Readers Shelf

VOLUME NO:19	ISSUE NO: 05	February 2023
No. of Pages in this issue		44 pages
Date of Posting: 10-11 at RMS, Jodhpur		

Editorial Office

J.V. Publishing House
15, Gajendra Nagar, Near Old FCI Godown
Shobhawaton Ki Dhani, Pal Road, Jodhpur-5

Website: www.readersshelf.com
Email: info@readersshelf.com,readersshelf@gmail.com
Typesetting: Ankita, Jodhpur
Printed by: Manish Kumar, ManakOffset, Jodhpur

Published by
Smt. Neeta Vyas

For J.V. Publishing House,
Jodhpur
RNI No.: RAJENG/04/14700
ISSN No.:2321-7405

Subscription Charges: Single Copy: Rs.50.00
Annual Subscription: Individual: Rs.**500.00**
Annual subscription: Institution:Rs.**900.00**

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Kisan Drone in Agriculture

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Drones are also called Unmanned Aerial Vehicles (UAVs) which have been trading since around the early 1980s. However, the use of drones has never gained much popularity as it has nowadays. From then to the present time, drone solutions started and now the benefits of drones are giving a tremendous way. In the 2022 budget, the Finance Minister of India stated that "There is a need to introduce the Kisan Drone as a service model in India especially in relation to the agriculture sector. It will include the use of drones in spraying of insecticides, pesticides, and nutrients etc, digitize land records and to monitor the crop health.

Drones are the ground-breaking latest technologies introduced in every sector. This is looking to give the agricultural industry, a big technological makeover with proper planning and real time data collecting and processing. The selection of correct drone for agricultural operation needs can deliver unmatched benefits in terms of precision agriculture, data and monitoring, general monitoring, day-to-day agricultural tasks like as pesticides, herbicides, weedicides and fertilizers. Drones in agriculture, provides new apparatus for monitoring and managing of soils as well as irrigation.

Agriculture sector is the most promising sector, dealing with the lot of problems now a day's one of the innumerable problems is labour unavailability for farming. Other major problems or difficulties are extreme weather events, inadequate amount and inefficient application of fertilizer, infection, diseases, allergies and other health problems due to chemical application like fungicide, pesticide, insecticide etc., or insect bite. As a result, farmers are turning to high-level drone technology to help remedy these problems, and provide fast and efficient solutions. Drones can be used to collect data related to crop yields, livestock health, soil quality, nutrient measurements, weather and rainfall results, and more. This data can then be used to get a more accurate map of any existing issues, as well as create solutions based upon extremely reliable data.

Technological progress made in monitoring, supervision, management and control systems have opened a new era in which many traditional agricultural practices are outdated. Their replacement with new technologies falls into the "precision farming" category, which translates into applying the agronomic variables in the right place, at the right time and with precise control over the amount of material inputs or crop production.

"In the current milieu, use of sustainable information and communication technology in agriculture in not an option. It is a necessity."

"Gerard Sylvester"

Drones for Agriculture

The adoption of modern technologies in agriculture, such as the use of drones or unmanned aerial vehicles (UAVs) can significantly enhance risk and damage assessments and revolutionize the way we prepare for and respond to disasters that affect the livelihoods of vulnerable farmers and fishers

and the country's food security. Drones are transforming how agriculture and farming are done. By implementing drone technology, farms and agriculture businesses can improve crop yields, save time, and make land management decisions that'll improve long-term success.

Applications of Drone in Agriculture

1. Soil Analysis

By obtaining 3D maps of existing soil, relevant users can monitor the soil quality, nutrient management, or soil dead zones. This information can help farmers determine the most effective patterns for planting, managing crops, soil and more. This will also help to better utilize water resources, and more effectively manage crop nutrient levels.

2. Drone Spraying in Crop

Crops require regular fertilization and spraying in order to maintain high yields. Traditionally this was done manually as a time consuming process. These methods are not only inefficient and tedious, but they can be very costly as well. Using drones for crop spraying nutrients, fungicides, insecticides, herbicides etc., is much safer and cost effective. Drones can even be operated completely autonomously and programmed to run on specific schedules and routes.

3. Crop Mapping and Surveying

The great advantages of drone technology are the effectiveness of large-scale crop and acreage monitoring. With drone mapping and surveying, technology decisions can now be made based on real-time data, not outdated imagery. With agriculture drones we will be able to collect information like overall crop and plant health, land distribution based on crop type, crop life cycle, detailed GPS maps of current crop area.

4. Irrigation Monitoring and Management

Drones that are equipped with thermal cameras can help to spot irrigation issues, or areas that are receiving too little or excessive moisture. With this information, crops can be better laid out to maximize drainage, adhere to natural land runoff, and avoid water pooling, which can damage sensitive crops. Water and irrigation issues are not only costly but can ruin crop yields as well. With drone surveying, these issues can be spotted before they become troublesome.

5. Livestock Monitoring

Some drones are equipped with thermal imaging cameras that enable a single pilot to manage and monitor livestock. This allows farmers to keep track of livestock a much greater frequency and with less time. The drone operator can quickly check in on herd to see if there are any injured or missing livestock, as well as see livestock who are giving birth, which can be a huge advantage for some farm owners.

Drone technology is a phenomenal innovation that continues to have far-reaching effects across today's society, transforming our lives and the way we do business. The agricultural industry seems to have embraced drone technology with open arms, using these advanced tools to transform modern farming. From crop monitoring to planting, crop spraying, irrigation mapping, livestock management and many operations drones are extremely useful.

There are some limitations with this technology in the field of agriculture:

1. Required Skilled Workers
2. Knowledge of Drones and Software's
3. Weather Dependency
4. Battery dependent
5. Short Time of Fights
6. Highly expensive

2. AGRICULTURE

Transcriptomics – An introduction

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Introduction

Transcriptomics technologies are the techniques used to study an organism's transcriptome, the sum of all of its RNA transcripts. The information content of an organism is recorded in the DNA of its genome and expressed through transcription. Here, mRNA serves as a transient intermediary molecule in the information network, whilst non-coding RNAs perform additional diverse functions. A transcriptome captures a snapshot in time of the total transcripts present in a cell. Transcriptomics technologies provide a broad account of which cellular processes are active and which are dormant. A major challenge in molecular biology is to understand how a single genome gives rise to a variety of cells. Another is how gene expression is regulated.

The first attempts to study whole transcriptomes began in the early 1990s. Subsequent technological advances since the late 1990s have repeatedly transformed the field and made transcriptomics a widespread discipline in biological sciences. There are two key contemporary techniques in the field: microarrays, which quantify a set of predetermined sequences, and RNA-Seq, which uses high-throughput sequencing to record all transcripts. As the technology improved, the volume of data produced by each transcriptome experiment increased. As a result, data analysis methods have steadily been adapted to more accurately and efficiently analyse increasingly large volumes of data. Transcriptome databases getting bigger and more useful as transcriptomes continue to be collected and shared by researchers. It would be almost impossible to interpret the information contained in a transcriptome without the knowledge of previous experiments.

Measuring the expression of an organism's genes in different tissues or conditions, or at different times, gives information on how genes are regulated and reveals details of an organism's biology. It can also be used to infer the functions of previously unannotated genes. Transcriptome analysis has enabled the study of how gene expression changes in different organisms and has been instrumental in the understanding of human disease. An analysis of gene expression in its entirety allows detection of broad coordinated trends which cannot be discerned by more targeted assays.

Before Transcriptomics

Studies of individual transcripts were being performed several decades before any transcriptomics approaches were available. Libraries of silkmoth mRNA transcripts were collected and converted to complementary DNA (cDNA) for storage using reverse transcriptase in the late 1970s. In the 1980s, low-throughput sequencing using the Sanger method was used to sequence random transcripts, producing expressed sequence tags (ESTs). The Sanger method of sequencing was predominant until the advent of high-throughput methods such as sequencing by synthesis (Solexa/Illumina). ESTs came to prominence during the 1990s as an efficient method to determine the gene content f an organism without sequencing the entire genome. Amounts of individual transcripts were quantified using Northern blotting, nylon membrane arrays, and later reverse transcriptase quantitative PCR (RT-qPCR) methods, but these methods are laborious and can only capture a tiny subsection of a transcriptome. Consequently, the manner in which a transcriptome as a whole is expressed and regulated remained unknown until higher-throughput techniques were developed.

Application

The word "transcriptome" was first used in the 1990s. In 1995, one of the earliest sequencing-based transcriptomic methods was developed, serial analysis of gene

expression (SAGE), which worked by Sanger sequencing of concatenated random transcript fragments. Transcripts were quantified by matching the fragments to known genes. A variant of SAGE using high-throughput sequencing techniques, called digital gene expression analysis, was also briefly used. However, these methods were largely overtaken by high throughput sequencing of entire transcripts, which provided additional information on transcript structure such as splice variants.

Development of contemporary techniques

Comparison of contemporary methods

	RNA-Seq	Microarray
Throughput	1 day to 1 week per experiment	1–2 days per experiment
Input RNA amount	Low ~ 1 ng total RNA	High ~ 1 μg mRNA
Labour intensity	High (sample preparation and data analysis)	Low
Prior knowledge	None required, although a reference genome/transcriptome sequence is useful	Reference genome/transcriptome is required for design of probes
Quantitation accuracy	~90% (limited by sequence coverage)	>90% (limited by fluorescence detection accuracy)
Sequence resolution	RNA-Seq can detect SNPs and splice variants (limited by sequencing accuracy of ~99%)	Specialised arrays can detect mRNA splice variants (limited by probe design and cross-hybridisation)
Sensitivity	1 transcript per million (approximate, limited by sequence coverage)	1 transcript per thousand (approximate, limited by fluorescence detection)
Dynamic range	100,000:1 (limited by sequence coverage)	1,000:1 (limited by fluorescence saturation)
Technical reproducibility	>99%	>99%

The dominant contemporary techniques, microarrays and RNA-Seq, were developed in the mid-1990s avnd 2000s. Microarrays that measure the abundances of a defined set of transcripts via their hybridisation to an array of complementary probes were first published in 1995. Microarray technology allowed the assay of thousands of transcripts simultaneously and at a greatly reduced cost per gene and labour saving. Both spotted oligonucleotide arrays and Affymetrix high-density arrays were the method of choice for transcriptional profiling until the late 2000s. Over this period, a range of microarrays were produced to cover known genes in model or economically important organisms. Advances in design and manufacture of arrays improved the specificity of probes and allowed more genes to be tested on a single array. Advances in fluorescence detection increased the sensitivity and measurement accuracy for low abundance transcripts.

Isolation of RNA

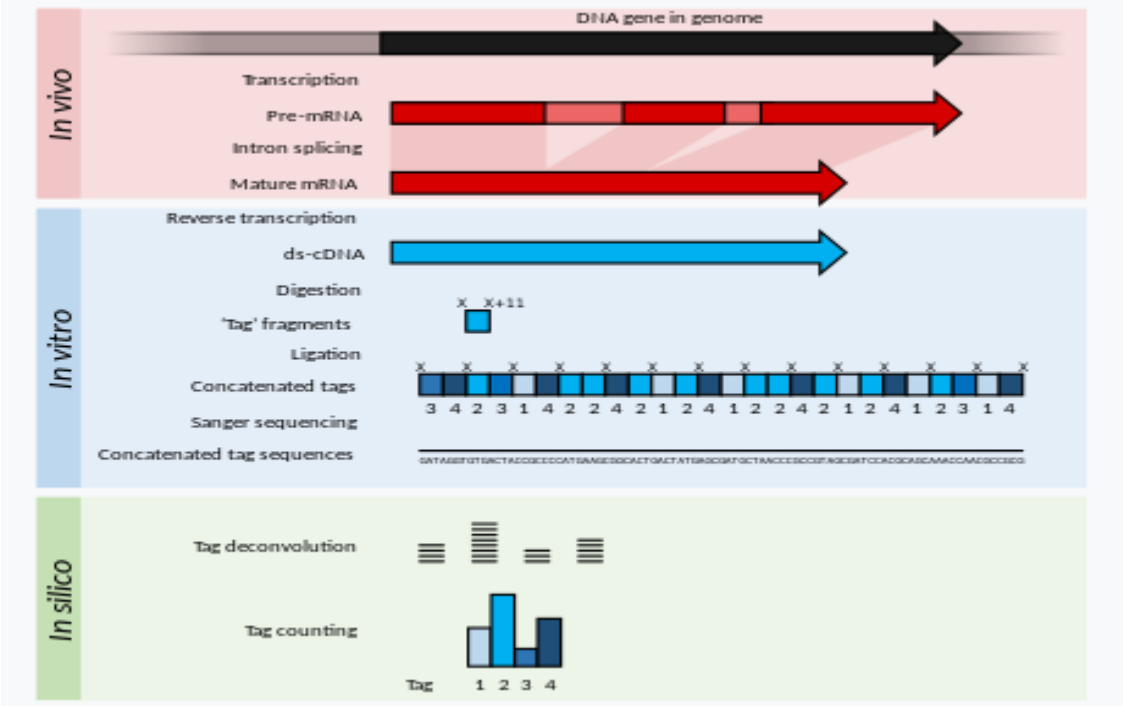
All transcriptomic methods require RNA to first be isolated from the experimental organism before transcripts can be recorded. Although biological systems are incredibly diverse, RNA extraction techniques are broadly similar and involve mechanical disruption of cells or tissues, disruption of RNase with chaotropic salts, disruption of macromolecules and nucleotide complexes, separation of RNA from undesired biomolecules including DNA, and concentration of the RNA via precipitation from solution or elution from a solid matrix. Isolated RNA may additionally be treated with DNase to digest any traces of DNA. It is necessary to enrich

messenger RNA as total RNA extracts are typically 98% ribosomal RNA. Enrichment for transcripts can be performed by poly-A affinity methods or by depletion of ribosomal RNA using sequence-specific probes. Degraded RNA may affect downstream results; for example, mRNA enrichment from degraded samples will result in the depletion of 5' mRNA ends and an uneven signal across the length of a transcript. Snap-freezing of tissue prior to RNA isolation is typical, and care is taken to reduce exposure to RNase enzymes once isolation is complete.

