, only a petiole stub remains. Caterpillars clip leaves to eliminate evidence of their feeding. Insects may cut petioles to prevent the movement of signaling molecules or induced defenses within vascular tissues and/or to reduce the release of volatiles attractive to predators and parasitoids. Several folivores both girdling and leaf clipping are found to suppress defensive responses that may include release of volatiles.

3. Glandular Secretions

Salivary secretions suppress plant recognition of herbivore attack. Salivary components such as glucose oxidase and ATP hydrolyzing enzymes allow caterpillars to feed without eliciting plant defenses. These effectors prevent both the production of defensive chemicals and the emission of volatiles sometimes by triggering inappropriate antipathogen responses due to cross talk between jasmonate and salicylate signaling pathways. Girdling and leaf-clipping species are known to produce high levels of glucose oxidase in their saliva. Caterpillars of the notodontid *Theroa zethus* on laticiferous euphorbs apply not just saliva to furrows and girdles, but also acid secretion from the ventral eversible gland. Acid secreted onto the plant surface softens and withers stems and veins allowing the larvae to compress these structures with their mandibles, thereby reducing latex outflow beyond the girdles where the caterpillar feeds.

4. Applications to Agriculture

The susceptibility of crops to pest attack is determined not just by the defensive characteristics of the plant, but also by the capabilities of the herbivore for overcoming plant defenses. Behaviors such as vein cutting, trenching and girdling not only tell us the presence of plant defenses, but also provide convenient assays for elucidating the defenses. Bioassays are available for both vein-cutting and trenching insects to guide the isolation of the chemical cues that trigger canal cutting. The three natural trenching stimulants identified so far from lettuce, parsley and cardinal flower. Cucurbits differ from other plants in having two distinct sets of phloem canals, one that functions primarily in sugar transport, and the other that emits exudates as a defense although differences exist between species. If both sap-sucking and mandibulate insects encounter sap in the defensive extrafascicular phloem constituents such as proteins could potentially protect cucurbits from diverse herbivores. Trenching by *Epilachna* beetles on cucurbits has been studied in considerable detail. A partially characterized N-alkyl pyridinium salt that triggers trenching by cabbage loopers has been isolated from cucumber sap. Because cucurbit sap and other exudates can be readily harvested in significant volumes for example, by slicing the skin of cucumbers the complete characterization of exudate allelochemicals and enzymes should be feasible with modern instrumentation with recent proteomic and metabolomic studies.

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77. EXTENSION EDUCATION AND RURAL DEVELOPMENT 16093

Training Needs for Human Resource Development

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Training is a way of teaching, or developing any kind of skills and knowledge that relate to specific useful competencies. It helps in improving one's capability, capacity, productivity and performance. It is a process through which a person enhances and develops his efficiency and

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effectiveness at work by improving and updating his/her knowledge and understanding relevant to his/her work. Ray (2012) mentioned that training is the process of acquiring specific skills to perform a job better. Thus, it helps to bring a desirable change in the behaviour and attitude of the trainee towards the work and other people.

Extension Training is a must important in Agricultural Extension work. This is because Agricultural Extension aims at bringing about changes in the farmers attitude and behaviour focussing attention on their immediate problems. Extension Training aims at providing timely education needed for both extension personnel and farmers specially to raise immediate action.

Extension Training has two important dimensions, *viz.*

1. To develop the required professional competency of the extension staff, and
2. To train voluntary leaders in rural areas to accelerate agricultural development with their assistance.

Human Resource Development

Human Resource Development (HRD) is the process of helping the personnel of the organization to acquire competencies (Jalihal and Veerbhadraih, 2007). It is the process by which the employees of the organization are helped in a continuous and planned way to develop various skills required in performing various function at present and in future, to exploit their inner potential for organizational development and to build a strong superior-subordinate relationships. This will ultimately lead to the wellbeing of both the employer and employee and hence, organizational effectiveness. It is one of the major factor in increasing productivity in any kind of organization or enterprise. It is directly proportional to productivity. They are the only active resources which has all the potentials needed by an organization or enterprise. These resources can be harnessed and utilized in its fullest form only if proper training are given to them. Majority of the problem in an organization are lack of trained personnel. Of course, there are other problems but if the personnel involved in any organization are properly trained then majority of the problems will be reduced, as it is the man who operates the organization. Thus, the need for training in HRD arises.

Why Training in HRD?

Training is required for all personnel for their own development whether it be a farmer, a farm women, an employee or an employer. People need knowledge, attitude, skills and other attributes to perform tasks. Also the quality of performance of task matters. It requires a high level or degree of skills to perform a task in a quality way. Quality performance always leads to increase in quantitative production. Various practices in any enterprise or organisation requires training for optimum utilization of resources and for productivity. Patel *et al.* (2016) has pointed out that the farm women under Rastriya Krishi Vikas Yojana of Dantiwada block of Banaskantha district, Gujarat have shown interest in training regarding various dairy practices *viz.* breeding, feeding, management and fodder production.

People also need encouragement and motivation to operate a task with zeal and enthusiasm. A motivated employee is essential for organizational survival, growth and excellence. Any organization that is interested in improving its services and productivity *viz.* cost reduction, reduction in delays, improved quality and promptness of services, clientele satisfaction etc. needs to develop its employee competencies and proficiencies to perform tasks to bring about improvements. Training helps the new errant to acquire occupational work skills and the latest knowledge, makes him familiar with the objectives of the organisation to which he belongs and helps to make his potential contribution in promoting the goals of his organisation. It helps to update the knowledge and skills of the employees. It refreshes the potentials of the employees there by leading to employee satisfaction. It also makes up for any deficiencies in the new recruits and maintains or boosts up the morale of the staff. It is conducive to cohesion in regard to methods of work and approach to problems. There are different types of training that are given accordingly to the employees at proper time to cope up with the developing world. For instance, Pre-service training is the training received before joining the actual job, orientation training is for the new errant to familiarise with his job and work environment, in-service training is for updating the skills and proficiency etc. Technology changes so fast and people have to chase the ever changing technology, upgrade their knowledge and skills to survive and grow.

Therefore, the importance of training in human resource development is quite large. Training and development go together hand in hand for the successful utilization of any resources. From all the available resources, human resources is the most important one because all the other resources depends on human resources for its application. Through the different types of training, viz. pre-service training, in-service training etc. different type of knowledge, skills and techniques can be imparted. For an all-round development training of human resource is a must and should be carried out whenever required.

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78. EXTENSION EDUCATION AND RURAL DEVELOPMENT 15893

Feminization of Agriculture

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India has a predominantly agrarian economy with 70 per cent of the population being rural; of those households, 60 per cent engage in agriculture as their main source of income. Agriculture is India's most important economic sector. About 80 per cent of agricultural families in India belong to either marginal or small farmers and for these families farming is not just an enterprise but a way of life where all members of the family including children contribute their mite in some way or the other. Agriculture in India defines familial tradition, social relations and gender roles. Female in the agricultural sector, whether through traditional means or industrial, for subsistence or as an agricultural laborer, represents a momentous demographic group. The role and contribution of women is no longer a matter of contention because in rural India, the percentage of women who depend on agriculture for their livelihood is supposed to be as high as 84 per cent. Although detailed statistics are not available and figures vary depending on the geographical context it is fair to say that women supply a large proportion of agriculture labour and in some societies produce upto 80 per cent of the food crops [FAO, 2007]. These statistics do not account for work in livestock, fisheries and various other ancillary forms of food production in the country.

Feminization of Agriculture

Feminization of agriculture refers to women's increasing participation in the agricultural labor force, whether as independent producers, as unremunerated family workers, or as agricultural wage workers.

Rural women form the most important productive work force in the economy of majority of the developing nations including India. Agriculture, the single largest production endeavor in India, contributing about 18 percent of GDP, is increasingly becoming a female activity. Agriculture sector employs 4/5th of all economically active women in the country, while 48 per cent of India's self - employed farmers are women. There are 75 million women engaged in dairying alone as against 15 million men, while there are 20 million women in animal husbandry as compared to 1.5 million men.

According to FAO, while the proportion of the labor force working in agriculture declined over the 1990s, the proportion of women working in agriculture increased and particularly in developing countries. In some regions such as Africa and Asia, almost half of the labor force is women. This trend has been called the feminization of agriculture. This feminization of agriculture is caused by increased "casualization" of work, unprofitable crop production and distress migration of men "for higher casual work in agriculture and non-agriculture sectors", leaving women to take up low paid casual work in agriculture.

Beyond the conventional market oriented narrower definition of "Productive workers", almost all women in rural India today can be considered as "farmers" in some sense, working as agricultural labour, unpaid workers in the family farm enterprise, or combination of the two. Moreover, several farm activities traditionally carried out by men are also being under taken by women as men are pulled away into higher playing employment. Thus rural India is witnessing a process which could be described as **"Feminization of Agriculture".**

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79. EXTENSION EDUCATION AND RURAL DEVELOPMENT 15982

Community Radio: A Voice for the Poor

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INTRODUCTION: In India, where literacy remains a substantial barrier to development, radio especially community radio can reach a large number of poor people because it is affordable and uses little electricity which is low supply in many countries and barely affordable for many poor. Community Radio gives a voice to the community and they serve with programmes in local languages, respecting local culture, traditions and interests. And it facilitates dialogue within the community; while on a national level it encourages diversity, creativity and citizens' participation in democratic processes. Community Radio provides a counterbalance to the increasing globalization and commercialization of media.

Most TV and radio stations, including public stations, are concentrated in urban areas. In the more remote, rural areas Community Radio stations are often the only media available, where they are listened to by large parts of the population. Community Radio stations fill the gap left by national and commercial media, and reach local audiences the national media ignore. They fulfil the role of public broadcaster, informing the public at a local level, and representing their views. In this way, they give a voice to the voiceless, enabling people to speak and make their opinions, grievances and ideas known to those who have the power to make decisions.

Community: For the purpose of community radio, a community is defined as a non-sectarian group of individuals who are traditionally bound and share a common socio-economic and cultural interest.

Community Radio: Community radio is a type of radio service that caters to the interests of a certain area, broadcasting content that is popular to a local audience but which may often be overlooked by commercial or mass-media broadcasters. (UNESCO 2002).

"A community radio station is one that is operated in the community, for the community, about the community and by the community."

Concept of Community Radio

Community radio is confined to a small geographical area. It depends on low power transmission covering not more than 20-30 km. radius. It serves a community which uses common resources for livelihood, has common development issues and concerns, which are relatively localized, nevertheless connected to national and regional development goals. Community radio is a vibrant community broadcasting system to enhance pluralism and diversity. It is a truly people's radio that perceives listeners not only as receivers and consumers, but also as active citizens and creative producers of media content. This form of radio is fully consistent with the letter and spirit of the Milan Declaration on Communications media have a responsibility to help sustain the diversity of the World's cultures and languages and that they should be supported through legislative, administrative and financial measures.

Community Radio is distinguished by Three Essential Principles as

- Non-profit making,
- Community ownership, management, programming and community it is authorised to serve
- Community participation.

Community Radio is also distinguished by its Characteristics like

- Limited local reach
- Low power transmission and
- Programming content that reflects the educational developmental and socio-cultural needs of the specific community it serves.

Characteristics of Community Radio

i) It serves a recognizable community.
ii) It encourages participatory democracy.
iii) It offers the opportunity to any member of the community to initiate Communication and participate in program making, management and ownership of the station.
iv) It uses technology appropriate to the economic capability of the people, not that which leads to dependence on external sources.
v) It is motivated by community wellbeing, not commercial considerations.
vi) It promotes and improves problem solving.

