Study Material on Agro-Ecological Practices For State Resource Persons (SRPs)

**DEENDAYAL ANTYODAYA YOJANA (DAY)–
NATIONAL RURAL LIVELIHOOD MISSION (NRLM)**

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Session —1: Livelihoods context
Duration - 60 mts

Learning outcome:

a. Basic definition of livelihood
b. Different elements that constitutes and/or influence livelihoods, relate these concepts to farm livelihoods

What is a livelihood?

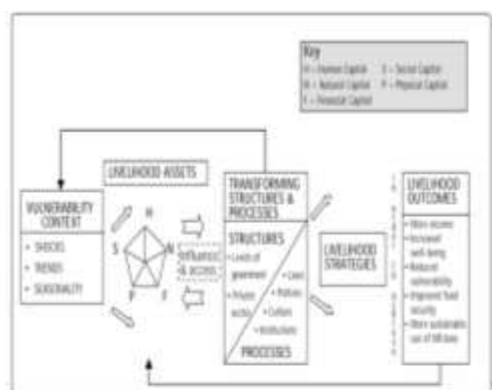
“Making a living”, “supporting a family”, or “my job” all describe a livelihood.

Chambers and Conroy, 1991:

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

DFID Framework:

The UK Department for International Development (DFID), developed the Sustainable Livelihoods Framework (SLF). This framework is an analysis tool, useful for understanding the many factors that affect a person’s livelihood and how those factors interact with each other.



1. Assets people draw upon

2. Context within which a livelihood is developed

3. Strategies they develop to make a living

4. Factors that make a livelihood more or less vulnerable to shocks and stresses

Livelihood assets: Assets may be tangible, such as food stores and cash savings, as well as trees, land, livestock, tools, and other resources. Assets may also be intangible such as claims one can make for food, work, and assistance as well as access to materials, information, education, health services and employment opportunities

Human capital	Skills, knowledge, health and ability to work
Social capital	Social resources, including informal networks, membership of formalized groups and relationships of trust that facilitate cooperation and economic opportunities
Natural capital	Natural resources such as land, soil, water, forests and fisheries
Physical capital	Basic infrastructure, such as roads, water & sanitation, schools, ICT; and producer goods, including tools, livestock and equipment
Financial capital	Financial resources including savings, credit, and income from employment, trade and remittances

Livelihood context: Livelihoods are formed within social, economic and political contexts. Institutions, processes and policies, such as markets, social norms, and land ownership policies affect our ability to access and use assets for a favorable outcome. As these contexts change they create new livelihood obstacles or opportunities.

Social relations:	The way in which gender, ethnicity, culture, history, religion and kinship affect the livelihoods of different groups within a community
Social and political organization: Governance:	Decision-making processes, civic bodies, social rules and norms, democracy, leadership, power and authority, rent-seeking behavior The form and quality of government systems including structure, power, efficiency and effectiveness, rights and representation
Service delivery: Resource access institutions: Policy and policy processes:	The effectiveness and responsiveness of state and private sector agencies engaged in delivery of services such as education, health, water and sanitation The social norms, customs and behaviors (or 'rules of the game') that define people's access to resources The processes by which policy and legislation is determined and implemented and their effects on people's livelihoods

Livelihoods are also shaped by the changing natural environment. The quality of soil, air and water; the climatic and geographic conditions; the availability of fauna and flora; and the frequency and intensity of natural hazards all influence livelihood decisions.

Livelihood strategies:

How people access and use these assets, within the aforementioned social, economic, political and environmental contexts, form a livelihood strategy. The range and diversity of livelihood strategies are enormous. An individual may take on several activities to meet his/her needs. One or many individuals may engage in activities that contribute to a collective livelihood strategy. Within households, individuals often take on different responsibilities to enable the sustenance and growth of the family. In some cultures, this grouping may expand to a small community, in which individuals work together to meet the needs of the entire group.

Livelihood Vulnerability:

The strength of a given livelihood is not only measured by its productive outcomes, but equally by its resilience to shocks, seasonal changes and trends. Shocks might include natural disasters, wars, and economic downturns. Availability of resources, income-generating opportunities, and demand for certain products and services may fluctuate seasonally. More gradual and often predictable, trends in politics and governance, technology use, economics, and availability of natural resources, can pose serious obstacles to the future of many livelihoods. These changes impact the availability of assets and the opportunities to transform those assets into a "living". Under such conditions, people must adapt existing strategies or develop new strategies in order to survive.

Livelihood Interdependence:

One final important characteristic of livelihoods is their interdependence. Very few livelihoods exist in isolation. A given livelihood may rely on other livelihoods to access and exchange assets. Traders rely on farmers to produce goods, processors to prepare them, and consumers to buy them. Livelihoods also compete with each other for access to assets and markets. Thus positive and negative impacts on any given livelihood will, in turn, impact others. This is a particularly important consideration when planning livelihood assistance.