Expressed Sequence Tags

An expressed sequence tag (EST) is a short nucleotide sequence generated from a single RNA transcript. RNA is first copied as complementary DNA(cDNA) by a reverse transcriptase enzyme before the resultant cDNA is sequenced. Because ESTs can be collected without prior knowledge of the organism from which they come, they can be made from mixtures of organisms or environmental samples. Although higher-throughput methods are now used, EST libraries commonly provided sequence information for early microarray designs; for example, a barley microarray was designed from 350,000 previously sequenced ESTs.

Serial and cap analysis of gene expression (SAGE/CAGE)



Serial Analysis of Gene Expression (SAGE)

Within the organisms, genes are transcribed and spliced (in eukaryotes) to produce mature mRNA transcripts (red). The mRNA is extracted from the organism, and reverse transcriptase is used to copy the mRNA into stable double-stranded–cDNA (ds-cDNA; blue). In SAGE, the ds-cDNA is digested by restriction enzymes (at location 'X' and 'X'+11) to produce 11-nucleotide "tag" fragments. These tags are concatenated and sequenced using long-read Sanger sequencing (different shades of blue indicate tags from different genes). The sequences are deconvoluted to find the frequency of each tag. The tag frequency can be used to report on transcription of the gene that the tag came from.

Serial analysis of gene expression (SAGE) was a development of EST methodology to increase the throughput of the tags generated

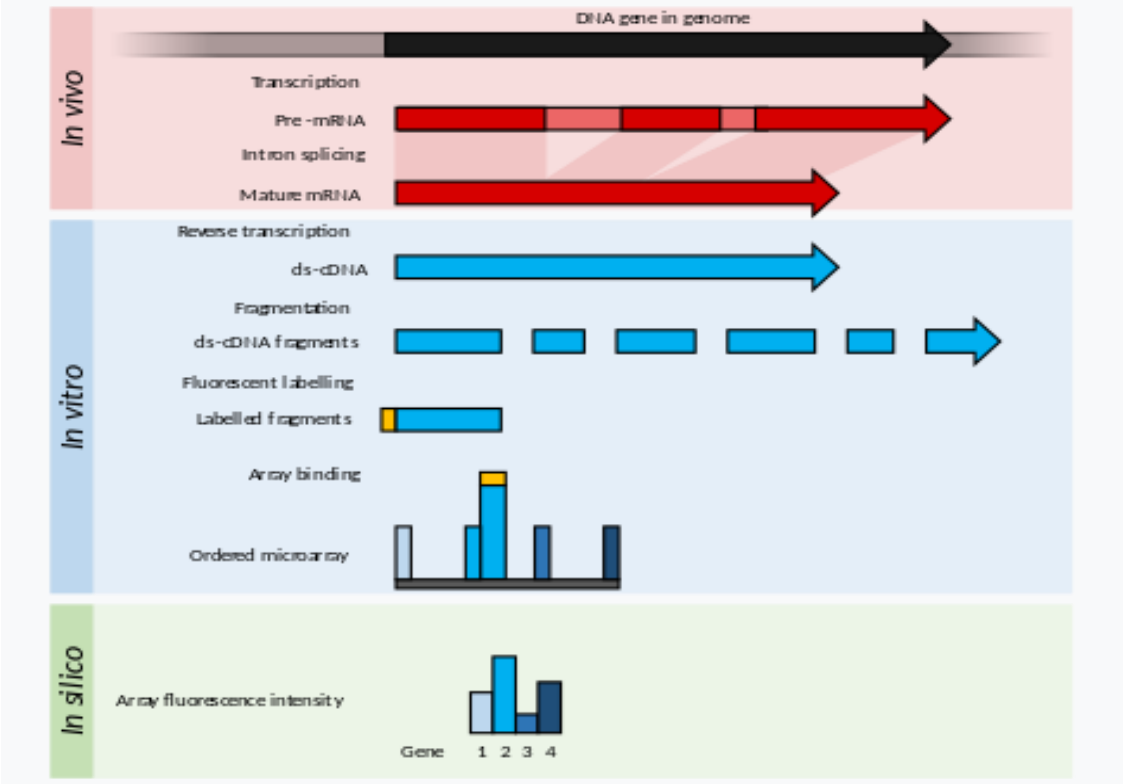
ISSN No.:2321-7405

and allow some quantitation of transcript abundance.cDNA is generated from the RNA but is then digested into 11bp "tag" fragments using restriction enzymes that cut DNA at a specific sequence, and 11 base pairs along from that sequence. These cDNA tags are then joined head-to-tail into long strands (>500 bp) and sequenced using low-throughput, but long read-length methods such as Sanger sequencing. The sequences are then divided back into their original 11 bp tags using computer software in a process called deconvolution. If a high-quality reference genome is available, these tags may be matched to their corresponding gene in the genome. If a reference genome is unavailable, the tags can be directly used as diagnostic markers if found to be differentially expressed in a disease state.

The cap analysis gene expression (CAGE) method is a variant of SAGE that sequences tags from the 5' end of an mRNA transcript only. Therefore, the transcriptional start site of genes can be identified when the tags are aligned to a reference genome. Identifying gene start sites is of use for promoter analysis and for the cloning of full-length cDNAs.

SAGE and CAGE methods produce information on more genes than was possible when sequencing single ESTs, but sample preparation and data analysis are typically more labour-intensive.

Microarrays



Summary of DNA Microarrays

Within the organisms, genes are transcribed and spliced (in eukaryotes) to produce mature mRNA transcripts (red). The mRNA is extracted from the organism and reverse transcriptase is used to copy the mRNA into stable ds-cDNA (blue). In microarrays, the ds-cDNA is fragmented and fluorescently labelled (orange). The labelled fragments bind to an ordered array of complementary oligonucleotides, and measurement of

fluorescent intensity across the array indicates the abundance of a predetermined set of sequences. These sequences are typically specifically chosen to report on genes of interest within the organism's genome.

Principles and Advances

Microarrays usually consist of a grid of short nucleotide oligomers, known as "probes", typically arranged on a glass slide. Transcript abundance is determined by hybridisation of fluorescently labelled transcripts to these probes. The fluorescence intensity at each probe location on the array indicates the transcript abundance for that probe sequence. Groups of probes designed to measure the same transcript (i.e., hybridizing a specific transcript in different positions) are usually referred to as "probesets".Microarrays require some genomic knowledge from the organism of interest, for example, in the form of an annotated genome sequence, or a library of ESTs that can be used to generate the probes for the array.

3. AGRICULTURAL ENGINEERING

Application of Drone in Agriculture

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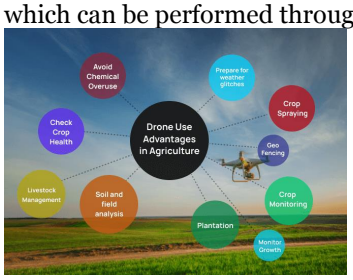
The use of drone is a modern technology in Agriculture aims at making production more efficient through precise spraying of pesticide and crop nutrients. A drone, in technological terms, is an unmanned aircraft. They are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UASes) weighing up to 2-20 kg. Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems, working in conjunction with onboard sensors and GPS. Concept of Drones have come into existence for the first time in 1849, when Austria attacked Venice with unmanned balloons laden with explosives.

Drones have a wide range of applications, including photography, agriculture, and military applications, Drones have a power source, such as a battery or fuel, which allows them to fly. The frame of a drone is typically made of light weight, composite materials. Drones require a controller, which can be launched, navigated, and landed remotely by an operator. Wi-Fi and radio waves are used by controllers to communicate with the drone. Component of agricultural drones includes Frames, Controller Systems, Propulsion Systems, Camera Systems, Navigation Systems, Batteries (power systems) and Other Components (Wires, connectors, carry cases, sprayers, and sprinklers)

Application of Drones in Agriculture

There are several agricultural activities like spraying of pesticides as well as soil and crop nutrients, monitoring and analysis of field moisture, fertigation, planting, harvesting etc., which can be performed through drones.



Soil and Field Analysis

Drones equipped with remote sensing cameras collect data from the ground with the help of electromagnetic spectrum to analysis the soil and field. Drones gather raw data and use

algorithms to transform it into useful information. As a result, they can be used in a variety of farming applications, such as monitoring the following parameters:

Crop Health: crop damage made by pests, nutrient deficiencies, color change

Vegetation Catalogues: leaf area, treatment effectiveness, phenology and yield.

Plant Growth: plant height, LAI and plant density.

Plant Inspection: plant size, field statistics, stand number, compromised field, planter skips **Water Requirements**: water requirement according to climatic situation, water-stressed parts of the field/ orchard in need of watering

Soil Investigation: nutrition concentration in plant, nutrient availability for plant nutrient management. This information aids farmers to determine the most efficient planting, crop management and soil management practices.

Planting of Seed from Air

Drones use a pneumatic firing device that shoots seed pods deeper into the soil in some areas, such as in hilly terrain or mangrove forests. Two flying drones can plant up to 40,000 seeds into the ground in a day. A drone in just ten minutes can plant equal to the average human can plant. It can achieve an emergence rate of 90 % and decrease planting costs by 85%.

Spraying Operation in Agriculture

For quicker spraying, drones can carry appropriately sized reservoirs that can be filled with fertilizers, pesticides, herbicide, plant growth regulators (PGRs) etc. Sometimes manual spraying operations are very difficult because of the crop's height, so smart farms use drones for spraying, which reduces the contact of humans with fertilizers, pesticides and other harmful chemicals Spraying capacity is up to five times faster than traditional machinery and completes a spraying in a 1 ha field in less than 40 minutes. It saves 30% pesticide application.

Crop Health Assessment

Drones equipped with sensors that can scan crops using visible and near-infrared light can be used to track crop health over the time and monitor response to remedial measures. This can be programmed to detect details such as NDVI, water stress or lack of specific nutrients in crops

Crop Count and Plant Emergence Analysis

Unmanned aerial vehicles (UAVs) are a useful, faster and cost effective technology for obtaining data on crop emergence, drive replanting decisions and help predict yield using drones and high-resolution data combined with Machine Learning algorithms (MLAs). This system produces 97% accuracy in its output using data obtained with drones and Photogrammetry. Drones equipped with LiDAR sensors allows for the estimation of tree/crop biomass change based on differential height measurements, which is used to estimate timber production in forests.

Irrigation Monitoring and Planning

With thermal cameras and remote sensing abilities, drones can help to solve irrigation related problems and can split the areas by different moisture regime. This helps in planning the irrigation precisely. The drones used by FAO in the Republic of the Philippines are equipped with photogrammetric and navigation equipment with a ground resolution of up to 3 cm.

Disaster Risk Reduction

FAO has partnered with national counterparts in developing systems to use drones for data collection that assist in Disaster Risk Reduction (DRR) efforts. These useful data are then loaded into modelling systems with analytics capabilities, which produce insightful results. Such data can help the government better organize disaster relief and response services while also providing high-quality, dependable recommendations to rural areas.