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What can Community Radio do?

Radio for the individual	
Provides relaxation and entertainment. It moves people away from their problems and anxieties Widens the horizons of people by stimulating interest in previously unknown topics Provides topics of conversation through shared experience and hence facilitates personal contacts Promotes creativity. Helps to solve problems by providing information and advice	Allow individuals to exercise choice, make decisions and act as responsible citizens Contributes to self-knowledge and awareness, enabling the listeners to see themselves in relation to others. Guides social behavior by setting standards and offering role Models Inspires the individual and can move him/her into action.
Radio for the community	
Speeds up the process of informing the community and therefore acts as a catalyst of change Helps to approach consensus and to develop common objectives by providing debate and discussing issues. Enhances artistic and intellectual culture Reinforces values to help maintain social order through the status quo.	Serves as a watchdog on power holders, affording active relationships between leaders and the citizens. Exposes options for community action Brings out and disseminates ideas promoting diversity and change. Offers chance for individuals and groups to speak to each other, thus developing awareness of a common membership of community. Mobilizes both private and collective resources for personal and community needs.

Advantages of community radio

- As community radio is usually run by volunteers using low-cost technology, it tends to be easy to obtain free or inexpensive air time.
- It offers an opportunity for contributions by people whose voice is not much heard on national radio – *e.g.* "ordinary" women and youth – which can be highly empowering.
- Community radio reaches a large section of the locality it covers, as listeners tend to be interested in local issues.
- It is also an excellent way to communicate with communities whose main language is not the official national language.
- Community radio stations can be mobilized for campaigns, for example by announcing campaign events, hosting talk shows with campaigners, or playing the campaign radio jingle and songs.
- Community radio helps to ensure people's right to information and community participation by expressing the voice and thoughts of grassroots people in the development process.
- Community radio can facilitates the disadvantaged and vulnerable groups of the country by raising their voice, focusing their problems, expressing their modern updated ideas and thinking for the development of the whole nation.
- It can play a significant role for the rural development through emphasizing agriculture, education, health and sanitation, recreation and social problems of a target community.

Some Notable Community Radio Systems in India are:

i) **Kunjal Panje Kutch Ji:** It relates to the concerns, aspirations of women in areas of Bhuj, Kutch etc. It broadcasts in Kutchi language (a dialect of Guajarati).

ii) **Namma Dhwani (our voices):** It is the India's first cable community radio station runs in Kolar district of Karnataka since from 2003. It focus on providing useful information to illiterate women in these areas and has been helping SHGs.

iii) **Kelu Sakhi:** Based in Karnataka, this CR broadcasts information related to the women's education, health, political institutions, and capacity building in rural areas. It is run by organizations namely "IT for Change" and "Mahila Samkhya Karnataka".

iv) **Sangham Radio:** Launched in Telangana (earlier in Andhra Pradesh), India, on World Rural Women's Day that is on October 15, 2008 (Sangham, referring to village level women's collectives) Sangham Radio is intended to give a voice to the excluded in general and to women in particular. This radio owned, managed, and operated exclusively by women from rural marginalised communities (the "Dalit" caste).

v) **Krishi Community Radio Station (KCRS)-** Raithrinda Raithrigagi : The first community radio starion in India under State Agriculture University and first in Karnataka. Established by University of Agriculture Science,

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Dharwad on May 17 2007. etc.,

Conclusion

Community radios act as a viable and trustworthy alternative to mainstream media (in terms of news and entertainment) and it can be used as a platform to enable participation of communities (of interest defined by geographical boundaries). It can be seen as a channel to document and keep languages and cultures alive on a daily basis, and can be employed as a means to promote values of access to education, economic and social justice, against class, gender, race, caste based violence, and transparency in governance. aIn terms of development, it can help the masses with respect to health, literacy, and income. It can provide access to useful, localized, contextual information, could be a source of job opportunities and enhance skill and capacity building.

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80. EXTENSION EDUCATION AND RURAL DEVELOPMENT 16044

Advertisement: Tool for Popularization of Products

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Advertisement

The American Marketing Association has defined advertisement as "any paid form of non personal presentation and promotion of goods or service by identified sponsor." In other words advertisement is paid use of any channel of communication – radio, television, film, press etc. to identify, explain or to urge the use or adoption of a product, service or idea.

The most standard definition of Advertisement is as follows: "Advertisement is the non-personal communication of information usually paid for and unusually persuasive in nature about products, services or ideas by identified sponsors through the various media" (Bovee, 1992).

Classification or Purpose of Advertisement

Product or non-product: A product is a good or service for which customers/clients will exchange something of value. The purpose of product advertising is to promote or sell the goods or services. Non-product advertising is also known as institutional advertisement; the aim is not to sell something, but just to let the public know that such an organization exist. Non-product advertisement constitutes institutional or corporate advertising in which the manufacturer/institution/advertise trying to polish or built up its image or influence public opinion about an issue.

Commercial or non-commercial: A commercial and non-commercial advertising is easy to understand. If the idea is to make profit, it is commercial. Otherwise it is non-commercial. Most of the ads we see are commercial.

Primary-demand and selective-demand advertising: These ads stimulate the need for a particular category and the aim is not to sell the brand. Once the need for a particular category is established, selective-demand advertising comes in picture; these ads concentrate on a particular brand of a product and try to promote it.

Direct-action and indirect-action advertising: Sometimes advertisements are designed to get the audience to respond immediately. These types of ads are called direct-action ads. Typically, these ads carry a toll-free number and sales-promotion incentives. Indirect-action advertisement is done primarily to build awareness of the product.

Advertising Layout

Advertising in print media constitutes a major part of any advertising campaign. Television ads are volatile and more expensive at the same time, print ads are relatively less expensive and have good reach. In advertising, the term media refers to communicational vehicle such as newspaper, magazine, radio, television, billboards, direct mail and internet. Advertisers use media to convey commercial messages to their target audience. Advertisement in print media can be designed keeping in mind the kind of audience the newspaper or magazine is expected to reach by. So in more than one ways, print media has an upper hand in an advertising campaign and it is essential to know about all the technicalities involved in print media.

Components of print Advertisement

1. Visual
2. Headlines
3. Copy
4. Slogan

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5. Logo

Visual: Though you don't absolutely require a visual, it will help draw attention to you ad. Research indicates that 70% of people will only look at the visual in an ad, whereas only 30% people will read the headlines.

Headlines: Headlines are the first component for the advertisement. Let the name of the product be used in the headline for better recall value. The most important thing to remember here is that your headline must be short, snappy and must touch the people who read it. You headline must influence the readers emotionally, by making them laugh, angry, curious or think.

Copy: This is second major category which constitutes the text of an ad. Here's where you, make the case. If you have compelling arguments, make them. If you have persuasive facts, state them. But don't overwhelm the ad with information. Two strong arguments will make more of an impression then a dozen weaker one. Finally, be clear, precise and honest. Any hint of deception will instantly detract from entire message.

Style: Like the headline, body copy also has different styles. **Straight-line** copy is continuation from the headline and is written in the words of an anonymous or unacknowledged source. **Narrative copy**, on the other hand, is used to tell a story in first or third person. It persuades the same selling point in different context. **Dialogue** lets the readers listen to the conversation of the characters that are in the advertisement. This make the advertisement more believable as the characters portrayed in the print ad speak from their own experience.

Slogan: The other name for slogan is theme line or tagline. It sums up the advertisement. Slogans are equally important as the headline as it is not only used for advertising but sales people and the company employees. It is the component of the ad which has maximum recall value.

Logo: Logo is symbolic representation of a company. It can be picture, or combination of both. Sometimes its significance is so much that the advertiser relies on the logo completely.

81. EXTENSION EDUCATION AND RURAL DEVELOPMENT 16089

Policy Approach for Woman Entrepreneurship Development

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INTRODUCTION: The educated Indian women have to go a long way to achieve equal rights and position because traditions are deep rooted in Indian society where the sociological set up has been a male dominated one. The transformation of social fabric of the Indian society, in terms of increased educational status of Indian women and varied aspirations for better living, necessitated a change in the life style of Indian women. She has completed with man and successfully stood up with him in every walk of life and business is no exception for this. These women leaders are assertive, persuasive and willing to take risks. They managed survive and succeed in this out throat competition with their hard work, diligence and perseverance.

Definition: Women entrepreneur may be defined as the women or group of women who initiate, organize and operate a business enterprise.

Government of India has defined women entrepreneur "An entrepreneur owned and controlled by women have minimum financial interest of 51 per cent of the capital and giving at least 51 per cent of the employment generated in the enterprise to women"

Key Policy Recommendations for Women's Entrepreneurship Development

Increase the ability of women to participate in the labour force by ensuring the availability of affordable child care and equal treatment in the work place. More generally, improving the position of women in society and promoting entrepreneurship generally will have benefits in terms of women's entrepreneurship.

Listen to the voice of women entrepreneurs. The creation of government offices of women's business ownership is one way to facilitate this. Such offices could have programme responsibilities such as providing women's business centres, organising information seminars and meetings and/or providing web-based information to those wanting to start and grow a business.

Recommendations for the private sector for women's entrepreneurship development

- Conduct market research to identify the potential business case for women-targeted interventions.
- Look for opportunities to finance women-owned SMEs, including sources of finance and equity capital.
- Join programs that provide knowledge on

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how to profitably reach the women's market (*e.g.*, the Global Banking Alliance for Women for financial institutions).

- Explore partnerships that better link access to finance with capacity-building programs (including targeting entire value chains).
- Identify support-program mechanisms for women entrepreneurs that can have an impact on the entire value chains where women entrepreneurs are concentrated.
- In partnership with research institutes, improve results measurement frameworks so as to better capture the success factors of capacity-building programs for women entrepreneurs.

Approaches for women's Entrepreneurship Development

- Business opportunities are not created by external intervention-they arise from markets and entrepreneurial capabilities. The issue is to enable rural and women entrepreneurs to take advantage of market opportunities.
- Micro- and small-scale enterprises (MSE) are affordable and manageable by rural people. They create a large number of non-farm employment and income opportunities in relatively poorly developed areas and require small capital and little sophisticated managerial and technical skills. MSEs are also the seedbeds for a broad development of the private sector throughout the country, forming the foundation for the national economy and social development at the grassroots.
- Individual entrepreneurs are a driving force for competitive MSEs as a growth base. However, the policy and institutional framework needs to be conducive to encouraging entrepreneurial initiatives. Human capabilities and the right institutional framework are necessary conditions for entrepreneurship to flourish, particularly in rural areas.

ILO Approaches for women's Entrepreneurship Development

- Creating the optimal conditions for women's entrepreneurship to thrive.
- Strengthening the institutional capacity of both financial and non-financial service providers to better serve the needs of women entrepreneurs.
- Providing tailor-made tools and approaches to reinforce women's capacities to start and consolidate sustainable businesses.
- Organize training programmes to develop professional competencies in managerial, leadership, marketing, financial, production process, profit planning, maintaining books of accounts and other skills. This will encourage women to undertake business.
- Vocational training to be extended to women community that enables them to understand the production process and production management.
- Educational institutes should tie up with various government and non-government agencies to assist in entrepreneurship development mainly to plan business projects.
- International, National, Local trade fairs, Industrial exhibitions, seminars and conferences should be organized to help women to facilitate interaction with other women entrepreneurs.