Session —2: SDGs
Duration - 30 mts

SDGs: Sustainable Development Goals

Sustainable Development Goals (**SDGs**), officially known as **Transforming our world: the 2030 Agenda for Sustainable Development** is a set of aspirational "Global Goals". Spearheaded by the United Nations, through a deliberative process involving its 193 Member States, as well as global civil society, is a broader intergovernmental agreement that, while acting as the Post 2015 Development Agenda (successor to the Millennium Development Goals), builds on the Principles agreed upon popularly known as **The Future We Want**.

Learning outcomes:

At the end of the session participants will be able to;

1. What is SDGs?
2. Able to relate and connect farm livelihoods interventions with SDGs

- **The new Goals and targets came into effect on 1 January 2016 and will guide the decisions we take over the next fifteen years (2016-2030)**
- **There are 17 goals, 169 targets to be achieved by all member countries**
- **Some of these relates directly to livelihoods**
- **As a group can we all decide which goals, come in the purview of livelihoods**
- **And also see if some of our interventions directly address SDGs**

The Goals and targets will stimulate action over the next fifteen years in areas of critical importance for humanity and the planet:

PEOPLE	To end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfil their potential in dignity and equality and in a healthy environment.
PLANET	To protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations.
PROSPERITY	To ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature.
PEACE	To foster peaceful, just and inclusive societies which are free from fear and violence. There can be no sustainable development without peace and no peace without sustainable development.
PARTNERSHIP	To mobilize the means required to implement this Agenda through a revitalised Global Partnership for Sustainable Development, based on a spirit of strengthened global solidarity, focused in particular on the needs of the poorest and most vulnerable and with the participation of all countries, all stakeholders and all people.

1. **No Poverty** – End Poverty in all its forms everywhere

Poverty is more than lack of income or resources- it includes lack of basic services, such as education, hunger, social discrimination and exclusion, and lack or participation in decision making.

Gender inequality plays a large role in the perpetuation of poverty and it's risks; They then face potentially life-threatening risks from early pregnancy, and often lost hopes for an education and a better income.

Age groups are affected differently when struck with poverty; its most devastating effects are on children, to whom it poses a great threat. It affects their education, health, nutrition and security. It also negatively affects the emotional, spiritual and emotional development of children through the environment it creates.

Specific Target:

By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day

By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions

Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable

By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance

By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions

1.b Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions

2. **Zero Hunger** –End hunger food security and improved nutrition and promote sustainable agriculture

Globally, 1 in 9 people are undernourished, the vast majority of these people live in developing countries

Agriculture is the single largest employer in the world, providing livelihoods for 40 per cent of today's global population. It is the largest source of income and jobs for poor rural households. Women comprise on average 43 per cent of the agricultural labor force in developing countries, and over 50 per cent in parts of Asia and Africa, yet they only own 20% of the land.

Poor nutrition causes nearly half (45 per cent) of deaths in children under five – 3.1 million children each year.

Specific Target:

By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment

By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed

2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries

2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round

Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility

15. **Life on Land** - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Session —3: Adult learning
Duration - 60 mts

ADULT Learning:

NRLM lays special thrust to train and capacitate the poor and vulnerable women for enhancing their livelihoods skills. In that context knowing Adult learning in details is one of the prerequisite of trainers (the NRPs, SRPs and CRPs).

Learning outcomes:

At the end of the session participants will be able to;

1. Know nuances of adult learning
2. Be an effective trainer: knowing adult learning principles and adult behaviour

Adults learn in a different way (Malcom Knawels. 1968) as need an enabling environment where they feel comfortable and they can relax, express their need, experience they have and state their problems. They look for solutions rather than theories and principles and concepts – which are typically a child learns in a school. (Pedagogy).

Farmers across states and districts differ in cropping systems they follow, soils they cultivate water they give to their crops from monsoon rains, pests and disease they need to control. Added to these production problems they also face problem of getting investment and inputs, market uncertainties as middlemen control their lives as well as access to knowledge and services. All these factors need learning programs for farmers to be designed differently keeping in mind the Andragogy principles.

1.Adults are often concerned that participating in a group will make them look weak, either professionally or personally.

• Design training workshops, educational exercises, and discussion sessions that help people feel safe enough to ask questions and confident that they will be respected.

• Don’t ask people to take risks too early in a workshop or course (for example, engaging in a role play exercise) unless they already know each other well.

• Provide opportunities and allow time for people to establish themselves in the group.