Wildlife Conservation

Drones with thermal cameras can be used to track, inspect, and monitor livestock from multiple angles. Drones have the potential to revolutionize forest and wildlife conservation research. They provide a bird's eye view of forests and wildlife, as well as information, imagery, and data that would otherwise be difficult or prohibitively expensive to obtain.

Benefits of agri-drones

Security

Drones are operated by trained drone pilots.

So, there are no chances of their misuse. It is safer and more convenient for farmers to use drones to spray pesticides in terrains challenging to reach, infected areas, taller crops, and power lines. It also helps farmers from manual spraying to the crops, which leads to less pollution and ensures health and environmental security.

High Efficiency

Drones do not have any operational delays and can work double the speed of human labor.

Water-Saving

In comparison to traditional spraying methods, agricultural drones use ultra-low volume (ULV) spraying technology, thus saving more water.

Low Cost and Easy to Maintain

Agri drones are sturdy, low in cost, and require minimum maintenance. Some of the key features include a detachable container, low-cost frame, precise spraying of pesticides

Useful for Insurance Claims

Farmers use the data captured through drones to claim crop insurance in case of any damages. They even calculate risks/losses associated with the land while being insured.

Enhanced Production

The farmer can improve production capabilities through comprehensive irrigation planning, adequate monitoring of crop health, increased knowledge about soil health, and adaptation to environmental changes.

4. GENETICS AND PLANT BREEDING

Epigenomics: A novel Perspective of Looking at Functional Genomics

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Introduction

Crop husbandry plays a key role in human society. We mainly depend on the domesticated plants like rice, wheat, maize, soybean, cotton etc. for the supply of food, feed, fiber, and fuel. Ever since the domestication of plants, considerable progress has been made in agriculture because of the behavioral changes in human from food gathering to farming. While breeders aim at developing newer crop varieties with better tolerance to the environmental stresses, understanding the adaptation process to the changing climatic conditions is essential. Therefore, scientists have been interested in deciphering the underlying mechanisms that plants have evolved to adapt under diverse environment (Kumar *et al*., 2017). Explaining genotypic variations based on classical genetics and the rapid evolutionary changes under environmental pressure has become difficult. Additional mechanisms such as epigenetics can help to explain some of the enigmas (Kumar, 2017).

Genes which are continuously express in all tissues of living organism are called housekeeping genes. Less environmental effect observed in case of qualitative genes while quantitative one is changing with different environmental condition it means that either internal or external stimuli can change the expression of gene. This phenomenon of way of expression is called epigenetic changes at genetic level.

These controls of gene expression is very important for proper organ differentiation like stem, leaves, roots, conversion of vegetative phase to reproductive phase so on. For example callus is non differentiated mass of cells and genes of these are equally express but when hormonal changes made it works as signal for development of particular plant organ or we can say it induce epigenetic changes.

As mentioned above, epigenomics is important for abiotic stress improvement in crops. Tolerance level of plant against abiotic stress is depends on growth stage of plant. Even susceptible plant is tolerant at particular growth stage *i.e.* vegetative phase but at seeding and

flowering made susceptible. So, it is important to study that which portion of genome expression made it tolerant at vegetative phase and finally these all due to epigenetic changes.

Transcriptomics means study of transcription rate in particular tissue and at particular time. Hoeever, transcriptomics is results of epigenetic changes and that is identified by epigenomics study.

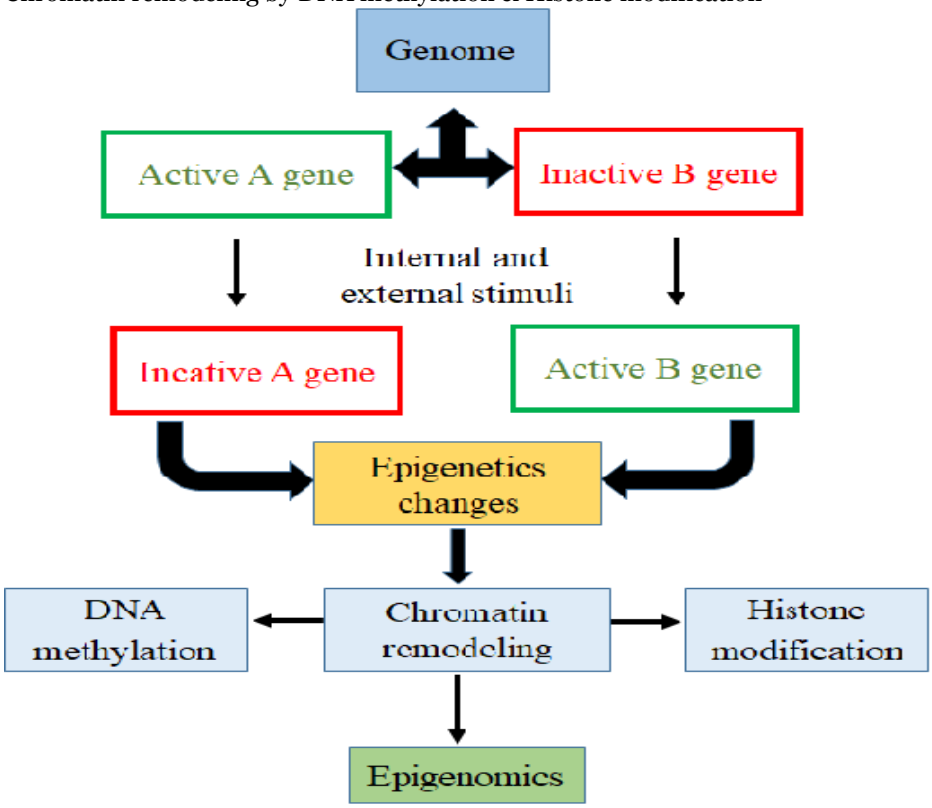
What is Epigenomics?

Epigenomics refers to the large-scale study of epigenetic marks on the genome. New high-throughput next generation sequencing techniques are making it easier to map genome wide epigenetic marks. Epigenomics gives better resolution of epigenetic changes across the entire genome or epigenome.

What is Epigenetics?

Epigenetics is the study of heritable changes in gene expression that occur without a change in the DNA sequence. In recent years, this field has attracted increasing attention as more epigenetic mechanisms affecting gene activity are being discovered. Three types of epigenetic mechanisms are identified (Liu *et al.,* 2012)

Chromatin remodeling by DNA methylation & Histone modification



Non-coding RNAs

Fig 1: Flowchart of epigenomics Study

Portion of genome which is not expressed is called as heterochromatin. However methylation play important role in repression of gene. After DNA replication, cytosines in the proper sections of the genome undergo methylation at the 5 position of the pyrimidine ring (5-Me-C), which is catalysed by cytosine methyltransferase enzymes utilising S-adenosyl methionine (AdoMet) as the methyl group donor. In the primary groove of B-form DNA, where it is exposed, the methylation 5 position of cytosine can act as a recognition factor for proteins that bind to DNA.

The flexible N-terminal tail of each core histone protein projects outward from the nucleosome surface. Histone modifying enzymes prefer to deposit (or remove) post-translational modifications (PTM), such as methylation, acetylation, and other changes, at these exposed tails. As a result, changed histones may cause nucleosomes to modify their conformation and act as docking sites for regulatory components. Therefore, downstream proteins can be recruited to specific chromosomal locations for distinct cellular activities by direct contact with changed histone tails.

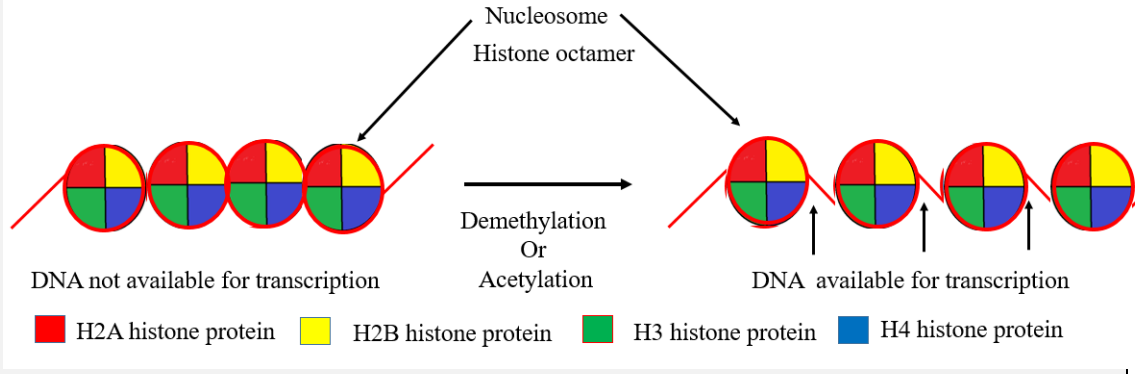


Fig 2: Chromatin remodelling by DNA methylation

Fig 2: Chromatin remodelling by DNA

Non-coding RNAs are a group of RNAs that do not encode functional proteins and were initially thought to just control post-transcriptional levels of gene expression. The most prevalent regulatory RNAs, however, appear to be long non-coding RNAs, endogenous siRNAs, piRNAs, and miRNAs, according to a wide range of recent research. Additionally, there is mounting evidence that regulatory non-coding RNAs are crucial for epigenetic regulation. These non-coding RNAs (ncRNAs) thereby emphasise the significant function of RNA in the control of gene expression.

Future Opportunities in Epigenomics

Epigenetic changes is result of evolution. Understating the way that how DNA and histone modifiers get signal to carried out changes in particular part of genome. Techniques to induce epigenetic changes in particular plant growth stage to achieve defined objective and to avoid the abiotic stress even in susceptible germplasm of plant.

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5. GENETCIS AND PLANT BREEDING

Microgreens: Fresh Life Sprouts

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Introduction

Microgreens are a new functional food crop that has the potential to sustainably diversify food systems and to advance economic, environmental, and human health. Microgreens are the immature, fragile, cotyledonary leafy

greens (including the hypocotyl, if present), primarily from the Brassicaceae, Asteraceae, Apiaceae, Amaryllidaceae, Amaranthaceae, Cucurbitaceae, Fabaceae, and Lamiaceae families of vegetables, cereals, and herbs. Microgreens are taken from seedlings that are ten to twenty days old and contain the cotyledons (seed, leaves), stems, and first genuine leaves. These young greens have recently become more widely used in restaurants as toppings and garnishes due to their variety in hues, textures, and flavours. Numerous studies have shown that young greens have higher concentrations of micronutrients and bioactive substances than mature greens.

Nutrient Composition

In fact, it has been demonstrated in numerous independent studies that different microgreen species have higher concentrations (up to 260-fold higher) of specific vitamins and minerals than their mature counterparts. These vitamins and minerals include provitamin A/betacarotene, vitamin C, vitamin E, and calcium. Additionally, they include carotenoids, total polyphenols, anthocyanins, glucosinolates, and chlorophyll. These findings suggest that microgreens can be used as a concentrated source of micronutrients and health-promoting bioactive compounds, but additional research is required to understand their nutritional and bioactive chemical qualities, particularly with respect to the influence of growing practises.

Why are Microgreens so Popular?

- Microgreens are highly nutritious foods that are also easy to grow and handle.
- When compared to open conditions, it can be grown commercially in controlled indoor agricultural environments (e.g., greenhouses, vertical farms, warehouses, terraces) with less influence from soil and climatic factors (temperature, rainfall).
- It can be grown year-round in most indoor locales and particularly in controlled environments, as they may be useful in facilitating adaptations to nexus of the population, urbanization, and global climate change.

Microgreens Growing Environment

Microgreens grow in only 10-15 days, take 93-95 percent less time, and require 158-236 times less water than mature greens. Microgreens grow best in cocopeat, grow mat, soil, or a mix of vermicompost and soil. Furthermore, fertiliser and pesticide applications are restricted or prohibited. Because nutrients and water are scarce, seed rate is critical. Microgreens are seeded in rows or broadcasted. Most growers believe that thick sowing increases yield, but in reality, increased population causes competition among plants and makes them more susceptible to pests and diseases. Coriander, celery, basil, radish, lettuce, fenugreek, broccoli, spinach, red beet, red cabbage, and other commercially cultivated microgreens

Common name	Scientific name	Family	Plant color
Celery	Apium graveolens	Apiaceae	Green
Spinach	Spinach oleracea	Chenopodiaceae	Green
Radish	Raphanus sativus	Brassicaceae	Green
Coriander	Coriandrum sativum	Apiaceae	Green
Fenugreek	Trigonella foenum-graecum	Fabaceae	Green
Basil	Ocimum basillicum	Lamiaceae	Green
Red cabbage	Brassica oleracea var. capitata	Brassicaceae	Red

Conclusion

Because of changes in consumer lifestyle and health consciousness, microgreens are becoming more popular in the market. Microgreens are nutrient-dense because they contain high levels of antioxidants, minerals, and vitamins, all of which have been linked to the promotion of good human health.