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http://www.unido.org

http://www.ilo.org

82. EXTENSION EDUCATION AND RURAL DEVELOPMENT 16114

Human Resource Development in Agricultural Extension

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Human Resource : Is defined as the total knowledge *i.e.,* abilities, talents and skills of an organization work force as well as the values, attitudes and belief of the individual involved.

Human resource development: Is designed for improving the human performance by increasing human capacity and productivity for ensuring a better quality of life to the individuals in and outside the organization.

Human Resource Management

- Is the set of organizational activities directed attracting, developing and maintaining for an effective work.
- HRM also consists of HRD unless the human resource are adequately trained and developed upto the required levels of proficiency and requirement, they cannot be deemed to be effectively managed.

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- Thus HRD makes the effective management of human resources.

HRD System

HRD system requires a thorough understanding of the principles and models of human resource development and a diagnosis of the organizational culture, existing HRD practices in the organization, employee perceptions of these practices, and the developmental climate within the organization.

Goals of HRD Systems

- To develop the capabilities of each employee as an individual.
- To develop the capabilities of each individuals in relation to his/her present role.
- To develop each employee in relation to his/her expected future role.
- The dyadic relationship between each employee and his/her supervisor.
- The team spirit and functioning in every organizational unit.
- Collaboration among different units of the organization.
- The organization overall health and self renewing capacities.

Outcomes of HRD

- People in the organization become more competent.
- People understand their roles better.
- People become more committed to their jobs.
- People develop greater trust and respect.
- Greater collaboration and team work.
- People equipped with problem solving capabilities.
- Lot of useful objective data.
- Top management becomes more sensitive to employees.
- Extension administration is the effective and efficient utilization and coordination of resources to achieve the objectives of extension organizations.
- The purpose of extension administration is to create and maintain an efficient organization manned by well trained and qualified personnel with proper bent of mind and aptitude to convey the latest technology to the farming community.
- Extension administration seeks to remain ever available and eagerly willing to solve problems soon after they are brought to the notice.

In addition to these, if the following things are observed it increases the efficiency of the administration in the extension organizations. (Ray, 1998).

- Fixed hours of work.
- Red tapism.
- Delay leads to corruption.
- Formalism.
- Obscurities.
- Abuse of power.

Functions of HRD

1. Supportive role

- Strengthening and operating at executive levels.
- Consolidating existing strengths.

2. Developing various systems

- Deals with people and their problems

3. Managerial role

- Planning for future man power needs.
- Getting best people available.
- Utilizing people selected.
- Retaining, motivating and integrating people.

- Assessing people for their contribution.
- Planning growth of people.
- Developing healthy relations.

4. Developing competencies

- Technical competencies.
- Managerial competencies.

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5. Process role

- Creating necessary culture and values in the organization.
- Diagnosis and interventions.

HRD Mechanisms /Sub-Systems

- **Human Resource Planning:** Refers to establishing job specifications or the qualitative requirement of jobs and determine the number of people required based on the goals and objectives.
- **Performance appraisal:** Refers to all formed methods of judging the relative worth or ability of an individual employee in performing his tasks.
- **Counseling:** Is a confidential, non-directive face-to-face relationship. It is about helping people to understand themselves and their feelings with regard to specific problems.
- **Career planning:** Is the process by which an individual selects his careers goals and the paths to achieve these goals.
- Career planning involves identifications of individuals and charting out their career paths and designing an organizational system of career movement and growth opportunities for employees from initial stage to the retirement stage.
- **Training and development:** Is tries to improve skills or add to the existing level of knowledge.
- So, that employee is better equipped to do his present job or prepare him in a higher position with increased responsibilities.
- **Organizational Development:** Refers to a wide range of strategies for organizational improvement.
- Is a response to change, a complex educational strategy intended to change the beliefs, attitudes, values and structure of organizations.
- **Motivation and rewards:** Goal directed behavior of an individual in an organization.
- **Quality of work life:** A process through which the stakeholders in the organization management union and employees learn how to work together

Conclusion

- The key factor in the success of extension organizations is improving their human resources.
- The above discussion has various dimensions of human resource management which will help extension managers to improve their human resource system.
- proper planning and implementation of the human resource system will result in overall development of extension personnel.
- This will also enable extension organizations to adopt to the rapid changes occurring in the extension environment of developing countries.

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83. EXTENSION EDUCATION AND RURAL DEVELOPMENT 16125

Indigenous Technical Knowledge in Agriculture

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INTRODUCTION: Indigenous Technical Knowledge (ITK) also referred to as local or traditional knowledge is the cumulative body of knowledge generated and evolved over a long period of time and generations of experience (Grenier, 1998). It includes the skills, beliefs, norms, practices and behaviour patterns handed down from one generation to the next (Matowanyika et al., 1994).

Indigenous Knowledge refers to the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area. Indigenous knowledge is the local knowledge - knowledge that is unique to a given culture or society.

Indigenous knowledge system (IKS): delineates a cognitive structure in which theories and perceptions of nature and culture are conceptualized. Thus it includes definitions, classifications and concepts of the physical, natural, social, economic and ideational environments. The dynamics of IKS takes place on two different levels, the cognitive and the

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empirical. On the empirical level, IKS are visible in institutions, artifacts and technologies.

Indigenous Technical Knowledge (ITK): is specifically concerned with actual application of the thinking of the local people in various operations of agriculture and allied areas.

Characteristics of ITK

1. ITK is not static but dynamic, exogenous knowledge and endogenous creativity brings change to ITK.
2. ITK is intuitive in its mode of thinking; ITK is mainly qualitative in nature.
3. ITK study needs a holistic approach, ITK, if properly tapped can provide valuable insights into resources, processes, possibilities and problems in particular area.
4. ITK is recorded and transferred through oral tradition.
5. ITK is learned through observation and hands-on experience ITK forms an information base for variety.
6. ITK reflects local tradition.

Roles of ITK

1. ITK can aid development efforts
2. ITK can facilitate local people‘s participation
3. ITK is a valuable source of developing appropriate technologies.

Classes of ITK in Agriculture

1. Climatology
2. Local soil and taxonomy
3. Soil fertility
4. Primitive cultivar
5. Inter cropping
6. Agronomic practices
7. Irrigation and water management
8. Plant protection
9. Post harvest technology and methods.

Importance of ITKs

Agricultural traditional knowledge has also proven to be an invaluable adaptation tool for indigenous peoples in agriculture. In coping with excessive or low rainfall, drought and other environmental changes, indigenous peoples rely on a diversity of crops, varieties and planting locations. This serves as a safety measure to ensure that, in the face of severe environmental change, some crops will survive. The Chipaya people of Bolivia monitor the wind, snow, clouds and stars to determine what species to plant and when and where to plant them (Llosa Larrabure, Pajares Garay and Toro Quinto, 2009). In Chile, the Mapuche have a complex traditional seed bank for conserving genetic variability within species (Chehuaicura, Thomet and Perez, 2010). Such diversity provides security for the Mapuche against environmental change and other stresses.

Indigenous knowledge systems have enabled the various communities in the area to live in harmony with their environments for generations, and that their traditional knowledge systems are important tools in environmental conservation and natural disaster management. Based on this traditional knowledge and peoples long- standing experiences concerning cloud formation, lightning wind direction, occurrence of rains in a particular period of the lunar calendar, the Indigenous rain forecasters predict the reasonably exact nature of rainfall for the entire season, including good and undesired effects (*e.g.*, flooding, droughts). There are well known Sutras given in the ancient books to predict the monsoon and inform people about prospects of agriculture in a given year. Even in villages it is very common for farmers to consult Brahmans about the monsoon in a year.

Monsoon predictions are also made according to the nature, colour, and direction of flow of clouds and lightning in the clouds. In the prediction that a particular year is likely to be a drought year, the nature of clouds is described as follows: “There would neither be prosperity nor rain in the land should the clouds be rough and small, tossed about by the wind have the shape of camels, corms, dead bodies, monkeys or other inauspicious creatures, and be silent” The tribal peoples of Rajasthan face many natural hazards, but the major ones are drought and floods; these invariably cause famine, food insecurity and poverty. However, the people have developed a variety of measures to contend with these situations, such as growing drought-resistant and early-maturing indigenous crop varieties, gathering a diversity of wild fruits and vegetables, wetlands cultivation, livestock diversifying and splitting, that have enabled them to survive climatic hazards independently, with little or no support from the outside world. The people are well aware of the disasters they face and in most cases had the knowledge and administrative structures, or social institutions to cope with them.

Traditional local communities have continued to rely heavily on their own indigenous knowledge systems in observing the environment and dealing with natural disasters. These communities, particularly those in hazard prone areas, have collectively generated a vast body of knowledge on disaster prevention and mitigation, early warning, preparedness and response and post disaster recovery. This knowledge is acquired through observation and study, and is often based on cumulative experience handed down from generation to generation. Such traditional environmental knowledge systems are important tools today in environmental conservation and natural disaster management.

In Africa, many communities have used IK as a critical knowledge base and survival tool for adapting to extreme climate events and other natural hazards. They have developed techniques and strategies for forecasting, and managing

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climate variability including coping mechanisms to respond to both normal and harsh conditions of their local environments.

Some of the Examples of ITKs

Ficus species: Flowering and generation of new leaves indicates near rainfall onset. Butterfly: Appearance of many butterflies indicate early rainfall onset and also gives a prospect of good season. Ants : Appearance of ants indicate imminent rainfall onset and signifies a prospect for good season Termites : Appearance of many termites indicates near rainfall onset. Frogs: When frogs start to make a lot noise, it indicates near rainfall onset. The tribal of Rajasthan also have faith in the sayings of elders about the prediction of weather, for *E.g:* – Sukarvar ri badri, rahi shanichar jaye, barsa bina na jaya. It means that if clouds form on Friday and remain till Saturday then they will not go without rain, such indications predict rains. In another saying – Nada tankan, balad bikavan.mat baje tu, adhe saawan. It means that in mid monsoon if South east wind blow then farmer of marwar region cries because it indicates famine in the particular region. Similarly – Pawan baje Suryo, to hali halav kim puryo, means that if winds flow in the North –west direction then farmer should not plough his field because it indicates heavy rains. Indicators such as the position of the sun or the cry of a specific bird on trees near rivers help people to predict the onset of the rainy season.

The farmers of Kenya, Uganda and Tanzania already adapted to climate change led soil erosion in the form of heavy snowfall, landslide and rainfall through – Fanya Zuu Terraces (terrace cultivation) in more scientific way (40-50 cm high terraces and 10-20 m apart with suitable agro-forestry practices). Therefore, this century old traditional practices need to be relooked in context of climate change in more scientific and participatory way for better adaptation to climate change led soil erosion.

84. NEMATOLOGY 16002

Entomopathogenic Nematodes (EPNs)

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Nematodes which are capable of killing, sterilizing or seriously hampering the development of insect and completing at least one stage of their life cycle in the host. They are also called as entomogenous, entomophilic, insect parasitic nematodes etc.

Important groups of EPNs

1. Family: Mermithidae :(Order: Enoplida)
2. Family: Steinernematidae (Order; Rhabditida)
3. Family: Heterorhabditidae

Special Qualities of Steinernematidae and Heterorhabditidae

1. Quick mortality of the host (24 – 48 hr)
2. Wide host range (> 200 insect species of 10 Orders)
3. Wide distribution – found all parts of the world except Antarctica
4. Symbiotic association with bacteria (*Xenorhabdus;* Steinernematidae and *Photorhabdus;* Heterorhabditidae)
5. Infective stage (3rd stage) is non feeding, free living, durable and capable of withstanding adverse climatic changes
6. Can be mass produced both on natural host and artificial diet
7. Good shelf life
8. Easy to apply
9. Safer to non target organisms

Advantages of Microbial Agents as Component in IPM

1. Exploitation for pest control is environmentally safety due to host specificity
2. Microorgansims have natural capability of causing epizootic levels due to their persistence in soil and efficient transmission
3. Compatible with chemicals insecticides
4. The cost of development and registration of microbial insecticide is much less than that of chemical insecticides
5. Large scale culture and application is relatively easy and inexpensive
6. No resistant development

Factors Affecting Biological Control

1. Tolerance limit of crop to insect injury - Successful in crops with high tolerance limit
2. Crop value - Successful in crops with high economic value
3. Crop duration - Long duration crops highly suitable
4. Indigenous or Exotic pest - Imported NE more effective against introduced pest
5. If alternate host available for NE, control of target pest is less
6. If unfavourable season occurs, reintroduction of NE required
7. Presence of hyperparasites reduces effectiveness of biocontrol

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8. Tritrophic interaction of Plant-Pest-Natural enemy affects success of biocontrol, *e.g. Helicoverpa* parasitization by *Trichogramma* more in tomato than corn
9. Use of pesticides affect natural enemies
10. Selective insecticides (less toxic to NE required)
11. Identical situation for successful control does not occur
12. Depends on life cycle of NE

General Limitations of Biological Control include

1. The host (pest) population will continue to exist at a level determined by the properties of the host, its natural enemies and of the habitat they occupy
2. The effectiveness of natural enemies must be considered relative to man's economic thresholds
3. The attainment of biological control of one major pest on a crop necessitates the elaboration of a system of integrated control for other pests of the crop, if any exist; and the research necessary in seeking a biological control solution to a problem is often demanding in terms of scientific and technical staff, funds, and time, and a solution cannot be guaranteed in advance

85. STATISTICS AND BIOMETRY 15983

ANCOVA and its Application in Agriculture Research

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INTRODUCTION: The test of significance based on t-distribution is an adequate procedure for testing the significance of the difference between two sample means. The basic purpose of ANOVA is to test the homogeneity of several means *i.e.* to test the hypothesis that several means are equal. This technique is an extension of the two-sample t-test.

Analysis of covariance is an extension of the analysis of variance technique. The question is whether the variation in the response variable over the classes is due to class effects or due to its dependence on the other variables x's, called the independent or concomitant variables, which also vary from class to class. In the field experiment there is always an uncontrollable variable (in addition to the main variable (variable of interest)) which influences the values of the main variable. This uncontrollable variable is called concomitant variable or simply covariate.

For example, in a field experiment where rodents have (partially) damaged some of the plots, covariance analysis with rodent damage as a covariate could be useful in adjusting plot yields to the levels that they should have been had there been no rodent damage in any plot.

Definition: "The statistical technique used to analyze the effect of treatments on the main variable after removing the effect of covariate is called covariance analysis".

Whether the variation in the response variable over the classes is due to class effects or due to its dependence on the other variables x's, called the independent or concomitant variables, which also vary from class to class. ANCOVA controls the experimental error by taking into consideration the dependence of y on the x's.

Mathematical Model

The mathematical model used for combining both (Anova + Regression) procedures is known as ANCOVA model for two way classifications. The typical mathematical model appropriate to the analysis of covariance is

$$y_{ij} = \mu + \ i + \rho j + \beta(x_{ij} - x_{..}) + e_{ij} \quad (1)$$

Where,

y_{ij} is the yield or response, while x_{ij} is an auxiliary variate, sometime called the concomitant variate or covariate, on which y_{ij} has a linear regression with regression coefficient β.

The constants μ, $_i$ and ρ_j are the true means response and the effects of the ith treatment and jth replication, respectively. The residuals e_{ij} is random variates, assumed in standard theory to be normally and independently distributed with mean zero and common variance. The covariance analysis is the mixture of regression analysis and analysis of variance. This technique split the total covariations of a bivariate sample into different components, each of which is again a source of variation. The covariance effects are sorted out to check the existence of regression and its effects are then removed before testing the treatment effects.

To compare the treatments or block effects we need to remove the effect of regression from the model, therefore we can write as

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$$y_{ij} - \beta (x_{ij} - x_{..}) = \mu + \ _i + \rho_j + e_{ij} \quad (2)$$

Equation (2) is analogous to ANOVA model with observations $y_{ij} - \beta (x_{ij} - x_{..})$ And $_i$ may be regarded as the true treatment effect.

Assumption Required for ANCOVA

The assumptions required for the valid use of the analysis of the covariance are the natural extension of those for an analysis of variance, namely:

- Error term has zero mean and constant variance σ^2
- Error is independently distributed
- The covariate is unaffected by the treatments
- y and x have a linear relationship
- Errors follow a normal distribution

Uses of Covariance Analysis in Agricultural Research

1. To control experimental error and to adjust treatment means.
2. To aid in the interpretation of experimental results.
3. To estimate missing data etc.,

Some specific applications of the covariance technique in controlling experimental error and in adjusting treatment means are

1. Soil heterogeneity
   a) The pattern of soil heterogeneity is spotty or unknown
   b) Variability between plots in the same blocks remains large despite blocking
2. Uniformity trial data
   a) Uniformity trial data is an ideal covariate to correct for variability due to soil heterogeneity.
   b) It clearly satisfies the requirement that it is not affected by the treatments since measurements are made before the start of the experiment and thus before the treatments are applied.
3. Data collected prior to treatment implementation
   a) In experiments where there is a time lag between crop establishment and treatment application, some crop characteristics can be measured before treatments are applied.
   b) Such data represent the inherent variation between experimental plots. In such cases, one or more plant characters that are closely related to crop growth, such as plant height and tiller number, may be measured for each experimental plot just before the treatments are applied.
4. Residual effects of previous trials: With the covariance technique, the covariance could be plot yield in the previous trial or an index representing the expected residual effects of the previous treatments.
5. Stand Irregularities: ANCOVA with stand count as the covariate is one of the best alternatives, provided that stand irregularities are not caused by treatments. Such a condition exists when:
   a) The treatments are applied after the crop is already well established.
   b) The plants are lost due to mechanical errors on planting or damage during cultivation.
   c) The plants are damaged in a random fashion from causes such as rat infestation, cattle grazing.
6. Non uniformity in pest incidence and environmental stress: The distribution of pest damage is usually spotty and the pattern of occurrence is difficult to predict. Consequently, blocking is usually ineffective and covariance analysis, with pest damage as the covariate, is an ideal alternative.

To monitor the variation in the stress condition over an experimental area, a commonly used field plot technique is to plant, at regular intervals, a check variety whose reaction to the stress of interest is well established. A susceptible variety is commonly used for this purpose. The reaction of the susceptible check nearest to, or surrounding, each test variety can be used as the covariate to adjust for variability in the stress levels between the test plots.

Statistical Packages for Analysis of Covariance

SAS, SPSS, MINITAB, R-software etc.,

Conclusion: Analysis of covariance (ANCOVA) is a statistical technique to account for variability in response variable using linear regression. When heterogeneity between experimental plots does not follow a definite pattern, then blocking may not be a very effective method for controlling error variation. In such situation ANCOVA is an alternative. ANCOVA is used to improve the estimate of error variance and to adjust treatment means for the value of the covariate. It is also used to estimate the missing observation(s).

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86. ECONOMICS 15762

Gold Monetisation

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INTRODUCTION: Nearly 18 months after it was first launched, the gold monetisation scheme is yet to find many takers. In response to a Lok Sabha question, the government revealed that till mid-February this year, the scheme has led to deposits worth only 6,410 kg of gold since it was launched, less than 2% of the annual imports of the yellow metal in 2016.

What is Gold Monetisation Scheme?: Launched to curb India's massive gold imports, which contributes significantly to India's trade deficit, the scheme allows a bank's customers to deposit their idle gold holdings for a fixed period of time in return for an interest in the range of 2.25% to 2.50%, and redeem it on maturity either in the form of gold or its rupee-equivalent amount.

What was Expected out of this Scheme?: Indian households (and temples) collectively own 20,000 tonnes of gold, a figure that is equivalent to the combined amount of gold held by the central banks of the US, Euro area and China. The government hoped that its initiative will help monetize a significant chunk of such gold holdings, which would then be melted and sold/lent to jewellers (and other users of gold), to reduce India's dependence on imports.

Performance of the Scheme: So far, the response to the scheme seems to have been extremely tepid. Gold imports still account for more than one-fourth of India's trade deficit and the country remains the largest importer of gold in the world despite having ceded the title of the "largest consumer" to China in the last few years.

Reasons for Poor of the Scheme: The reasons for the lacklustre response of GMS are manifold and vary from structural issues, and deficiencies in design and dynamics related to economics of gold consumption in India.

- The reasons need to be contextualised in structural disadvantage where gold is perceived to be more useful than any other asset, as it can be simultaneously used to indicate social status, stored, transferred inter-generationally and, increasingly, even pledged.
- Many households are unwilling to park their gold in banks because of the low interest rates on offer. 2-3% interest on gold not deemed attractive by many.
- Nearly three-fourth of India's gold stock in held in the form of jewellery and carries a lot of sentimental value. There is also a gender aspect to it, as gold in the form of jewellery allows women some sort of control over ownership and inheritance. Given this aspect, many households might prefer private schemes, which allow them to get back the gold in form of jewellery as opposed to the government's scheme which offers cash or solid gold.
- Also, it is difficult for gold purchased with unaccounted money to ever become part of official economy, since it invariably leads to questions about how the gold was acquired?

What Needs to be Done?

- The Gold Monetisation scheme design has to examine the rate of interest being offered as well as the lock-in period. Bonds can be made more attractive by linking the tenor with interest rates, more dynamically. This will make it attractive for high net-worth investors and money managers who may be interested in taking calculated risk on price while earning additional returns.
- The government should also actively extend the campaign to households—away from the focus on temple trusts —maybe through the use of vernacular press and electronic media.
- To make the scheme market-friendly, assaying could also be assigned to select jewellers, especially branded chains, to ensure presence in at least all districts.
- To incentivise collection of gold, the commission that is being offered to commercial banks—2.5% including handling charges—could also be offered to select jewellers.
- Finally, and most importantly, it is necessary to undertake household-level surveys to determine the attitude of households towards gold in different parts of India, and then focus on a strategy to collect gold under the scheme.

Conclusion: Gold monetisation scheme is a progressive measure introduced by the government for optimum utilisation of gold by the investors and also towards reducing India's current account deficit. However, for the scheme to be successful, the government has to identify the gaps and correct them at the earliest.

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87. ECONOMICS 15782

Bottom Up Approach for Agricultural Development

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To increase agricultural production and thereby to improve the economic condition of the farmers, farm women and agricultural labourers, attempt must be made to educate and motivate them for adoption of improved agricultural practices. This could be done through a well developed and effectively executed village level planning.

Agricultural Development mainly depends upon the following factors

1. Transfer of Technology in a manner which will be understood, accepted and adopted by the farmers.
2. Creation of necessary infrastructure such as, irrigation, electrification, road and transport, cold storage and processing units etc.
3. Arrangement for supply of inputs such as quality seeds, planting materials, fertilizers, pesticides and insecticides and production credit in time.
4. Facilities for remunerative marketing. These facilities if extended to the farmers, it will definitely help increase agricultural production and at the same time help improve economic condition of the farmers and farm labourers.