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6. AGRICULTURE

Plants' Retrograde Signalling

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Introduction

A highly integrated cellular signalling mechanism underlies the operation of the complex eukaryotic cell. DNA, the genetic material that serves as the blueprint for the whole metabolism of the cell or organism, is found in the nucleus, which is the cell's controlling structure. The DNA is also present in the two endosymbiotic organelles, mitochondria and chloroplast, which are symbiotic with the nucleus. Additionally found in mitochondria and chloroplast, respectively, are the critical genes for respiration (oxidative phosphorylation) and photosynthesis. To develop a thorough organelle-nucleus communication for their coordinated expression of their genome with the nuclear genome, these organelles are therefore also deeply integrated into cellular signalling.

Mechanism of Anterograde and Retrograde Signaling

Retrograde signaling: Signaling molecules from chloroplast and mitochondria act on the nucleus and regulate the nuclear gene expression.

Anterograde signaling: Signals or substances encoded in the nucleus that communicate with organelles (such as chloroplasts or mitochondria) and control the expression of specific genes that are expressed in those organelles. As a result, the chloroplast and mitochondrial genes are coordinated in relation to the internal and external stimuli that the nucleus perceives.

Classes of Retrograde Signals from Organelles

1. Degradational signals: In order to govern the regulated breakdown of the organelle (autophagy) and the redistribution of resources (amino acids, lipids) from the degrading organelle, signals released from organelles destroyed in response to internal and external stimuli are important.
2. Biogenic signals: Signals originated from plastids that are undergoing biogenesis (ie., chloroplast development) to adjust nuclear gene expression for novel organelles within growing or multiplying cells.
3. Operational signals: signals sent by fully functional organelles in response to changes in either internal or external stimuli. To balance organelle and cell metabolism, for instance, signals are emitted by stressed mitochondria under energetic conditions. This prompts the proper cellular response.

Nature of Retrograde Signals

1. Calcium ions: In response to various stresses Ca2+ ions are released from organelles into the cytoplasm which affects the cytosolic Ca2+ concentration, in turn, activating the expression enzymes responsible for the re-establishment of Ca2+ balance thereby cell homeostasis.
2. ROS and oxidized metabolites: During imbalance or dysfunction of organelles there originates reactive oxygen species or any other oxidized metabolites which act as retrograde signals to establish redox homeostasis.
3. Organelle-specific metabolites: Exchange of molecules between the membranes initiates natural retrograde signals.
4. Dual localized proteins: Act as a direct signal for retrograde mechanism, these nuclear-encoded proteins target organelles and are redirected to the nucleus under specific conditions.

Requirement for Organelle-To-Nucleus Communication

The chloroplast and mitochondria, which are endosymbiotic organelles, contain and have the

ability to express their genomes. These also contain genes for essential metabolic processes including photosynthesis and oxidative phosphorylation. Two theories have been put up to explain why these organelles have retained their genomes during evolution:

1. Redox signals from the relevant electron transport chain must be handled quickly, and the organellar genome is better able to do this than the nuclear genome, which is located far from the site of action.
2. The hydrophobicity of the membrane would make it difficult for effective targeting of these activities when encoded from the nucleus because the essential redox reactions take place inside these double-membrane organelles.

Conclusion

Understanding the changes in nuclear gene expression in response to various internal and external stimuli is provided by an understanding of organellar retrograde signalling. Furthermore, chloroplasts and mitochondria play a crucial part in the energy biology of any eukaryotic cell, therefore analysing the signals coming from these organelles can help us better understand how these genes work in tandem with nuclear genes to regulate the essential metabolic processes.

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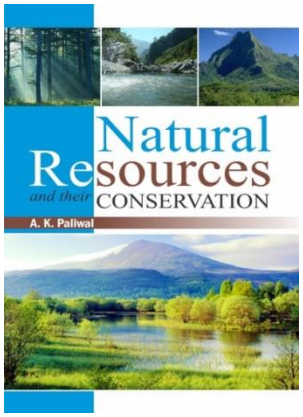

7. SOIL SCIENCE

Integrated Nutrient Management

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Integrated Nutrient Management is one of the important nutrient management technique in Agriculture.

Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner.(TNAU Agriportal).

Integrated Nutrient Management (INM) technique helps in overcoming the deterioration that is caused by the continuous application of inorganic fertilizers to the soil. The soil health (or) the soil quality is affected because of the acidity that is resulted because of the acid forming fertilizers like urea.

The organic materials like Green manures, Green Leaf Manures, biofertilizers, vermicomposts, enriched FYM, VAM, Azolla will help in evading the problems that are caused due

to application of artificial fertilizers.Moreover the use of biocontrol agents like *Trichoderma viride* , *Metarhizium anisopliae*., *Bacillus subtilis* can also help in preventing the losses caused due to pesticide and fungicide application.

Concepts Adopted in INM

- Regulated nutrient supply for optimum crop growth and higher productivity.
- Improvement and maintenance of soil fertility.
- Zero adverse impact on agro – ecosystem quality by balanced fertilization of organic manures, inorganic fertilizers and bio-inoculant

Factors Deciding the Role of INM

- Nutrient requirement of cropping system as a whole.
- Soil fertility status and special management needs to overcome soil problems, if any
- Local availability of nutrients resources (organic, inorganic and biological sources)
- Economic conditions of farmers and profitability of proposed INM option.
- Social acceptability.
- Ecological considerations.
- Impact on the environment

Advantages of Adopting the INM Practice

- Enhances the availability of applied as well as native soil nutrients
- Synchronizes the nutrient demand of the crop with nutrient supply from native and applied sources.
- Provides balanced nutrition to crops and minimizes the antagonistic effects resulting from hidden deficiencies and nutrient imbalance.
- Improves and sustains the physical, chemical and biological functioning of soil.
- Minimizes the deterioration of soil, water and ecosystem by promoting carbon sequestration, reducing nutrient losses to ground and surface water bodies and to atmosphere

Components of INM

Organic Sources :

The byproducts of farming and allied industries (eg.) Pressmud – byproduct of sugar industries. FYM , droppings from poultry – poultry manure (or) Guano, crop waste like paddy straw, Oil cakes, Neem seed Kernel extract, residues eg. Paddy straw, sewage, sludge contains industrial waste.

Organic source	Composition (N : P : K) (%)		
	N	P	K
Farm yard Manure (FYM)	0.80	0.41	0.75
Poultry Manure (Guano)	3.80	3.50	1.90
Groundnut oil cake	7.30	1.50	1.30
Neem Seed Kernel Extract (NSKE)	5.20	1.00	1.40
Sewage sludge	1.50 – 3.50	0.75 – 4.00	0.30 – 0.60
Paddy straw	1.59	1.34	3.37
Pressmud	1.25	2.25	0.50

Biological Sources:

The application of Microbial inoculants can substitute upto 15 - 40 Kg N/ha. Further the application of the biofertilizers will mobilize the unavailable nutrients (eg) Application of Phosphobacteria to the soils converted the fixed form of iron and aluminium phosphates to available forms.

Bio-innoculant	Crop used
Azospirillum	Paddy, Sugarcane
Rhizobium	Pulses – Blackgram, Greengram, Bengalgram
Azolla	Paddy
Frankia	Casuarina
Phosphobacteria	Sugarcane
Azophos	Sugarcane
Zinc solubilisers Phosphorus solubilisers	Multiple crops

Potash mobilisers	

Bio-innoculant

Greenmanures and Green Leaf Manures:

Application of Green manures and Green Leaf Manures like Sunhemp, Daincha, Sesbania to the soil increased the soil health, thereby minimised the application of inorganic ferilizers by 25 per cent.

Green manures

Vermicompost

The farm wastes can be composted by the earthworms which will release vermicastes which is called as the vermicompost which consists of the following nutrients. Application of this vermicompost can reduce the inorganic fertilizer. Moreover this will increase the soil fertility and physical property.

Vermicompost

Composition of Earthworm

Nutrient	Content (%)
Nitrogen	1.4 – 1.6
Phosphorus	1.6 – 2.5
Potassium	0.6 0.8
Calcium	0.44
Magnesium	0.15
Iron	175.2 (ppm)
Manganese	96.51 (ppm)
Zinc	24.43 (ppm)
Copper	4.89 (ppm)
Carbon : Nitrogen	15 : 1

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8. HORTICULTURE

Biological Weed Management - Eco Friendly Way for Weed Management

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Weeds are undesirable plant plays a significant role in different agro-eco-systems which cause direct and indirect losses. Weeds not only cause yield reduction (37 per cent) but also increase cost of cultivation, reduce input use efficiency and loss of potentially productive lands. Generally farmers follow several practices for control of weeds in different crops and cropping systems. In which herbicide application mostly practiced one due to labour shortage. But herbicide applications create soil and water pollution and also develop weed resistance and tolerance due to continuous application of same herbicide year after year. It also creates heavy financial burden to the framers. To overcome these problems, biological control appears pollution free and economic option for weeds control. Biological control of weeds is the deliberate use of natural enemies to reduce the weed population to a tolerable level. Insects, mites, plant pathogens, nematodes, fish, birds, animals, and their toxic products are major weed controlling biotic agents. Among these, insects are one of the important and widely used biological agents.

List of Weed Species Controlled by Insects

Weed species	Insects
Salvinia molesta	Cyrtobagous salviniae, Paulinia acuminata
Alternanthera philoxeroides	Agasicles hygrophila
Opuntia spp	Dactylopius ceylonicus, D. opuntiae, D. tomentosus, D. indicus
Lantana camara	Ophiomyia lantanae, Crocidosema lantana
Parthenium hysterophorus	Zygogramma bicolorata
Cyperus rotundus	Bactra verutana, Athesapaeuta cyperi
Orabanche spp.	Phytomyza orobanche

List of Microorganisms used in bio Herbicides and their Target Weeds and Ecosystems

Microorganism	Target weed Crops	Crops	Commercial product
Colletotrichum gleosporioides	Aeschynomene viriginica	Rice, soybean	Collego
Phytopthora palmivora	Morrenia odorata	Citrus groves	De Vine
Alternaria destruens	Dodders	Cranberry	Smolder
Biopolaris sorghicola	Sorghum halepense		

Bahadur *et al.* (2015)

Factors to be Considered in Selecting Agents

- Agent must target a particular plant species
- It must have high level of predation and parasitism on the host plant and its entire population, must be prolific.
- It must be able to thrive in all habitats and climates where the weed exists and should be able to spread easily and widely
- It should be a strong colonizer
- The overall cost of introducing the agent must be cheaper compared to other control methods

- The technology that will be involved in introducing and managing the agent must be as simple
- It should maintain natural biodiversity

Advantages

- Biological control can be cost effective in the long term.
- A high degree of specificity of target weed
- No effect on non-target and beneficial plants or man
- Absence of residue build-up in the environment
- Effectiveness for managing herbicide- resistant (HR) weeds populations.

Disadvantages

- Weed must be highly specialized
- Developing suitable and successful system involves huge money.
- It is a slow very process. It takes larger time to develop and work on weed populations.
- Requires government support.

Conclusion

Biological weed management is gaining popularity in the recent times due to its eco friendly nature. Overuse of herbicides affects the crop and soil environments in negative way. This may be reduced by adopting biological weed control methods.

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9. SOIL SCIENCE

Remediation of Heavy Metal Contaminated Sites by Green Technologies: Special Reference to Sustainable Remediation in Soil

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Introduction

Soil is non-renewable sources and nowadays the anthropogenic activities like manuring, fertiliser application and industrial waste leads to heavy metal contamination in soil as well the whole ecosystem in an earth.

Metals that have the specific density of > 5 g cm^{-3} are classified as heavy metals and specifically, Lead (Pb), Chromium (Cr), Arsenic (As), Zinc (Zn), Cadmium (Cd), Copper (Cu), Mercury (Hg) And Nickel (Ni) may be harmful to human as well Soil - Plant - Animal - Human continuum.

In America, Hg has used for mining of Gold and Ar in Wood Preservatives and tetraethyl lead remains a common additive to petrol and it may be emitted in to the environment while natural and anthropogenic activities. Also, soil reserve as a major source of heavy metal and it's not undergo a microbial chemical degradation like organic contaminants to carbon (IV) oxide hence metal persist in soil for long run.