Transfer of Technology

For Transfer of Technology we have to streamline our extension system. Frankly speaking our extension programme today is very weak. Although we have extension personnel at Panchayat, Block and District level, they have not been given required facilities for transfer of technology and motivation of farmers using various extension tools. It is a matter of great regret that village level Agricultural worker (VAW) who is supposed to be the main contact person at the village level does not have a office. He is not supplied with leaf lets, booklets, posters, samples or specimens or any other teaching materials which could facilitate transfer of technology. He is not given facility to conduct method or result demonstrations, field days or field trips or to use any type of audio visual aids.

V.A.W.

The V.A.W. must stay in one of the village under his jurisdiction. This is a must to improve credibility of the Agriculture Department. His residence-cum-office should be treated as a place of contact for all types of agricultural activities and information in the village. He should be supplied with leaflets, booklets, posters, magazines etc. as teaching materials. Samples of seeds, fertilizers, pesticides plant growth regulators, new implements if any should be also kept with him for demonstration.

Block Level Agriculture Office

Block Level Agriculture Office should be well organised. There should be sign-board displaying name of the office. Block Level Annual Plan should be prepared in consultation with the progressive farmers, V.A.W.'s, Panchayat members and other concerned. The plant should include :

1. Crops to be grown in Kharif, Rabi and Summer season
2. Infrastructures to be provided, such as :
   a) Irrigation facility
   b) Electrification
   c) Godown
   d) Cold storage
   e) Road and transport
   f) Processing units etc.
3. Inputs to be Required :
   a) Seeds, fertilizers, plant protection chemicals, production credit
4. Marketing facility for marketing of agricultural commodities at a remunerative price.
5. Training and demonstrations to be conducted, posters, leaflets, circular letters to be produced or effective transfer of technology.
6. A register should be maintained to record observations of the visiting farmers along with assistance given for solution of their problems.

The Committee Should Look into

1. Planning for the village and block
2. Progress of the work as per the plan
3. Problems faced
4. Actions to be taken for solution of the problems
5. Monitoring of the programme
6. Supervision of the work
7. Availability of inputs and other facilities
8. Marketing facility

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88. ECONOMICS 15829

Feminization of Agriculture.

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INTRODUCTION: Women constitute about 65% of all agricultural workers and about 74% of the rural workforce. Yet, despite their hard labour in the field, women are not officially counted as farmers because they do not have a claim to land under their name in official records. Nearly three-quarters of rural women in India depend on land for a livelihood compared to about 60 percent of rural men, as lower farm incomes push many men to the cities for jobs. According to NSSO report, women lead almost 18% agricultural households and there is not a single area of agriculture in which they are not involved. As many as 87 per cent of women do not own their land primarily because of 2 reasons:

- Land, a state subject, is not governed by a constitutional uniform law that applies equally to all citizens, which tend to discriminate against women when it comes to land inheritance.
- The cultural aspect of the deep-rooted biases that hinder women's ownership of land in patriarchal societies cannot be discounted.

Further, Indian farmers, both men and women, face an uphill battle even in terms of leasing land. Despite restricting tenancy nearly 35 per cent of India's agricultural land is cultivated by tenant farmers, who tend to be landless, poor and marginal.

Feminization of Agriculture reflects the shift in the gender roles in the agriculture. Where earlier the image of agriculture or an agricultural farmer was associated deeply with men, in today's India, the image has been feminized due to increasing number of female workers in the agriculture sector.

Reasons behind Feminization

- ***Male Migration***- Increasingly there has been a need for men to find better avenues for income for the sustenance of their family. Urban centres have been seen as providing lucrative job opportunities for them. Men from rural areas migrate to cities seeking a means for regular income leaving behind the agricultural chores to women.
- ***Low level of Skills***- The women in turn face various handicaps and problems while operating agricultural chores such as low level of agricultural skills, lack knowledge to improve productivity thereby entering into a vicious cycle of poverty.
- ***Lack of Property Rights***- Given the social and religious set up in India, women do not generally enjoy equal property rights as their male counter parts. The property related rules and rights are governed by the religious laws which are inherently unequal.
- ***Lack of bargaining power to women***- Due to lack of property rights, women are generally not given the land rights in their name. Because of this, women lack bargaining power in the family as against the property holding male member. Also, due to low level of skills, they work much longer hours than men and are paid lesser than their counterpart.
- Also, their ignorance about their rights, opportunities and facilities make their participation in agricultural all the more tough.

Significance of Providing Ownership Rights

- Female farmers should be provided with the three critical driving factors — the incentive, the security, as well as the opportunity — to invest in the land they harvest. Raising voice for female farmers, platforms like MAKAAM have already been established.
- Many studies have shown that women have a greater propensity to use their income for the needs of their households. Land-owning women's offspring thus receive better education and nourishment. Therefore, it can be a win-win situation for farmer, her family and overall society.
- The wiping away of the debilitating feelings of insecurity and vulnerability for rural women can prevent physical and emotional abuse that they face. The chance of propertied women being physically abused is reduced from 49 per cent to 7 per cent due to an increase in the women's bargaining power. This suits the society's overall goal for women empowerment.
- Such a framework is in sync with the goals 2 and 5 of SDGs. The SDGs recognize the importance of property rights for women, especially in rural areas. It has set goals so that,
  - All men and women have equal rights to ownership and control over land by 2030; and

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– The agricultural productivity and incomes of small-scale food producers, especially women can be doubled.

Steps taken by Government

Earmarking at least 30% of the budget allocation for women beneficiaries in all ongoing schemes/ programmes and development activities. Focusing on women self-help group (SHG) to connect them to micro-credit through capacity building activities and to provide information and ensuring their representation in different decision-making bodies. The Ministry of Agriculture and Farmers Welfare decided to celebrate 15th October of every year as Women Farmer's Day.

Implications

Given the increasing feminization in agriculture, it becomes imperative to give women their due property rights which will have a widespread impact on improving various social factors. Giving agency to women farmers is critical in realising these outcomes as it would provide them security and would further incentivize the whole process of agriculture. It all may begin with creating a new image for the "Indian farmer".

89. ECONOMICS 15948

Integrated Farming System: A Means of Economic Development

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Integrated Farming System (IFS) is a type of farming which adopt and integrate the component of Crops, Livestock, Horticulture, Fisheries and Agro-forestry with the objectives of continuous and stable income generation, employment generation and environmental enrichment. Generally organic inputs are used in Integrated Farming System. Organic by-products of one enterprise is used as the input of other enterprise. IFS shows efficient use of inputs which ensure economic advantages as the price of every input in agriculture is increasing day by day. Government of India has also promoted Integrated Farming System under National Agricultural Development Programme which got good response in many areas of the country.

The integration of farm enterprises often suggested as the means for rapid economic development in India. Having achieved some success in increasing crop production through various technological and institutional changes, the country is now said to be poised for white and blue revolutions involving substantial increase in livestock and fish output. In view of the growing pressure of population and limited scope of increasing additional income through crop production, diversification is considered essential not only for the liberation of the rural masses from the squalor of poverty but also for meeting the demands of milk products, meat, fish, eggs etc. Which generally show rising trends with increasing levels of per capita income in the country. (Mangala B., 2008)

Components of Integrated Farming System

Integrated Farming System (IFS) literally means integrating different components of farming system. Different components of Integrated Farming System are:

1. Crops: Cereal Crops like Paddy, Wheat etc. Pulse Crops, Oilseeds etc.
2. Livestock: Dairy, Poultry, Duckery, Goatery, Piggery, Bee Keeping etc
3. Horticulture: Fruits & Vegetables, Flowers etc.
4. Aquaculture: Different kinds of indigenous and foreign Carps,
5. Agro-forestry: Timber Plants, Orchard

Advantages of Integrated Farming System

1. Productivity: Increase in economic yield per unit area - per unit time by virtue of intensification of crops and allied enterprises.
2. Stability in Income generation: Different and diversified components like dairy, fishery, poultry provide output in different time periods. So, this helps in income generation throughout the year.
3. Profitability: The system, as a whole provides opportunity to make use of produce/ waste material of one component as input on the other component at the least cost.
4. Potentiality/Sustainability: Integrated Farming System effectively utilises by-products of linked components and this will certainly provide opportunity to promote soil health and to sustain the potentiality of the soil which is the production base.
5. Balanced food: Integrated Farming System

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yields different farm products which produce different sources of nutrition, namely, protein, carbohydrates, fats, minerals, vitamins, etc from the same unit area. It will provide opportunity to mitigate malnutrition problem of the farming households.

6. Waste Recycling: Application of huge quantity of fertilizers, pesticides, weedicides, insecticides, etc pollutes soil, water and air. Much of the wastes could be converted /recycled to some other forms of economic, ecological & social values, under the Integrated Farming System.
7. Employment Generation: Hired and family labours can be used in more effective and efficient manner throughout the year as different enterprises are labour intensive.
8. Minimising Risk: If crop failures the farmer can make up their losses through other enterprises.
9. Social values: Integrated Farming System enhances social status of the farmers and higher income generation enhances their standard of living of the farmers.

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90. ECONOMICS 16064

Food Wastage: An Area of Prime Concern

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Food loss and waste is a global problem, but unaffordable high in India. Minimising food wastage should be taken up as a priority. According to the United Nations, Food and Agriculture Organisation, one-third of all food produced for human consumption, roughly 1.3 billion tonnes, is lost or wasted. And it's not just the food going to waste; it's also the energy, water, fertilizer and other resources used to produce the food that is wasted. This is a trend that cannot continue. The global population is growing. By some accounts, it will reach 9 billion people by 2050. The planet isn't getting any larger, so finding ways to produce and preserve more food efficiently will be a key to meeting the demands of the future. Think about this: if we reduced the current food waste by 20 per cent, that would equal 260 million more tons of available food without using one more kilowatt of energy, one more drop of water or one more acre of land.

The harvest and post-harvest losses were estimated of nearly Rs 93,000 crore in 2012-13 nearly 16 per cent of fruit and vegetables and 6 per cent of cereals were lost. Missing processing capacity, transport links and storage facility are to blame for most wastage. Reducing post-harvest loss can increase the amount of food available to farmers for their own consumption and for sale. It can contribute to addressing the country's hunger and malnutrition problem. With nearly 200 million people undernourished, India ranks 100th among 119 countries on the 2017 Global Hunger Index (IFPRI). Food produced but unavailable for consumption exacts an environmental toll, using up water, degrading land and producing emissions of greenhouse gases. So far, governments and industry have stressed on the need for storage. The focus needs to be on moving the produce from the field to the consumer. This means marketing freedom for farmers, motorable roads, refrigerated vans and smooth movement across state borders, besides investing in the food processing industry, particularly close to the areas of production. This will minimise food loss during transport.

Indians waste as much food as the whole of United Kingdom consumes – a statistic that may not so much indicative of our love of surfeit, as it is of our population. Still, food wastage is an alarming issue in India. Our street and garbage bins, landfills have sufficient proof to prove it.

Weddings, canteens, hotels, social and family functions, households spew out so much food. According to the United Nations Development Programme, up to 40 per cent of the food produced in India is wasted. About 21 million tonnes of wheat are wasted in India and 50 per cent of all food across the world meets the same fate and never reaches the needy. In fact, according to the agriculture ministry, Rs. 50,000 crore worth of food produced is wasted every year in the country.

The theme for this year's World Environment Day campaign is 'Think Eat Save'. It is an anti-food wastage and food loss campaign aimed at reducing the wastage footprint. Wastage of food is

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not indicative of only hunger or pollution, but also many economic problems in the economy, such as inflation. Only government policies are not responsible for the problems we are facing today, but our culture and traditions are also playing a lead role in this drama. In India, the bigger the wedding, the larger the party and the more colossal the waste.

Food Wastage: A Problem in India

- About 25 per cent of fresh water used to produce food is ultimately wasted, even as millions of people still don't have access to drinking water. When you calculate the figures in cubic kilometers, this is a bit more than an average river.
- Even though the world produces enough food to feed twice the world's present population, food wastage is ironically behind the billions of people who are malnourished. The number of hungry people in India has increased by 65 million more than the population of France. According to a survey by Bhook (an organization working towards reducing hunger) in 2013, 20 crore Indians sleep hungry on any given night. About 7 million children died in 2012 because of hunger/malnutrition.
- Acres of land are deforested to grow food. Approximately 45 per cent of India's land is degraded primarily due to deforestation, unsustainable agricultural practices, and excessive groundwater extraction to meet the food demand.
- 300 million barrels of oil are used to produce food that is ultimately wasted.

Food wastage cripples a country's economy to an extent that most of us are unaware. If food is wasted, there is so much waste of water used in agriculture, manpower and electricity lost in food processing industries and even contributes to deforestation. Taking all of into consideration, the actual worth of money per year in India from food wastage is estimated at a whopping Rs. 58,000 crore. Some measures that the government needs to take include containing wastage in transportation, improve storage facilities (the cold storage chain is 50% less than required and that too needs to be brought up to world standards), food processing also needs to be sped up so food is saved and wasted less to feed more. While you may not be able to reduce food lost during production, you can certainly reduce food at your personal level of food waste.

Control Food Wastage at Personal Level

- Plan out your meal and make your shopping list to determine what you actually need for the week. About 20% of what we buy in urban India ends up being thrown away. You could in the week after cut down on the surplus and soon in two or three weeks you will have a precise list of your family's weekly consumption. You have no idea how amazed you will be at how much you buy and what you actually consume.
- Buy in quantities you can realistically use. Avoid impulse buys. It will more or less find the bin.
- If you cook at home, make sure you cook keeping in mind there is no excess. You can always complete your meals with a few fruits rather than keep some extra food in the refrigerator. It's a lot better and a healthier practice too.
- Select according to their shelf life. Use the green vegetables first. Don't throw out fruits and veggies with 'aesthetic only' blemishes. Use canned and bottled food before expiry dates.
- Reuse the refrigerated left-overs (if any) for the very next meal.
- Even if food gets spoilt then compost it.
- If you work in an office that has a canteen, check with them on how they manage excess food. Cooked food, especially since it has a low shelf life needs to be managed better and faster. Check with NGOs who offer to transport excess food to the needy.
- If you host a family get together either at home, a marriage hall or throw a party at a hotel, make sure you plan for the food to be transported to a place like an orphanage or an old age shelter.
- Make finishing your plate a habit. Try to inculcate it further to as many possible.
- Motto: Love Food, Hate Waste!
- As the sale of packaged and processed food with an expiry date becomes more commonplace, better packaging to extend the life of packaged food and practices to distribute food bought but unused by the consumer also become salient

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91. ECONOMICS 16073

Planning Commission *vs* NITI Aayog

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Planning Commission was set up in March, 1950. The following are the tasks assigned to the Commission:- (i) To make an assessment of the material, capital and human resources of the country, including technical personnel and investigate the possibilities of augmenting such of these resources as are found to be deficient in relation to the nation's requirements; (ii) To formulate a Plan for the most effective and balanced utilization of the country's resources; (iii) On determination of priorities, to define the stages in which the Plan should be carried out and propose the allocation of resources for due completion of each stage. (iv) To indicate the factors which are tending to retard economic development, and determine the conditions which, in view of the current social and political situation, should be established for the successful execution of the Plan; (v) To determine the nature of machinery which will be necessary for securing successful implementation of each stage of the Plan in all its aspects; (vi) To appraise from time to time the progress achieved in the execution of each stage of the Plan and recommend for adjustments of policy and measures that such appraisal may show to be necessary; and (vii) To make such interim or ancillary recommendations as appear to it be appropriate either for facilitating the discharge of the duties assigned to it; or, on a consideration of the prevailing economic conditions, current policies, measures and development programmes; or on an examination of such specific problems as may be referred to it for advice by Central or State Governments. 2. Besides, the Government of India (Allocation of Business) Rules have assigned responsibilities to the Planning Commission in respect of (a) Public co-operation in National development (b) Hill area development programme (except in the North Eastern Region), and (c) Institute of Applied Manpower Research.

NITI Aayog – How it is different from Planning Commission?

Planning Commission has been renamed as NITI (National Institution for Transforming India) Aayog. According to the official press release, "The centre-to-state one-way flow of policy, that was the hallmark of the Planning Commission era, is now sought to be replaced by a genuine and continuing partnership of states."

The institution will serve as a 'think tank' of the government – a directional and policy dynamo. NITI Aayog will provide governments at the Central and State levels with relevant strategic and technical advice across the spectrum of key elements of policy. The Aayog, instead of being in the controlling seat, is going to provide a direction. It is going to be an 'enabler' instead of a 'provider of first and last resort.

NITI Aayog is a pro-people, proactive & participative development agenda stressing on empowerment & equality is the guiding principle behind it. Through NITI Aayog, we bid farewell to a 'one size fits all' approach towards development. The body celebrates India's diversity & plurality

In the Planning Commission, there was just one central figure that practically controlled every aspect of the commission: the Deputy Chairman. It's another matter whether it was the Deputy Chairman to perpetuate their own policies. For instance in the earlier days it was never clear whether the Commission was working to boost the country's economy or was trying to keep it as backward as possible. To do away with the central authority and to make the Aayog more useful in terms of policy, direction and implementation, the Deputy Chairman has been replaced by a CEO and a Vice Chairperson (with a caveat that they'll be appointed by the PM). Instead of control, the focus will be on being a catalyst and providing a platform for the States and the Centre to come together and discuss matters of economic policies and development plans. The planning will be orchestrated at the village level and an aggregation of these inputs shall be used to formulate national-level plans and policies. Even during the formation of the Aayog, Chief Ministers from all the States were invited to participate.

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92. FOOD TECHNOLOGY 16008

Lean Manufacturing: A Waste Minimization Technique in Food Industry

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INTRODUCTION: Food industry is an important sector and is growing day by day due to the need of feeding the increasing population. Due to this, many enterprises showing interests in food product manufacturing which creating competitive environment within the existing food production units. As we can see food industry is a low profit margin business and its profitability depends upon the volume of product being sold. Increase in volume with limited resources put pressure on overall production system and sometimes it become inevitable to run the plant with same efficiency. Frequent plant breakdown, machine halts, non-maintenance of production schedule, product wastages all sums into increasing the cost of production. Lean manufacturing techniques are used by other industries to get the optimize use of resources in a manufacturing plant and same can be replicate in food industry to manage the production activities in order to get better control over production costs. Lean manufacturing aimed at providing the feasible solution to control the cost that are associated with production, processing and marketing of the product.

What is Lean Manufacturing?: Lean manufacturing is a concept which aims at sounder, more productive and more effective manufacturing by eliminating all elements of waste in the manufacturing process. Lean manufacturing aims to perform production with zero defects, to reduce costs, to meet customer requests at the moment and amount desired, to hold no excess inventories, and to continually make improvements by eliminating waste.

Is Lean Applicable in Dairy and Food Industry?: There has long been a perception that the Lean process is not easily applied to industries that have large batch processes like the food and beverage industry. However, the food industry has the most need to reduce waste as food is more susceptible to literal waste in the form of spoiling or expiration. Therefore, when you take a closer look at each process during the supply chain of food source, the same seven types of waste can be found. Over production, waiting time, transportation, processing, inventory, motion, and product defects are all areas of waste that can also be found in the food and beverage industry. The improvements made include streamlining several packaging lines, improving the flow, reducing the lead time through the packaging process, reducing the number of people in the lines, reducing waste through improved food handling methods, and improving the changeover time between different production runs on the same line.

Lean Manufacturing Basics: The Lean approach is based on finding efficiencies and removing wasteful steps that don't add value to the end product. It classifies waste into following seven categories;

Seven Types of Wastes

1. **Over production**- Extra products may spoil or become obsolete requiring disposal, extra hazardous materials used result in extra waste disposal.
2. **Inventory**- More packaging to store work-in-process (WIP), Waste from deterioration or damage to stored WIP
3. **Transportation and motion** -More packaging required to protect components during movement, time loss in carrying of raw material from cold/dry store to process section
4. **Defects**- product damage, poor quality and substandard product generate waste
5. **Over processing**- overheating and reheating while processing, Unnecessary processing increases waste
6. **Waiting**- Potential material spoilage or component damage causing waste, short stoppages at line, frequent breakdowns

Lean Manufacturing Process

Stage 1 – Identify waste: The key factor in implementing the Lean concepts is to identify the waste within a system. One of the key tools used to find this waste is a Value Stream Map (VSM). This shows how materials and processes flow through your organization to bring your product or service to the consumer.

Stage 2 – Analyze the waste, and find the root cause: Find out the root cause for every identified waste using root cause analysis. In case of an equipment failure, analysis could show that the real problem is poorly trained operators who don't use the machine properly. Other effective tools for finding a root cause include Brainstorming and Cause and Effect Diagrams.

Stage 3 – Solve the root cause, and repeat the cycle: Using an appropriate problem-solving

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process, decide what you must do to fix the issue to create more efficiency.

Tools to Reduce Waste

Following are some of the tools which are commonly used to reduce the identified waste:

Just in Time – `Just-in-time' is a management philosophy and not a technique. It emphasis on procuring the stock and resources, produce and distribute products when required.

Kanban – This is an active involvement of the people in an organization to get the solution from themselves. Kanban helps in visualize the work, identification and elimination of bottlenecks and achieve significant operational improvements. It ultimately increases the throughput and quality.

Zero Defects – It focuses on getting the right product at the first time rather than devoting extra time in fixing poor-quality products. Zero Defects system ensures that production system will be defect free and no defect is acceptable. It also encourages people to do things right the first time.

Overall Equipment Effectiveness (OEE): A number of management techniques has been developed over the years to manage the manufacturing. Waste of time, energy, money, and overworked staff are common issues faced by any manufacturing company. Overall equipment effectiveness (OEE) is a novel technique to measure the effectiveness of machine. OEE measures of the performance of a machine or production line and is not concerned with labour cost, so can be used to compare machine performance in a wide variety of situations. An OEE of 85% is thought to be World Class manufacturing.

Causes of Reduction in OEE: Following are some causes which affect the loss of OEE in the machine:

a) Equipment failure b) Reduced speed c) Set-up and adjustment d) Idling and minor stoppages 6) Reduced yield e) Product rejects

Measurement of OEE: OEE measurement tool was developed from the TPM concept launched by Nakajima (1988). The goal of TPM is to achieve zero breakdown and zero defects related to equipment. OEE calculation is based on a composite of the six big losses of equipment broken down into three main areas; Availability, performance and quality. It is a very simple calculation:

Availability: Availability takes into account all events that stop planned production long enough where it makes sense to track a reason for being down (typically several minutes). Availability is calculated as the ratio of Run Time to Planned Production Time

Performance: Performance takes into account anything that causes the manufacturing process to run at less than the maximum possible speed when it is running (including both Slow Cycles and Small Stops). Performance is the ratio of Net Run Time to Run Time.