Remediate the contaminated sites by using various available techniques like, immobilization, soil washing and phytoremediation. In developing countries like India, have the thickly populated and scares of funds to restore and reclaim the contaminated sites, low cost with ecologically sustainable remedial options are also

be there for reducing the risk and enhance the soil health, environment sustainability, agricultural production and food security.

To overcome that, green and sustainable remediation strategies might have used for sustainable restoration of soil and human health. Techniques employed for remediation by Green and sustainable remediates are as follows;

(1). Amendment for green remediation **Biochar** **Industrial waste byproducts** **Natural Mines** **Metal Oxides** **Nano material from green synthesis method**	**(2). Resource recovery strategies** **Phytomining** **Soil Washing**
(3). Nature Based solutions Bioremediation (Microbes) Phytoremediation (Plants) Immobilization Stabilization	(4). Energy Efficient Strategies Low-temperature thermal desorption Bio-electro kinetic remediation

Sustainable Remediation in soil:

Remediation by using Amendments

Biochar (amorphous & high surface area), fused with nano particles leads to increases its potential for metal sorption. The principle of metal removal mechanism includes such as physical adsorption, ion exchange, surface complexion, co-precipitation (oxidation, reduction & surface precipitation), electrostatics attraction, donor acceptor interaction involved in soil. The advantages of using biochar are easy to fabricate (pyrolysis) from plant biomass and wood wastes, instead the charred products have polycyclic hydrocarbons that has polluted to the soil. Sustainability concerns, the application of modified biochar sequester the carbon in soil and the sorbed heavy metals where fixed in sorption sites by clay metal complexes.

Remediation by using Plants and microbes

Plants are widely used to extract, stabilize or volatilize the toxic metals in soil and the metallophytes could accumulation of metals in their tissues, which reflect the concentration in solid liquid interface in soil phase. In this method, proper handling has needed for various purpose such as bio-energy production, animal feeding and soil fertility improvement after harvesting. Familiar plants such as castor, alfalfa, sunflower, corn, date palms, certain mustards; even willow and poplar trees can be used to reclaim contaminated soil – a cheap, clean and sustainable process

Microbes such as bacterias like ureolytic bacteria could induce the Calcite precipitate, which favors the metals co- precipitate with $CaCO_3$ by $PbCO_3$, $CdCO_3$ and $CuCO_3$.this results the oxidation and reduction of toxic metalloids decreasing their toxicity (Mahbub et al, 2016).

Remediation by resource recovery approach

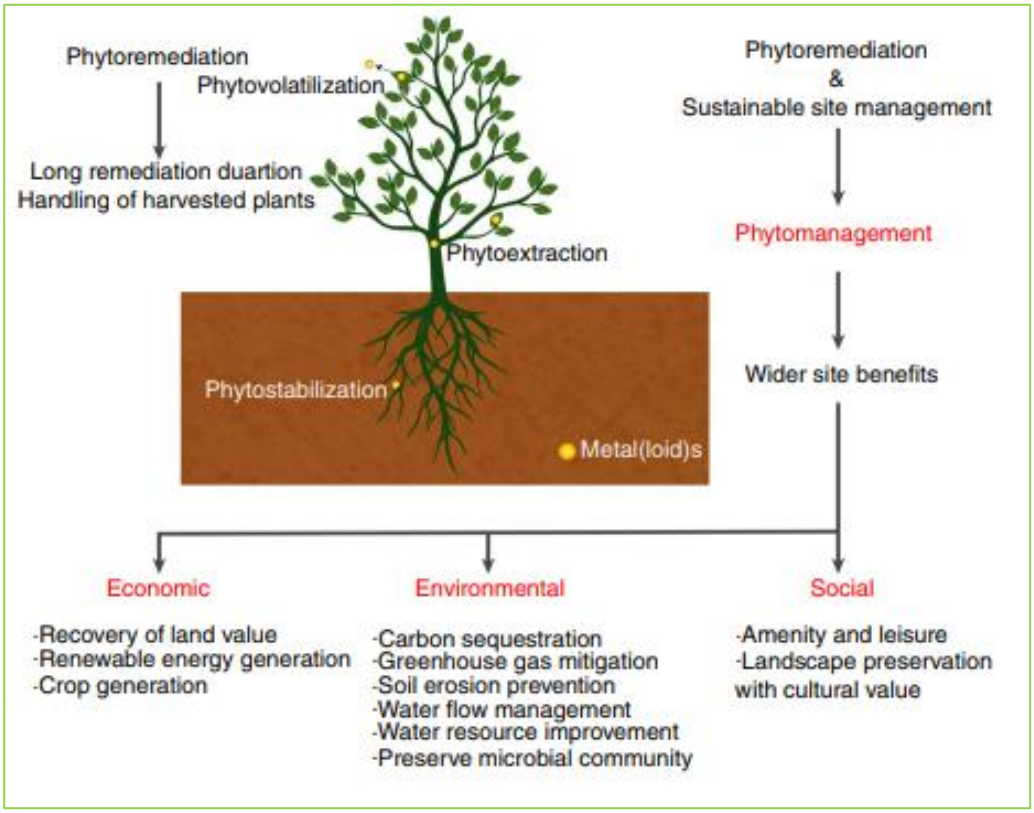
Phytomining can be used the plant covers to reduce the migration of pollutants from wind or percolation to water. Targeted metals are such as Ni, Ti, Co, Ag and Au instead the economic point of view Au, Ag, Pb and Pt are suitable for photo mining.

Soil washing is also a technique to wash the heavy metals thoroughly and rapidly from the soil by two process (dissolving or suspending and by concentrating them into smaller volume of soil through particle size distribution, gravity separation and attracting scrubbing) and the extractants such as strong acids and chelates are contaminant to soil.

Remediation by energy efficient strategies

Low temperature thermal desorption, the targeted metals is Hg and the soil treated at low temperature are used for agriculture because in low temperature desorption of metals from sorption site is low.

Bio- electro kinetic remediation, all metals can removed by enhancing agents (citric acid, NaCl & EDTA) and properly sequestered but this technology has not commercialized because of problems like waste of current and short circuiting (Wang et al, 2020).



Conclusion

In the view to sustainable remediation strategies, phytoremediation, soil washing are being commercialize. Integration of green technologies like phytoremediation, microbial oxidation and reduction, energy efficient techniques such as low temperature thermal desorption and Bio- electro kinetic remediation which are employed for extract, stabilize and detoxification of metals in contaminated sites.

"BE THE SOLUTION TO SOIL POLLUTION"

Reference

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10. AGRICULTURAL ENGINEERING

Robotics in Agriculture an Overview

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Introduction

Agriculture has fast becoming a high - tech activity and face of Indian agriculture is changing and technology is playing a crucial role in making farming techniques smarter. Precision farming techniques are enabling farmers to improve their agriculture production. The present focus in agriculture is GPS technologies and big data which is anticipated by 2023.The worldwide agri – robots market will cross $12.50 million. North America and Europe lead in precision farming and usage of farming robots. With the growing usage in Asia-Pacific, naturally China and India are at fastest rate. The growing awareness about Internet of Things (IoT) is helping farmers to use agricultural robots for speeding up agricultural operations, making activities efficient, and preventing manual errors.

The role of Drones and Sensors

Drones are being extensively used in modern agriculture for land mapping, pest detection and crop inspection. In the modern agriculture ecosystem, sensors play a crucial role. Soil moisture sensors constantly track the soil moisture levels, humidity etc., of the soil, send the data to the cloud network, and generate irrigation notifications for farmers which results in optimum use of water. In developed countries like New Zealand, Smart N is being used to track the places where grazing cows have urinated as such areas do not need any further fertilizers or chemicals.

Types of Farming Robots

Now a days implementation of data – backed, tech based agriculture is increasing. Different types of agbots are coming into the market. Robots with advanced artificial intelligence(AI) capabilities and built – in analytics systems are being used for carring out advanced agriculture operations such as dairy management, soil monitoring and augmenting agriculture yield.

Different types of drones such as, agricultural drones and GPS-powered smart tractors, milking robots, unmanned spraying helicopters and material management systems are gaining popularity. Water management and irrigation is another domain wherein agbots are delivering considerable benefits to farmers. There are “smart harvesting robots” and “intelligent” tools for farm inventory management. AGCO Lely, John and Deere, and Clear path Robotics are some of the biggest companies in the worldwide agri-robots industry.

Micro – Level Crop Monitoring

In the United States, the average size of agricultural farms is 444 acres and it is extremely difficult to manually monitor them. Lack of actionable data and insights increase the uncertainty factor associated with agriculture farming. To mitigate such risks, agbots and drones play a vital role. These farm robots make use of powerful sensors and geo-mapping technologies to bring holistic and real-time crop information to the farmer. There are certain agbots, like Boni Rob that are used to deliver granular-level crop information.

Agricultural robotics system has following 5 key components

- Cloud network
- Satellite system
- Actual farm robot
- Smart phone/tablet
- Logistic unit.

Robotic Applications

Agricultural robots automate the farm operation and improve production yields. Common used robots in agricultural operations such as:

Planting and Seeding with Agbots

Across the world, a lot of wastage occurs at the time of planting/seeding because farmers follow the traditional/outdated methods of planting. Farm robots with cutting-edge geomapping functionality is an alternative to prevent seeds from being wasted. These agbots

are designed in the form of 'robotic seeding attached to tractors and they can accurately determine all relevant soil features, so that right seeds are distributed at the right places at the right time. Agbots is also used for automation of all greenhouse activities, like potting, seeding, and warehousing. With rapid urbanization, agbots are helping in creation, management and maintenance of indoor farms in urban areas.

Irrigation and Fertigation with Robots

Fertilizer application on agricultural fields has been revolutionized by using farm robots and it ensures effective utilization of nitrogen fertilizers.

Micro –spraying and weeding

Micro-spraying and weeding robots come as an alternative to spraying pesticides on field crops manually, which

- is unduly time-consuming,
- leads to wastage of chemicals,
- an adverse effect on the environment

Weeding agbots are powered with advanced computer vision for correctly identifying the weeds and weed affected areas. Spraying required amounts of herbicides results in reduction of herbicide use and cuts down on unnecessary expenses. Robots that spot and uproot weeds are also being used in modern agriculture farming. Autonomous weeding technique with agbot skills 90% of pests and save 75% of pesticide usage. Laser technology is also used by some of the agri robots to the kill weeds.

Mowing, Pruning and Thinning

What should be the ideal spacing between plant to plant and row so that the chances of healthy crop growth would be optimal? Traditionally, experience was the only answer to this question. The situation has now changed with specialized agbots having the capability of assessing the "correct" density of plants, for proper growth. Agri-robots make use of high-level computer vision technology for pruning and training of the plants in the best possible manner. Automated pruning is already being done in grapevine and blueberry farming.

Picking, Sorting and Harvesting

Harvesting and picking is one area where robotic applications are most used in agriculture due to the accuracy and speed that robots can achieve to improve the size of yields and reduce waste from crops being left in the field. Applications for picking and sorting of soft fruits are being tested and deployed and these applications have manual handiness required for the agriculture operations like packing, sorting & harvesting. Octinion company has released a prototype of its strawberry-picking robot. The robot can sort and pick 70% of all ripe strawberries. Autonomous apple picking robots, armed with vacuum removal mechanics and computer vision are being used in recent past and are expected to become main stream in the next couple of years. Agbots gauge the ripeness of the fruits, detect the presence of dust on them, and monitor temperature/wind conditions. Damage of agriculture produce during harvesting is a big issue in traditional agriculture and farming and robotics is designed to overcome this concern. USA (California) based 'Abundant Robotics' and Israel based 'FF Robotics' companies developed apple picker robots wherein built-in AI Sensors are used to detect correct harvesting times for specific crops.

Robotics for Dairy Farming

Agbots are used to sprinkle disinfectants on animals, prior to the milking process and prepare the animals for milking, which ensures that the volume and quality of milk obtained is optimal. With proper management and regulated operations, cow-milking robots yield will have definite advantages.

Sheep/Cattle Herding with Robots

Sheepherding is one of the oldest and the trickiest tasks associated with sheep/goat rearing. Agricultural robots have automated this process and are being used in developed countries like Ireland, New Zealand etc.,to control sheep herds. These drones are operated remotely and their constant tracking operations make sure that not a single animal strays away from the herd. In Australia, many farmers use helicopters for cattle herding. Drones are an excellent and much cheaper alternative.