Quality: Quality takes into account manufactured products that do not meet quality standards, including product that need rework.

Benefits of Lean implementation

- Better quality performance and less defects and rework
- Decrease in machine and process breakdowns and short stoppages.
- Inventory control.
- High levels of stock turnover.
- Less space required.
- Higher efficiencies, more output per man hour
- Increase in customer satisfaction.
- Decrease in overhead costs
- Improved employee morale and involvement.
- Improved supplier relations.
- Higher profits and increased business

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93. FOODS AND NUTRITION 16040

Therapeutic Diet in Diabetes

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A therapeutic diet in diabetes (diabetes diet) is a nutritional guide for people with diabetes that helps them decide when to consume meals and snacks as well as what type of foods to eat. As we all know that diabetes is raised sugar level in urine and then in blood. Sugar, if we think as a lay person implies table sugar or processed sugar, carbohydrates as starch. There is no one

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predetermined diabetes diet that works for all people with diabetes. The motive of any diabetic diet is to aquire and maintains good control over the disease, including control of blood glucose and cholesterol levels as well as to maintaining a healthy weight and appropriate nutrition.

The most important implication for diabetic patient is to have a regular check-up of his/ her blood glucose levels. One must prepare a chart and consult a doctor whether the blood glucose levels could be managed by diet alone or other medications are required. Some may have to inject insulin in severe conditions or where insulin secretion is really low.

Two important aspects to control diabetes are modified diet and physiological activities. Taking diet into consideration we have to remember 3 simple rules regarding this.

1. What to eat?
2. How to eat?
3. When to eat?

If a patient emphasise on above said questions conditions can be controlled properly.

What to Eat?

Diet should consist of low carbohydrates and healthy foods. Let us know what are the low carb foods

Healthy eating includes eating a wide variety of foods including:

- Vegetables- Bottle gourd, ridge gourd, pointed gourd, bitter gourd, Cabbage, Spinach, corns Tomatoes, cauliflower, cucumber, mushrooms, green beans, and all green leafy vegetables
- Whole grains- Ragi, Bajra, Chana, jowar, brown rice, wheat with bran, quinoa and oats.
- Fruits-Papaya, Guava, apple, pear, plum, Cherries, berries, pomegranate etc
- Non-fat dairy products- skimmed milk and products
- Beans
- Lean meats, poultry, and fish

Take Care of

- Limit fat to 25%-35% of total daily calories, getting no more than 7% of your daily calories from saturated fat, 10% or less saturated fats, and up to 20% from monounsaturated fats (like plant oils or nuts).
- Carbohydrates should account for no more than 50%-60% of your daily calories.
- Try to eat 20-30 grams of fiber each day.
- Allow 15%-20% of your daily calories for protein.
- Limit cholesterol to 200 milligrams per day.

High glycemic index foods include and they should be avoided:

- White bread, bagels
- Short-grain white rice
- Corn flakes or puffed rice cereal
- Russet potatoes
- Saltine crackers, pretzels, rice cakes
- Pumpkin
- Melons
- Pineapple
- Popcorn

The number of carbohydrates (carbs), fats, and proteins in your plan will depend upon the ideal number of calories you should consume each day. Your age, gender, the amount of exercise you get, and your activity level affect the number of calories you need to eat in order to gain, lose, or maintain a healthy weight.

How to Eat?

Eating pattern is of great importance while following any diet. Small meals are recommended in diabetes. Main meals should not be heavy. Instead of 4 chapatis in main meal try to eat 2 chapatis with salad, pulses, vegetables and low fat curd. Fruits should be included in mid snacks. And then again, fruits should be consumed in limited quantity say 100 to 150 gm per serving and the serving should be 1 at one snack time. Small portion triggers the insulin secretion which in result decreases the level of glucose in blood.

When to Eat?

A meal plan of diabetic patient should be divided into 6 parts-

1. Morning-Water+ Almonds (5 soaked)+Walnut (2)
2. Breakfast
   a) Milk (200ml)/ Curd (100gm)/Buttermilk (250ml)/Paneer (30gm)/Egg white (2)
   b) Fruit (one medium sized)
   c) Upma/ daliya/ Poha with vegetables/ 2 chapati/ one stuffed roti
3. Mid-morning- Coconut water/ Buttermilk/ lemon water/ roasted chna/ diet namkeen/ murmure/multigrain buiscuit/sprout chat/Fruit
4. Lunch- Salad (1 plate)/ Chapati (2)/Dal (half bowl)/ vegetable (one bowl)
5. Evening snack- same as mid-morning
6. Dinner- Salad (1 plate)/ Chapati (2)/ vegetable (one bowl)
7. Sleep time- Skimmed milk

Physical Activities: It is already proved in many studies that performing any kind of physical activity like yoga/ walking/ cycling/ swimming etc increases the metabolism and catalyse the secretion of insulin in body. Any form of exercise is recommended in morning or evening when the stomach is little empty. It should not be done in absolute empty stomach.

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94. HUMAN HEALTH 15991

Effect of Education on Women's Health

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Education is a 'powerful determinant of an individual's life choices and opportunities'. It enhances human capacity and capability to exercise choices at the social, economic and political areas. Exercise of choices may be to become creative, productive and empowered or to enjoy self-respect with dignity.

Education enhances a person's knowledge about the immediate environment, understanding of various socio-economic and political issues, and capacity to comprehend and take decision concerning her in the society.

Education is the starting point for women's advancement in many different fields

A Woman Who has been to School for a Few Years is more likely

- To marry at a later age (4yrs later than an uneducated women on average)
- To have smaller family & to use modern family planning methods
- To seek pre-natal care & have a trained attendant at child birth
- To have healthy children and less likely to have children who die in infancy and early childhood
- To make use of health services in generally
- To have larger earning capacity
- To have healthy children and less likely to have children who die in infancy and early childhood

Environmental Factors Influencing Women's Health

High Literacy Rates Correlates with

- Low total fertility rate (TFR)
- Low infant mortality rate (IMR)
- High life expectancy
- Low maternal mortality rate (MMR)
- Higher mean age at marriage
- High rate of acceptance of family welfare methods

Female Literacy and fertility

- Significant co-relation between spread of female literacy and decline of fertility has been observed throughout the country although there are regions where fertility has declined despite prevalence of illiteracy.
- A lot of gains have been made in the recent years in female literacy. The rate of growth of female literacy has outpaced that of males.
- The gap between male and female literacy is still as wide as 22 percentage points.

Schemes for Improving Education and in turn the Health of Women

- Sarva shiksha abhiyaan
  - National Program for Education of Girls at Elementary level
  - Shiksha Karmi Project
- Mid day meal
- Mahila samakya
- Bal bhavan (drop outs)
- National Literacy Mission (15-35yrs)
- Kasturba Gandhi Balika Vidyalaya

Schemes for Improving the Health of Women

- Reproductive and Child Health phase 2
- National Rural Health Misson
- Accrededited Socioal Health Activist (ASHA)
- Janani Suraksha yojana
- Surakshita Madilu
- Family Planning Program
- Pre-natal Diagnostic Techniques (Regulation and Prevention of misuse) Act
- MTP for Safe abortions

Significance of Education

- Role of women goes much beyond home and upbringing of children
- Equal partnership must be allowed to continue in the fight against hunger, poverty, ignorance and health
- It leads to healthy, social, economic and political changes that are needed to improve the position of women
- Women would be able to utilize their full

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potential to play constructive roles in the family and community

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95. DAIRY SCIENCE 15877

Microfluidization: New Concept in Dairy Industry

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INTRODUCTION: Microfluidization is high pressure homogenization technology which facilitates reduction of uniform size of fat globule, cell disruption & bacterial destruction in fluids. Microfluidization technology is very unique type of high pressure homogenization in order to produce spherical particles that can act as fat substitute (Paquin *et al* 1992). Microfluidization homogenization results in fat globules with a narrow size distribution and smaller average fat globules size than the usually found using traditional valve homogenizer. It is new alternative to produce fat substitute which give spherically shaped particles from a complete aggregated protein (Whey protein) dispersion into small spherical shaped to mimic the ball bearing effect of fat particles in food.

Uses of Microfludization

1. Microfluidization can be used to extend shelf life of product such as cream, liquers and infant formulae by producing fine emulsion (Particle size 0.1 micron) compared with conventional homogenizer.
2. New technology used in ice cream industry and it allow optimal emulsifier concentration around 1% at pressure of 1200 bar
3. Decrease in the rennet coagulation time and curd firming rate in the cheese
4. Manufacture of low fat cheese with desired texture
5. Microfluidization mostly used for the manufacturing of low fat frozen desserts
6. Microfluidization produces low fat ice cream that usually had a slower melt down without affecting sensory properties

Applications of microfluidization in dairy

Sample description	Pressure (psi)	pass	Results
Dairy based	10,000	3	Heated to 60^0 C for
Emulsion			processing then was cooled to 45^0 C. Particle size reduced from 0.91 micron m to 0.13 micron m.
Vitamins Filtered Whey protein	5,000	1&3	Particle size reduced to 10 micron m 1 pass and between 2 to 5 micron m in 3 pass
Cheese slurry, 10% solids	10,000	1-3	Particle size reduced from 100 micron m down to 30 micron m
Low fat ice cream Proprietary Formulation	18,200	1	Particle size from 0.42 micron m reduced to 0.23 micron m. Moth feel was smother and creamier

Conclusion

1. Microfluidization gives fat globule particle size about 25% smaller than that found with conventional homogenization.
2. There is no major change in fat globule size over the storage period.
3. Microfluidization can be used for fat substitute production
4. Microfluidization can offer better testing low fat ingredients since finer emulsions closely immediate the mouth fill of full fat products.
5. It is possible to design a pasteurizer
6. Microfluidizer system that would inactivate most bacterial spores in dairy foods without the extreme heat treatment currently required in commercial processing operations.

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Role of Natural Preservatives in Dairy Products

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INTRODUCTION: Preservative is a substance that is added to products such as foods, pharmaceuticals, paints biological samples, wood, etc. to prevent decomposition by microbial growth or by undesirable chemical changes."Natural preservatives are the substance or preservatives that are obtained naturally."

Natural Preservatives

1. Salt
2. Sugar
3. Honey
4. Desirable microbes (Fermentation)

1. Salt

- Sodium chloride or table salt is an ingredient used as natural preservative.
- Salting draws out water and tying up the water within, making it unavailable for chemical that causes decay.
- High concentration of salt also interferes with the replication of bacteria.
- Salt is used to regulate and aid the process of fermentation.
- It has antibacterial property and also prevents the growth of moulds.
- It is used in preserving of traditional products like chhanna, paneer, chass, mathha, different type of cheese.
- Salt is used in frozen dairy products like Kulfi.
- Salt is used for preparing brine solution for paneer.

2. Sugar

- Sugar is used as natural preservatives in traditional dairy product.
- Bacteria involved in environment where they cause the deterioration of product.
- High sugar concentration cause bacterium to loss water by osmosis and it does not have any cellular machinery to pump it back in against osmotic gradient.
- Without enough water, bacteria can't grow and divide.
- Hence this reduces the spoilage of traditional dairy products and hence acts as preservatives.
- Also sugar enriches growth of healthy bacteria that prevent bacteria that will make you sick from growing.
- Almost many of the traditional dairy products like burfi, pedha, gulabjamun are containing lot of sugar.