Conclusion

The exponentially rising global population is

the main factor behind the rapid developments in precision farming with robots. As there are more mouths to feed with limited land resources, yields must be maximized. Now a days increasing labour cost is motivating farmers to replace a section of the labour with agbots. Unavailability of sufficient manpower is another factor with the youth who are uninterested in traditional farming. The growing food scarcity levels, the constant climatic changes and farmland transfers and the existing bottlenecks of manual farming are also making farmers switch over to agbots as viable alternatives. The impact of the Internet of Things (IoT) in agriculture is growing fast and robotic farming offers manifold advantages.

In India use of agri robots is at a very nascent stage. As it helps to increase the annual yields, lower crop/food prices ensure better food accessibility levels, and make farming standards more efficient than ever before. Indian agriculture is becoming tech-based and the impact of IoT and robotics on farming has been profound. With the need for improving agricultural productivity levels increasing every day, it can safely be assumed that agbots will become more main stream in the coming years. Robotic farming is the answer to several issues facing agriculture and is set to be the future of Indian agriculture.

11. AGRICULTURE

Spectroradiometer

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[2] M.Sc Dpartment of soil science and agricultural chemistry, UAS, GKVK BangaloreSPECTRORADIOMETER

A spectroradiometer is a light measurement tool that is able to measure both the wavelength and amplitude of the light emitted from a light source. Spectrometers discriminate the wavelength based on the position the light hits at the detector array allowing the full spectrum to be obtained with a single acquisition. Most spectrometers have a base measurement of counts which is the un-calibrated reading and is thus impacted by the sensitivity of the detector to each wavelength. By applying a calibration, the spectrometer is then able to provide measurements of spectral irradiance, spectral radiance and/or spectral flux. This data is also then used with built in or PC software and numerous algorithms to provide readings or Irradiance (W/cm2), Illuminance (lux or fc), Radiance (W/sr), Luminance (cd), Flux (Lumens or Watts), Chromaticity, Color Temperature, Peak and Dominant Wavelength. Some more complex spectrometer software packages also allow calculation of PAR µmol/m2/s, Metamerism, and candela calculations based on distance and include features like 2- and 20-degree observer, baseline overlay comparisons, transmission and reflectance.

Spectrometers are available in numerous packages and sizes covering many wavelength ranges. The effective wavelength (spectral) range of a spectrometer is determined not only by the grating dispersion ability but also depends on the detectors' sensitivity range. Limited by the semiconductor's band gap the silicon-based detector responds to 200-1100 nm while the InGaAs based detector is sensitive to 900-1700 nm (or out to 2500 nm with cooling).

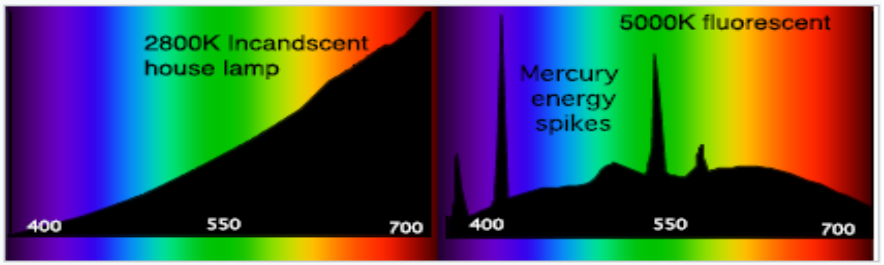
Lab/Research spectrometers often cover a broad spectral range from UV to NIR and require a PC. There are also IR Spectrometers that require higher power to run a cooling system. Many Spectrometers can be optimized for a specific range i.e. UV, or VIS and combined with a second system to allow more precise measurements, better resolution, and eliminate some of the more common errors found in broadband system such as stray light and lack of sensitivity.

Portable devices are also available for numerous spectral ranges covering UV to NIR and offer many different package styles and sizes. Hand held systems with integrated displays typically have built in optics, and an onboard computer with pre-programmed

software. Mini spectrometers are also able to be used hand held, or in the lab as they are powered and controlled by a PC and require a USB cable. Input optics may be incorporated or are commonly attached by a fiber optic light guide. There are also micro Spectrometers smaller than a quarter that can be integrated into a system, or used stand alone.

Spectral Power Distribution

The spectral power distribution (SPD) of a source describes how much flux reaches the sensor over a particular wavelength and area. This effectively expresses the per-wavelength contribution to the radiometric quantity being measured. The SPD of a source is commonly shown as an SPD curve. SPD curves provide a visual representation of the color characteristics of a light source, showing the radiant flux emitted by the source at various wavelengths across the visible spectrum. It is also a metric by which we can evaluate a light source's ability to render colors, that is, whether a certain color stimulus can be properly rendered under a given illuminant.



Characteristic spectral power distributions (SPDs) for an incandescent lamp (left) and a fluorescent lamp (right). The horizontal axes are in nanometers and the vertical axes show relative intensity in arbitrary units.

Sources of Error

The quality of a given spectroradiometric system is a function of its electronics, optical components, software, power supply, and calibration. Under ideal laboratory conditions and with highly trained experts, it is possible to achieve small (a few tenths to a few percent) errors in measurements. However, in many practical situations, there is the likelihood of errors on the order of 10 percent. Several types of error are at play when taking physical measurements. The three basic types of error noted as the limiting factors of accuracy of measurement are random, systematic, and periodic errors.

- *Random errors* are variations about that mean. In the case of spectroradiometric measurements, this could be thought of as noise from the detector, internal electronics, or the light source itself. Errors of this type can be combated by longer integration times or multiple scans.
- *Systematic errors* are offsets to the predicted "correct" value. Systematic errors generally occur due to the human component of these measurements, the device itself, or the setup of the experiment. Things such as calibration errors, stray light, and incorrect settings, are all potential issues.
- *Periodic errors* arise from recurrent periodic or pseudo-periodic events. Variations in temperature, humidity, air-motion, or AC interference could all be categorized as periodic error.

In addition to these generic sources of error, a few of the more specific reasons for error in spectroradiometry include:

- The multidimensionality of the measurement. The output signal is dependent on several factors, including magnitude of measured flux, its direction, its polarization, and its wavelength distribution.

- The inaccuracy of measuring instruments, as well as the standards used to calibrate said instruments, cascaded to create a larger error throughout the entire measurement process, and
- The proprietary techniques for reducing multidimensionality and device instability error.

How it Works

The essential components of a spectroradiometric system are as follows:

- Input optics that gather the electromagnetic radiation from the source (Diffusers, Lenses, Fiber optic light guides)
- An entrance slit, determines how much light will enter the spectrometer. A smaller slit with have greater resolution, but less overall sensitivity
- Order sorting filters for reduction of second-order effects
- Collimator directs the light to the Grating or prism
- A grating or prism for dispersion of the light
- Focusing optics to align the light onto the Detector
- A detector, CMOS sensor or CCD array
- A control and logging system to define data and store it

Applications

Spectroradiometers are used in many applications, and can be made to meet a wide variety of specifications. Example applications include:

- Solar UV and UVB radiation
- LED measurement
- Display measurement and calibration
- CFL testing
- Remote detection of oil slicks
- Soil research
- Plant research and development.

12. AGRONOMY

Diversity of Small Millets

A. Premalatha[1] and S. Saravanakumar[2]

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Introduction

Small millets are a group of grazy plants which are comprised of C4 with short slender culm and small grains possessing remarkable ability to survive under adverse conditions like limited rainfall, poor soil fertility and land terrain. They are the hardiest crops including an estimated 8000 species belonging to some 600 genera. Among them, six important small millets grown in India are finger millet (*Elusine coracana*), foxtail millet / Italian millet (*Setaria italica*), Kodo millet (*Paspalum scrobiculatum*), common or proso millet (*Panicum miliaceum*), little millet (*Panicum sumatrense*) and barnyard millet (*Echinochloa frumentacea*). Essential similarities of the members of this group of species are the resilience and ability to thrive in harsh environments, along with nutritious grains. Small millets account for less than one percent of the food grains produced in the world today, but they are strategic in terms of their nutritional contribution and their role in local agro-eco systems. They are used as food sources mainly in arid and semi-arid regions of the world due to their low water requirement and capacity to grow in marginal lands. Small millets can be stored for long period without insect damage and to provide security during famine situation. Among the small millets barnyard millet, kodo millet, and little millet have abundant within species racial diversity.

Finger Millet (Eleusine coracana)

Finger millet was domesticated in Western Uganda and the Ethiopian highlands at least 5000 years ago before introduction to

India approximately 3000 years ago. The morphology of the inflorescence can be used to differentiate between the two subspecies, *africana* and *coracana*. Each subspecies can be further divided into several races. Finger millet is an allotetraploid. Genomic donors of the "A" genome are most likely Eleusine indica and Eleusine trisachya. The "B" Genome has yet to be uncovered and may have been contributed by an extinct ancestor. The crop is highly valued in part due ti its nutritional content, being especially calcium rich. Finger millet also contains methionine and tryptophan, amino acids which are often absent in starch-based diets of some subsistence farmers.

Barnyard Millet (Echinochloa frumentacea)

Barnyard millet has two distinct cultivated species, the Indian barnyard millet (*E. colona* L) Link] and Japanese barnyard millet [E.crus-galli (L) Beauv] each with two sub species: colona and frumentacea in the former and crus-galli and utilis in the latter. Subspecies colona of Indian barnyard millet has no races while frumentacea has four races: stolonifera, intermedia, robusta,and laxa.Subspecies crus-galli and utilis of japanese barnyard millet have two races each: crus-galli and macrocarpa in crus-galli and utilis and intermedia in utilis. The beneficial effects of barnyard millet protein on plasma levels of adipinectin, high-density lipoprotein (HDL) cholesterol, glucose and triglycerides have been documented in obese diabetic mice.

Little Millet (Panicum sumatrense)

Little millet is cultivated or naturalized throughout India. It is also known as samai. It is considered to be indigenous to Indian subcontinent due to the luxuriant presence of its wild ancestor Panicum psilopodium throughout India.On the basis of inflorescence morphology, the species is divided into sub species sumatrense, the cultivated little millet and sub species psilopodium, its wild progenitor. *P.sumatrense* subsp.sumatrense is divided into subraces laxa and erecta and race robusta into laxa and compacta.

Foxtail millet (*Setaria italica*)

Foxtail millet was domesticated in China approximately 8700 years ago. It is considered one of the world's oldest crops and ranks second in total world millet production. Foxtail millet is closely related to the hardy weed Setaria viridis, which is assumed to be its progenitor. S.viridis, or green foxtail, often exists in close proximity to its cultivated cousin.

Kodo Millet (Paspalum scrobiculatum)

Kodo millet was domesticated roughly 3000 years ago in India and it is recognized by three races: regularis, irregularis, and variabilis.To date, no antinutrients from barnyard and kodo millets have been reported. It is a highly drought resistant crop. Among all millets, Kodo millet has the highest free radical quenching potential and good antioxidant property. The grain contains a diverse range of high – quality protein and has high anti –oxidant activity (anti- cancer) even when compared to other millets. Like finger millet, Kodo millet is rich in fiber and it is useful for diabetics.

Proso Millet (Panicum miliaceum)

Proso millet also called as panivaragu or broomcorn and common millet. Proso millet is important minor millet grown in India. It might have originated for *Panicum psilopodium* which is found in its wild state in Burma, India and Malaysia. The crop is able to evade drought by its quick maturity. Being a short duration crop (60 -90 days) with relatively low water requirement, this escapes drought period and, therefore, offers better prospects for intensive cultivation in dry land areas. Under unirrigated conditions, proso millet is generally grown during kharif season but in areas where irrigation facilities are available, this is profitably grown as summer catch crop in high intensity rotations. The benefits of consuming proso millet include its high protein content which ranges from 11.3 to 17% of grain dry matter.

Conclusion

The small millets are valued by traditional farmers for their nutritional content, health promoting properties, ability to grow under

low input conditions and tolerance to extreme environmental stress especially drought. In a world facing limiting natural resources and climate change, these crops thus hold tremendous potential as valuable instruments in the toolkit of the New Green Revolution. It is hoped that germplasm resources combined with modern genomic tools can help to accelerate exploitation of this biodiversity. In the present climate changing scenario and in the context of micronutrient malnutrition, these small millets has a large hidden potential as a promising crop of the future. This untapped potential should be properly exploited for our food and nutritional security in the coming years.

13. MCQS

This section, in the magazine has been specially introduced with the intention that the students and readers, who are planning to appear for the competitive exams, may get benefit. As the readers are aware that the exams are held by various Government departments and recruiters every year and the agriculture and allied subjects remain key subjects in some exams which are related to agriculture stream. We hope the students and readers will certainly like this and we invite the subscribers to send MCQs for publication in the magazine. We are, this time, concentrating on seed science and are providing 20 questions on the subject. The answers shall be provided in the next issue now onwards.

****

1. First elaborated definition of seed technology was given by
   a) Cowan, 1973
   b) Mc Donald, 1975
   c) Heydecker, 1969
   d) Moore, 1975
2. How many notified seed testing laboratories are there in the country?
   a) 103
   b) 106
   c) 107
   d) 108
3. Who classified dormancy into 3 classes: physical, physiological and morphological
   a) Nikolova, 1969
   b) J M Baskin, 1989
   c) C C Baskin, 1989
   d) Moore, 1942
4. ..... commission recommended the spread of improved varieties and seed certification
   a) Mehta commission
   b) Chopra commission
   c) RoyalCommissionof Agriculture (1925)
   d) Union review commission for Agriculture
5. The list of important factors responsible for the deterioration of varieties was given by
   a) Kadam, 1942
   b) Agrawal, 1980
   c) Harthem, 1918
   d) Visser, 1977
6. Who described steps to maintain the genetic purity of variety during seed production?
   a) Hartmann and Koster, 1968
   b) Agrawal, 1980
   c) Both a & b
   d) Kadam, 1942
7. The technique 'bud pollination' was given by
   a) Copeland, 1976
   b) Tateb, 1939
   c) Zabotor, 1962
   d) Deloche, 1973
8. Pollination by electrical and mechanical methods was given by
   a) Roggen, 1972
   b) Van Dijk, 1973
   c) Both a & b
   d) Roggen, 1974

9. Pollination by carbondioxide treatment was given by
    a) Visser, 1977
    b) Nakanishi, 1969
    c) Van Dijk, 1973
    d) Kadam, 1942
10. Who developed a formula to describe the relationship of seed viability with temperature and moisture content
    a) Roberts, 1972
    b) Harrington, 1972
    c) Isley, 1972
    d) Harman, 1972
11. The first seed testing laboratory in the world, in Tharandt, Germany was established in
    a) 1859
    b) 1869
    c) 1959
    d) 1969
12. When the first seed testing station was established in the United States?
    a) 1856
    b) 1866
    c) 1876
    d) 1886
13. The International seed testing association was established in
    a) 1914
    b) 1924
    c) 1934
    d) 1944
14. Association of official seed analysts was established in
    a) 1939
    b) 1949
    c) 1959
    d) 1969
15. First seed testing laboratory in India was established in
    a) 1941
    b) 1951
    c) 1961
    d) 1971
16. The first manual for seed testing was published in
    a) 1947
    b) 1957
    c) 1967
    d) 1977
17. Seed viability test was first developed by
    a) George Lakon, 1942
    b) Roberts, 1942
    c) Moore, 1942
    d) Isley, 1942
18. The seed act was formulated in
    a) 1966
    b) 1976
    c) 1986
    d) 1996
19. International seed trade federation was formed in
    a) 1924
    b) 1934
    c) 1944
    d) 1954
20. National seed policy was formulated in
    a) 2000
    b) 2001
    c) 2002
    d) 2003
21. Who suggested the addition of classes of seed germination viz. semihypogeal and durial type
    a) Leach, 1947
    b) Ng, 1991
    c) Lewis, 1954
    d) Koouneef, 1994

14. SOIL SCIENCE

Nutrient Deficiency in Guava and Their Management Practices

A. Premalatha[1] and S. Saravanakumar[2]

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Introduction

Guava (*Psidium guajava* Linn) belongs to the family Myrtacease and native of tropical America. Guava is one of the important commercial fruits in India. It is the fourth most important fruit after mango, banana and citrus. It has gained considerable prominence on account of high nutritive value, pleasant aroma and good flavor so it is called "Apple of Tropics". The fruit is a good source of vitamin C, Pectin, Calcium and Phosphorus. The fruit is used for the preparation of processes products like jams, jellies and nectar. The puree can be used in juice, cakes, puddings, sauces, ice-cream, jam and jelly. Fruits can be preserved by canning as halves or quarters, with or without seed core (shells). Good quality salad can be prepared from the shell of ripe fruits. Leaves of guava are used for curing diarrhea and also for dyeing and tanning. The most important factor which limits the production of guava is nutrient and seasons of crops. Imbalance fertilizer application and avoiding of organic manures in crop cultivation leads to nutrient deficiency in guava.

Nitrogen Deficiency in Guava and their Management Practices

Nitrogen

Nitrogen plays a dominant role because it is an essential constituent of protein, nucleic acid, protoplasm, chlorophyll, vitamins, etc.,

Deficiency Symptoms

- Pale green to light yellow color (Chlorosis) appearing first on older leaves, usually starting from tips of the leaves.
- Dropping of older leaves.
- Plant growth is slow, plants will be stunted and will mature early.

Management Practices

Foliar spray of Urea 1-2 % at fortnightly intervals.

Phosphorus

Phosphorus is involved in energy transfer, photosynthesis, transformation of sugars and starch, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next.

Deficiency Symptoms

- Slow, weak and stunted growth with dark to blue – green coloration to appear on older leaves of some plants.
- Under severe deficiency, purpling in leaves and stems may appear.
- Delayed maturity and poor seed and fruit development.

Management Practices

Foliar spray of DAP 2% at fortnightly interval.

Potassium

- Potassium plays a major role in transport of water and nutrient throughout the plant in Xylem.
- It increases root growth and improves drought tolerance.
- Potassium is also responsible for activation and synthesis of protein – forming nitrate reeducates enzyme.

Potassium Deficiency Symptoms

Chlorosis along the edges of leaves (leaf margin scorching) occurs first in older leaves. Plants lacking K will have slow and stunted growth. Stems become weak. The size of seeds and fruits and the quantity of their production is reduced.

Management Practices

Foliar spray of 2% K_2SO_4 at fortnightly interval.

Calcium

Calcium is also an important nutrient in plant nutrition. Calcium is an important for beneficial effects on fruit quality and shelf life. It plays important role in controlling the metabolism of plant cells.

Calcium Deficiency Symptoms

The growing tips of roots and leaves turn brown and die. Newly emerging leaves may stick together at the margins, which causes tearing as the leaves expand and unfurl. Younger leaves may be cupped and crinkled, with the terminal bud deteriorating.

Management Practices

- Soil application of Gypsum @ 20 kg/ha
- Calcium ammonium nitrate – 600 g/plant

Magnesium

The deficiency symptom of interveinal chlorosis first appears in older leaves. Leaf tissue between the veins may be yellowish, bronze or reddish, while the leaf veins remain green. In severe cases, symptoms may appear on younger leaves and cause premature leaf drop. Symptoms occur most frequently in acid soils and soils receiving high amounts of K fertilizer or Ca.

Correction Measure

Foliar spray of $MgSO_4$ @ 2% at fortnightly interval.

Boron:

Boron is another crucial micronutrient limiting crop production. Boron is mainly considered for reproduction, germination of pollen tube, fertilization and improving fruit quality. It is involved in sugar transport and lignifications. B is present in soils in the form of mineral tourmaline which is extremely resistant to wreathing, thus relatively immobile in plants resulting in deficiency symptoms.

Deficiency Symptoms

The symptoms are showing first in the growing part (young leaves) and cracking of fruits finally.

- Boron deficient tree exhibits little shoot growth, some buds may fall to open, whereas others may open and then shrivel and die.
- Shoots may grow for some time and then tips cease growing and die.
- Leaves are distorted in shape, with regular serration, leaves may cup or roll in a downward direction.
- Fruits may become hard shriveled and blotches.
- Fruit cracking is observed in severe boron deficiency.

Management Deficiency

- Application of borax 50g or 75g/tree
- Foliar spray of Borax 0.5% at fortnightly interval.

Iron

Deficiency Symptoms

Iron deficiency in fruit trees is characterized by chlorotic young leaves, resulting from decreased leaf chlorophyll concentration because of inadequate Fe absorption and/or utilization, and is responsible for significant decreases in yield, fruit size and fruit quality. When plants cannot acquire enough Fe to sustain growth, Fe chlorosis appears.

Corrective Measure

Soil application of $FeSO_4$ @ 10kg/ha.

Conclusion

The perusal of the literature suggests that nutrient application of macro, secondary and micronutrients fertilization rate are the most pivotal agro-inputs which describe the guava yield and fruit quality to a major extent. Nitrogen, Phosphorus and potassium, being the essential major elements, are required by plants in relatively large quantities especially responsible for maximizing physiological activities of the plant, water and soil relationships, which ultimately affect fruiting and quality but excess amount of application can result deteriorate fruit quality. In conclusion, application of plant nutrient source singly or combinations with organic manure showed positive effect on vegetative and reproductive growth, fruit yield and ultimately fruit quality of guava. Application of macronutrients, secondary nutrient and micronutrients application improves leaf nutrient and fruit quality of guava plant.

15. SOIL SCIENCE

Use of Liquid Waste (Human Urine) as a Fertilizers Source for Aerobic Rice Cultivation

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In order to grow plants that supply our food, fertilizers containing nitrogen, phosphorus, potassium and other additional elements are needed. Today, chemical fertilizers account for the largest share of these nutrients but, at the present rate of use, the available resources will be rapidly depleted. Use of human excreta as fertilizer has been implemented only to a limited extent. Rather, they have been flushed out into the rivers, resulting in pollution of the aquatic bodies. These resources have also been polluted with pathogenic microorganisms to the extent that many large rivers have become virus infected more or less permanently. It is thus better to create a closed system, with no pollution from bacteria or viruses, where human fertilizers are harvested and used to feed the following year's crops. Nutrients are removed from fields with the harvested crops; in sustainable agriculture, therefore, the amount of nutrients removed from a field should be returned to it .Today, there is mainly an out flow of nutrients from farms to society. For a sustainable society, it is necessary to recycle these excreta back to the farm.

One of the best options in the present day context is to utilize human urine as a liquid fertilizer and cow urine to meet part of the nutrient requirement of crops in an integrated way. Based on a modest calculation it is estimated that even if 30 per cent of the urine produced by the Indian population is properly collected and used, approximately 7.8 million tonnes of nutrients (NPK) are recycled and this can help to narrow down the gap between the nutrient demand and supply.

The use of cow urine as a fertilizer has been understood and documented well. But to recommended human urine for direct application the protocol of dosage, timing, extend of dilution, schedule of application and crop suitability were not worked out till now. Early workers have documented clearly the high nutrient content of anthropogenic liquid waste (human urine) range of nitrogen percentage. In this background the research problem was identified to assess the potentiality of using human urine and cow urine directly for aerobic cultivation and its impact on crop growth

Methodology

I. Characterization of Human and Cattle urine

Human urine samples was collected from the different diet and age group person from boys hostel, University of Agricultural Sciences, GKVK at Bangalore and local area of Gauri Bindur , Bangalore. Care was taken for drawing the sample from pilot site. The samples were placed in sterilized white cans and subjected to analysis for its nutrients status as per standard procedures

Plate 1. Collection of Human urine samples and stored for characterization

Usually, human urine is treated with disgust. But lab tests conducted so far reveal

that it contains no toxins. On the contrary, it is rich in nutrients such as nitrogen in large quantity, phosphorus and potassium in medium quantities, secondary nutrients in suffient range and micronutrients in small quantity. Hence it is considered as a liquid fertilizer (Table 1). In addition to nutrient elements it also has lots of sodium and sugar and may also have some plant growth promoting substances in small quantities.

Nutrient Composition of Urine and FYM Used in Experiment.

The nutrient composition of urine of differs from country to country and is basically based on diet. The composition of cow urine and FYM may also vary. Hence these were analysed. The nutrient composition of human urine and cattle urine used for experiment are as below (Table 1).

Table 1. Initial nutrient content of Human urine, cow urine and FYM used for experiment

Sources	N (%)	P_2O_5 (%)	K_2O (%)
Human urine	0.3	0.12	0.08
Cow urine	0.2	0.08	0.11
FYM	1.6	1.40	1.84

The nitrogen and phosphorus content of human urine was slightly higher than that of cow urine while FYM was found to have much higher N, P and K than urine sample.

Research on Use of Urine as a Liquid Fertilizer for Aerobic Rice Cultivation

Crop Details

The details of crops, varieties, plot size, date of planting and harvest and the quantity of fertilizers, human urine and cattle urine are given in Table 2.