3. Honey

- Since ancient times honey is used as preservative.
- If high concentration of sugar forces are water out of yeast and bacteria cells that could otherwise contaminate food.
- It acts same as sugar and can be used to preserve as an alternative for sugar.
- A study indicated that a concentration dependent inhibition of bacterial growth in comparison with catalase positive strains, highlighted role of hydrogen peroxide.
- Due to bactericidal property of hydrogen peroxide and its preservative nature, honey is chiefly a various combination of sugars and hydrogen peroxide can be used as preservative of milk sample.

4. Various Desirable Microbes

- Various acid forming bacteria like *Lactobacillus spp.* and *Streptococcus spp.* can be used.
- Foods like cheese, dahi, shrikhand, etc can be preserved by this.
- These micro organisms keep pathogens in check by creating an environment toxic for themselves and other micro organisms by providing acid and alcohol.
- Whereas acid produced itself act as preservative.
- This method used to create specific controlled conditions that will support desirable organism that produce food fit for human consumption.

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97. VETERINATY 16112

Optimization of Puberty: Initial Step for Enhancing the Profitability of Stakeholder

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INTRODUCTION: Puberty in heifers is characterized by a decrease in the steroid feedback mechanism and an increase in LH concentration, which result in the first ovulation followed by a short estrous cycle and the onset of normal regular cycles thereafter. It is the postnatal age, when gonads produce gametes and sex hormones in sufficient quantities to enable an animal to reproduce. It is a gradual process of maturation of the endocrine and reproductive systems enabling the animal for successful reproduction. Hypothalamus plays a very important role in regulation of onset of puberty. The onset of Puberty with initiation of normal estrous cycles involves maturation of the hypothalamic-pituitary-ovarian axis, which depends on various physiological and endocrinological factors like species, genotype, adequate body weight, age, nutrition, environment, photoperiod, growth rate and GH, IGF-1, leptin, NPY, and energy status respectively. Age at puberty is one of the significant traits that affects the productive life of the animal and thereby profitability to the farmer.

Neuroendocrine mechanisms underlying puberty: The onset of puberty could be explained by the concept of "gonadostat hypothesis" which states that prior to puberty; the small amount of oestrogens produced from the growing follicles inhibits the surge center of hypothalamus and the tonic secretion of LH prior to puberty was not sufficient for the maturation of follicles. However as the puberty is advanced, the increased LH pulses augments the follicular development with a subsequent increase in production of 17β-estradiol. This increased production of 17β-estradiol was associated with a decreased sensitivity of the tonic center of hypothalamus (ventral) due to fall in oestrogen receptors with a simultaneous increased sensitivity of the surge centre (anterior). This depicts the positive feedback effect of increasing levels of oestrogens produced by the growing follicles on the hypothalamus at the pubertal onset. Stimulation of surge centre releases LH in a surge fashion triggering follicular maturation. Maturation of the hypothalamo –pituitary-ovarian axis was dependent on the adequate body weight and age. Nutrition, environment, species, genetics, endocrine and paracrine factors affect the age at puberty. Integrated efforts of modulation of GnRH and NPY levels on the body weight and earlier pubertal onset through feed across different species was reported. The significant role of feed and GH in the hastening of puberty was reported in heifers. The factors involved in the regulation of the endocrine maturation are obligatory for the normal cycling activity. This is dependent on the sufficient somatic growth of animal and pubertal age. The manipulation of nutrition and hormones supplemented to animals results into early attainment of puberty weight. The attainment of puberty weight is more important than age because weight play major role in successful conception of heifers than age of the heifers. This early puberty leads to increase in the productive life of the animals and income of stakeholder in terms of extra milk production and atleast one more calves in the productive life of animals.

Factors Affecting Puberty

Nutrition: Nutrients particularly energy and protein are essential to optimize reproduction. Pubertal age in heifers is determined by the nutritional status during early sexual maturity period. Malnourished females lack ovarian activity owing to the suppression of luteinizing hormone in a pulsatile fashion. LH pulse generating system in the hypothalamus and its pre pubertal rise is influenced by the plane of nutrition. Nutrition effects synthesis and release of GnRH, FSH, LH and GH due to its action on hypothalamus and anterior pituitary respectively. The Ovarian follicular growth and steroid synthesis are influenced by nutrition. Acute /chronic dietary restriction results in a gradual reduction of growth rate of dominant follicle.

Environment: Pubertal onset in beef heifers was dependent on the birth time. Heifers born in autumn attain puberty earlier compared to spring-born heifers. Autumn and winter environments during first six months of life accelerate the pubertal onset while the same conditions after six months delay it.

Age and body weight: The effect of age and weight on the pubertal onset differs among various breeds. The body weight of heifers at puberty was 40% to 60% of adult. Better growth rates decrease the negative feedback of estradiol

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on LH secretion and thus stimulate the follicular growth.

Photoperiod: It is the duration of daily light exposure. There are two common time divisions of photoperiod namely long-day photoperiod (16 hours of light and 8 hours of dark) and short-day photoperiod (8 hours of light and 16 hours of dark). Heifers born in autumn attain puberty at younger ages than do spring-born heifers. The role of melatonin in transduction of light stimuli into neuroendocrine signals influencing LH secretion was proposed. The outcome of long day photoperiod on feed efficiency followed by early breeding activity was suggested.

Endocrine Factors Affecting Puberty

1. **Leptin:** It is produced primarily by the adipose tissue with other sites being stomach, skeletal muscle, fetal cartilage, pituitary, mammary tissue and placenta. It signals nutritional status of the organism to the central reproductive axis. An increase in the circulatory leptin at the pubertal onset was reported in rodents and heifers [20] and it play role in the activation of GnRH neurons via hypothalamic proopiomelanocortin system (Amstalden et al., 2014).
2. **Growth hormone:** Delayed puberty due to declined LH pulses was attributed for the nutrient restriction. This was correlated with changes in mean concentration and amplitude of GH pulses just before puberty. Pubertal onset was positively associated with circulatory IGF-I independent of growth rate, leptin concentrations, and body fat.
3. **Insulin:** The role of Insulin in setting pace for the pubertal onset by monitoring the nutritional status was proposed. However, its role through IGF-I by an increased LHRH levels was proposed. It was proposed that circulatory IGF-I is used as a means for studying interactions between nutrition and reproduction and as an ancillary test for high reproductive potential in cattle.
4. **NPY:** The role of NPY in the inhibition of GnRH and subsequent LH release regardless the steroidal milieu was proposed. This was correlated with a fastened puberty in calves whose metabolic status was favorable with increased leptin and decreased NPY levels.
5. **Pineal gland:** It secretes the hormone melatonin. Its activity is dependent on the photoperiod. It enhances the early attainment of puberty irrespective of increase in body weight and ADG.

CONCLUSION: Age at which the pubertal onset occurs is the most important factor that influences the reproductive as well productive life of an animal. The physical factors body weight of approximately 60% of the adult along with age is the most important factors that determine the puberty. Therefore a well balanced feed from weaning period to puberty should be given to ensure proper growth and maturity. There are a number of endocrine and paracrine factors at the hypothalamic level that essentially influence puberty. The concerted effects of feed/nutrition mediated via various hormones can be employed to early onset of puberty and utilized for the benefit of the mankind.

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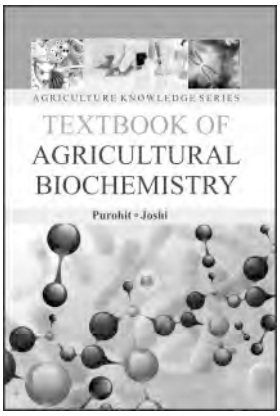

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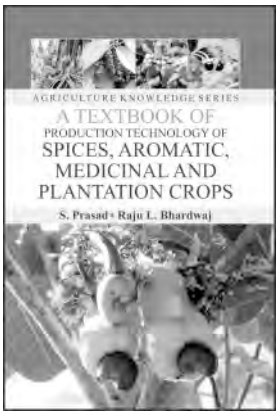

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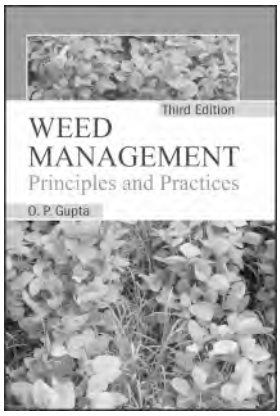

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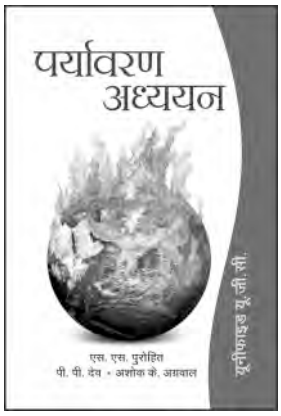

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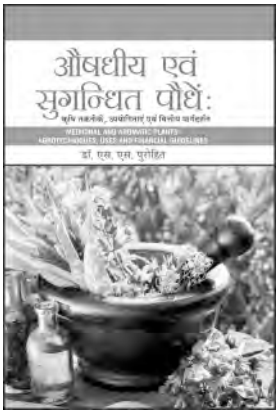

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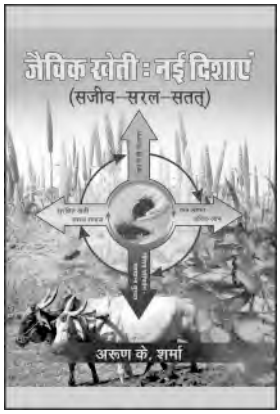

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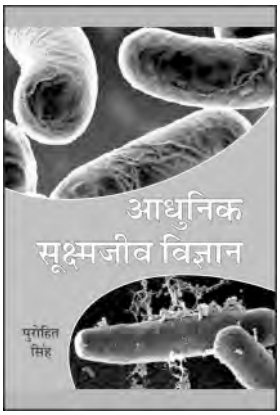

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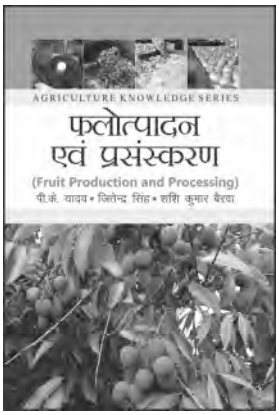

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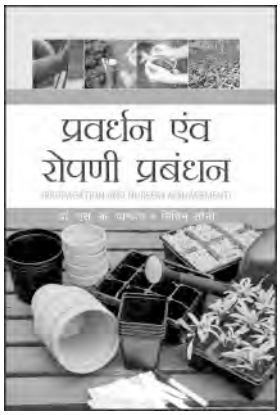

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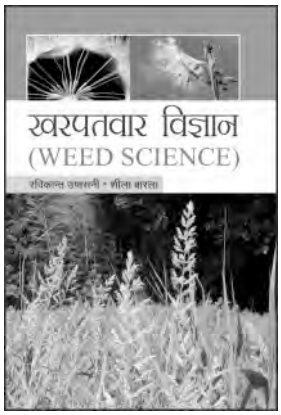

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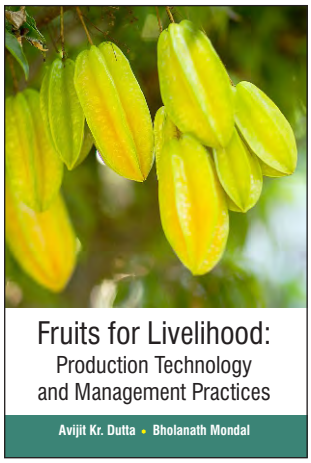

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