Table 2 : Crop details

Crops	Variety/ hybrid	Spacing (cm)	Plot size (m)	DOS/DOP	DOH	RDF/ Ha	HU (l/ ha)	CU/ (l/ ha)
Aerobic rice	IR 20	30 x30	3.6x 2.5	31 /7 /10	25/ 12/ 10	100 :50: 50	33 ,33 3	50 ,0 00

Grain and Straw Yield

The results of grain yield and straw yield obtained are described in the following pages. The data on grain yield as influenced by various treatments of paddy is presented in Table 3.

Table 3. Effect of human urine, cattle urine, fertilizers and FYM on grain yield and straw yield (t ha^{-1}) of Aerobic rice

Treatments	Grain yield (t/ha)	Straw yield (t/ha)
T1 Rec. N -Human urine (HU) @ 40% basal + 60 % in 3 splits without gypsum	2.60	4.31
T2- Rec. N -Human urine (HU) @ 40% basal + 60 % in 3 splits with gypsum	2.63	4.35
T3- Rec. N -Cow urine (CU) @ 40% basal + 60 % in 3 splits without gypsum	1.88	3.11
T4- Rec. N -Cow urine (CU) @ 40% basal + 60 % in 3 splits with gypsum	1.92	3.18
T5- 40% Rec. N through FYM basal+ 60% through human urine	2.74	3.52
T6- 40% Rec. N through Chemical fertilizers basal + 60% through human urine	1.40	2.32
T7- 40% Rec. N through FYM basal+ 60% through Cow urine	1.35	2.24
T8- 40% Rec. N through CF basal + 60% through Cow urine	1.30	2.15
T9- Absolute control	1.12	1.79
T10- RDF	2.58	4.28
SEm +	0.01	0.02
CD(P =0.05)	0.04	0.06

The different treatments tried in this experiment significantly influenced the Aerobic rice yield (Table 3). The aerobic rice yield (2.74 t ha^{-1}) was recorded in T_5 treatment which received 40% recommended dose of N through FYM as basal+ 60% through human urine, while the treatment which received 40% recommended dose of N through FYM as basal+ 60% through cow urine recorded (1.35 ha^{-1}). But all these treatments were significantly superior over absolute control. Similar trend of results was observed in straw yield. The treatment differences are clearly depicted in Plate 2.

Absolute control and Recommended dose of fertilizers

Human urine + gypsum FYM + Human urine

Plate 2: Effect of human urine on Aerobic rice

Conclusion

From the research work conducted so far it can be concluded that human urine can be used as a liquid fertilizer and can be a supplement to fertilizers.

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Dear Readers

We have received, in the past, some complaints from the readers that they did not receive the hard copies of the magazine for few months in which their articles were published specially from January 2022 onward.

We have done our best to find out the solution and contacted the postal department too. We have also sent the hard copies separately to some of the subscribers but since we did not have the number of copies needed (at par with the complaints received) so we could not dispatch the magazines to all separately. Therefore, we decided, looking to the need and demand of the subscribers, to reconsider those articles once again and republish the same in the coming issues. We are doing this for all the articles received after November 2021 onwards till August 2022. The number of articles every month to be considered has not been fixed yet we shall include those articles one by one.

It is therefore, requested all those who have not received hard copies to keep the track of their articles once again as the same would be there in the magazine in any issue coming down the line

16. HORTICULTURE- VEGETABLE SCIENCE

Exotic Vegetable: Importance and Uses

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Anything of foreign origin, something not of native growth, as a plant is called exotic. Exotic vegetable are the species introduced to a country or location. Globally important source of cash income for small holders in India. The diverse climate of India ensures the availability of all varieties of fresh vegetables. India is the second largest producer of vegetables in the World, after China. Globalization has brought many changes in developing nations such as India. We now have an improved lifestyle and living standards. The introduction of big food chains has brought international cuisines to our dinner tables. It has also resulted in a changed food preference, especially among the younger generation. Vegetables help us to be fit and healthy due to the abundance of proteins, vitamins, and other essential nutrients found in them. Surveys show that almost 42 % of India's population consists of vegetarians. Indians

always love to have at least 1-2 types of vegetables along with their meals.

Importance of Exotic Vegetables

- As a Nutritional and medicinal value: Essential for balanced diet and good health provide micronutrients & phytochemicals. Reduce the risk of obesity, diabetes, cardiovascular diseases and cancer. Correct cooking improve the nutritional value of exotic vegetables
- As a economic sources: Important source of cash income for farmers. Public and private sector supplies seeds to farmers at reasonable prices.
- For commercial purpose: Lend themselves well to small scale and part time farming operation. Commercial production and marketing requires knowledge.
- As a home garden: Growing organically at a home makes exotic vegetable excellent choice.

Uniqueness of Exotic Vegetables

- High price in retail market
- Eaten raw/ semi cooked
- Mostly health conscious people eat
- Farming efforts are same as normal vegetables
- Super healthy food proven scientifically

Opportunities

- Vegetables considered under super healthy food category
- The open area for exotic vegetable cultivation is negligible
- Exotic vegetables market demand has increased five fold in India
- Only 10 % polyhouse are doing cultivation of exotic vegetables

Most Famous Exotic Vegetables

1. **Cherry tomatoes:** These are small and round. These are called cherry tomatoes since they are the size of cherries. These tomatoes, although small in size, taste the same as normal tomatoes. Cherry tomato are rich in lycopene, which is great at fighting free radicals that cause disease. Lycopene also limit UV damage to skin from sun exposure and promote better heart health. They are used in a variety of dishes such as salads and curries and can be eaten raw too. These are quite expensive and are mostly available at supermarkets.

2. **Broccoli:** Broccoli is one of the most nutritious vegetables in the list of exotic vegetables and is rather exotic with dark green, crisp, and sturdy florets. Broccoli ranks as the world's fifth-most famous vegetable. Some of the popular broccoli dishes are baked broccoli, broccoli salad with French dressing, buttermilk chicken with chargrilled broccoli, chatpati broccoli, broccoli and cheddar crepes, broccoli soup, broccoli pasta, salmon with broccoli, roasted bell pepper with broccoli salad, broccoli soup with wasabi, broccoli, baby corn, and colourful pasta. Broccoli contains rich source of Sulphoraphane compound associate with reducing risk of cancer. It contain Glucoraphinanin having anti cancer property.

3. **Coloured capsicum:** Red, Green, Yellow or Orange, they all are essentially, just green capsicum that have been allowed to ripe. The different colours are simply caused by the fruit ripening. Capsicums are rich in vitamins, help in the formation of collagen, and improves skin health. They also increase our metabolic rate. Capsicums can be eaten raw in salads or marinated and tossed into pasta, pizza, fried rice and noodles. They can also be grilled and eaten with chicken and fish or other vegetables such as zucchini, onions,

and tomatoes and served as a vegetable platter. They are also perfect for stuffing due to their hollow shape.

4. **Baby corn:** Baby corn also known as young corn, cornlets or baby sweetcorn. Along with used in Italian and Chinese dishes, baby corn is also the solo star of various starters like baby corn fritters and chili baby corn, it can also be teamed up with other ingredients in a salad, stir fry, pizza, roll or wrap such as double layered cheese veggie crunch pizza and cheesy vegetable dices. It is a very common ingredient in many Chinese dishes such as Schezuan fried rice, starters, gravies, and Manchurians.

5. **Lettuce:** It is hard to imagine having a salad without lettuce in it or biting on a burger without a crunch of lettuce to add to the texture. This crisp and crunchy green leafy vegetable is one of the most common and widely used vegetables among the list of exotic vegetables. Lettuce is a source of vitamin A, which plays a role in improved vision of eye. Extracts of multiple lettuce types have also been shown to promote sleep.

6. **Celery:** It is one of the most expensive vegetables in the list of exotic vegetables. It is a salad green that has a range of health benefits. It prevents inflammation and cancer, regulates blood pressure, and controls liver diseases, gout, asthma, psoriasis, and fever. It can be eaten both raw as well as cooked.

7. **Zucchini:** Zucchini is a summer squash in the Cucurbitaceae plant family and falls in the same category as cucumbers, melons, and spaghetti squash. This extremely healthy vegetable is a source of iron, calcium, zinc, and several vitamins. Cooked zucchini especially contains a high amount of vitamin A compared to raw zucchini, which contains slightly fewer vitamins. They have health benefits such as helping reduce blood sugar levels, aid in healthy digestion, improve heart health, and strengthen vision

8. **Asparagus:** The Asparagus is one of the must delicate, wholesome and luscious perennial plant of the garden. This tops the list of exotic vegetables due to their health benefits. Asparagus is low in calories, neutralized stomach acids and packed with essential vitamins, minerals, and antioxidants. It comes in a variety of colors, including green, white, and purple. It is popularly used in dishes worldwide, including frittatas, pasta, salads, and stir-fries.

9. **Parsley:** Parsley is one of the most versatile herbs used in Middle Eastern cooking and is popularly used as a spice. It is also used as a garnish on several dishes. Parsley is one of the foreign vegetables that is used as a garnish and sprinkled in soups, hummus, or mixed with ground meat.

10. **Red cabbage:** It belongs to the Brassica genus of plants. Although it tastes similar to green cabbage, it is richer in beneficial plant compounds that have been linked to health benefits such as stronger bones and a healthier heart. It lowers inflammation and protects against various kinds of cancers. It is an incredibly versatile vegetable that can be eaten raw, cooked, or fermented and added to a variety of dishes.

11. **Pak-Choy:** It is a type of Chinese cabbage, which used as food. Pak-Choy is a leafy vegetable that is delicious added to stir fries. Originally from China, it has become popular in European food and is now imported to India. Its structure looks like squat celery with white or very pale green, short, or chunky stalks and glossy deep green leaves. Its flavour is somewhat a mix of mild cabbage and spinach.

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17. PLANT PATHOLOGY

Spiroplasma: An emerging Threat to Crops

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Introduction

Spiroplasma was identified in 1971. Spiroplasmas are wall-less prokaryotes. Spiroplasma comes under mollicutes. It has a spiral shape. They grow well at 37°C. The impact of Spiroplasma diseases on agriculture is impressive and, at the present day, no effective curative strategy has been developed. Spiroplasmas are pathogens of agriculturally important plants like corn, citrus etc. It infects the phloem of the affected plant, causing fruit deformities.

Characters of Spiroplasma –

- Lack of cell wall.
- Helical
- Surrounded by a triple-layered unit membrane.
- Fried-egg colony morphology.
- They are mostly found in phloem tissues of plants.
- Cell of Phytoplasma are usually resistant to the antibiotics eg. Penicillin, cephaloridine, which act on cell wall, but sensitive to tetracyeline.

- Transmitted by vector like leaf hopper.

Systematic position of mycoplasma

Group	Prokaryotes
Class	Mollicutes
Order	Entomoplasmatales
Family	Spiroplasmataceae
Genera	Spiroplasma

Symptoms of Spiroplasma disease in plant

- Stunting.
- Numerous ear shoot develop
- Numerous tillers may also develop at the leaf axils and base of the plant, giving if a bushy appearance.
- On affected trees, fruits become small, crooked.

Important diseases caused by Spiroplasma

- Stubborn *disease* in citrus.
- Pear decline.
- Corn stunt.
- Grape Leaf roll.
- Periwinkle yellow.

Some major plant diseases symptoms

1. **Stubborn *disease* in citrus** – Causing agent *Spiroplasma citri*. The most common symptoms are different shape of fruits, effect on colour of fruits and fruit drop before maturity.

Figure 1

2. **Grape Leaf roll** – Leaf tissue between the veins turns deep red to purple, with downward curling or cupping of the leaf margins.

Figure 2

3. **Corn stunt -** The most characteristic symptoms of Corn stunt citrus discoloration panicle and twisting and distortion of inflorescence. Leaves – abnormal colours, abnormal forms, necrotic area, yellowed or dead. Witches broom and dwarfing.

Figure 3

4. Pear decline - The most characteristic symptoms are Poor shoot and spur growth. Also dieback of shoots, premature reddening and upper rolling of leaves. Reduced leaf and fruit size, and premature leaf drop.

Figure 4

Common Management practices for control of spiroplasma caused diseases

- Rouging of infected plants.
- Adjustment of date in sowing.
- Use of pathogen-free bud and grafting materials.
- Remove replants infected with disease and replant with disease-free trees.
- Vector controls are effective methods for the containment of spiroplasma-associated diseases. Spraying Monocrotophos, Cypermethrin, and demithoate will be effective for vector control.

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