2. Adults bring a great deal of experience and knowledge to any learning situation.

• Show respect for participants’ experience by asking them to share ideas, opinions, and knowledge. Verbally recognize that they may be a good resource for reaching your teaching goals.

• A needs assessment can tell you more about the individuals in the group. Or, if you already know the participants, you may realise that particular individuals can provide helpful input before, during, or after your session(s)

3. Adults are decision-makers and self-directed learners.

- Do not seek to make people obey you. Adults will do what they need to do.

- Be the "guide on the side" rather than the "sage on the stage".

- Listen to what they want and need and be flexible in your planning. Seek feedback from the group. Change your approach if your agenda or methods are not working.

4. Adults are motivated by information or tasks that they find meaningful.

- Conduct some type of needs assessment so that you are aware of what people want (and need) to learn, how much they already know, and the kinds of "generative themes" that might affect their attention span.

- Generative themes are concerns/issues that are most important in a person's life.

- Generative themes may enhance or challenge a person's ability to learn.

- They could include such things as the fear of losing a job, the health of a loved one, the desire for a promotion, the need for a change, the pending birth of a child, problems in a relationship, or new possibilities for growth and development.

5. **Adults have many responsibilities and can be impatient when their time is wasted**.

- Be thoughtful and kind.

- Begin and end your session on time.

- Understand who is in the audience and why they are participating.

- Learn what questions they have about the subject.

- Don't cover material they already know unless there is a good reason for it.

- Recognise that your subject is only one of many that participants may be interested in learning more about.

ADULTS LEARN BEST WHEN	**MATCHING ADULT LEARNING NEEDS WITH APPROPRIATE METHODS**
They feel valued and respected for the experiences and perspectives they bring to the training situation	Elicit participants' experiences and perspectives through a variety of stimulating activities
The learning experience is active rather than passive.	Actively engage participants in their learning experience through discussion and a variety of activities.
The learning experience actually fills their immediate needs.	Identify participants' needs; develop training concepts and learning objectives to these identified needs.

They accept responsibility for their own learning.	Make sure that training content and skills are directly relevant to participants' experiences so that they will want to learn.
Their learning is self-directed and meaningful to them	Involve participants in deciding on the content and skills that will be covered during the training.
Their learning experience addresses ideas, feelings, and actions.	Use multiple training methods that address knowledge, attitudes, and skills.
New material relates to what participants already know	Use training methods that enable participants to establish this relationship and integrate new material
The learning environment is conducive to learning.	Take measures to ensure that the physical and social environment (training space) is safe, comfortable, and enjoyable
Learning is applied immediately.	Provide opportunities for participants to apply the new information and skills they have learned.
Learning is reinforced.	Use training methods that allow participants to practice new skills and receive prompt, reinforcing feedback.
Learning occurs in small groups.	Use training methods that encourage participants to explore feelings, attitudes, and skills with other learners.
The trainer values participants' contributions as both learners and teachers.	Encourage participants to share their expertise and experiences with others in the training.

LEARNING STYLES	**CONSIDER USING**
Learn best with abstract concepts and lectures	Case studies and discussions about theories and research
Learn best while observing others	Demonstrations and videos
Learn best from exercises	Role playing and other experiential activities
Learn best through visual means	Videos, images, and slides

It is also important to recognise that people learn differently and that there are several learning styles. Training courses that recognize different types of learners and caters for their needs succeed a lot more in achieving their objectives than the ones that try to funnel all participants through a rigid narrow way of single or uni-learning mode.

Generally there are four modes of learning and people could be one or another or even switch between different modes depending on the subject matter:

• **Doer:** Likes to be actively involved in the learning process, wants to know how he or she will apply learning in the real world, likes information presented clearly and concisely.

• **Feeler:** People-oriented, expressive, focuses on feelings and emotions, thrives in open, unstructured learning environment.

• **Thinker:** Relies on logic and reason, likes to share ideas and concepts, analyses and evaluates, enjoys independent work.

• **Observer:** Likes to watch and listen, tends to be reserved, will take his or her time before participating, and thrives on learning through discovery.

Session-4: Farmer Field School

Duration – 45 mts

What is farmer Field School? Farmer Field School (FFS) is a group of farmers who get together to study a particular topic. The topics covered vary from conservation agriculture, organic agriculture, animal husbandry and soil husbandry, to income generating activities such as apiculture. FFS provides an opportunity for learning by doing. FFS is a forum where farmers and trainers debate observations, experiences and present new information from outside the community.

Why FFS?

- Empowers farmers with knowledge and skills
- Enable the farmer to take informed decisions
- Enable farmers to think innovatively
- Encourage farmers to take up experiments

Essential elements of FFS:

The group: The group (sasyamithra sangha) comprises of individuals (20-25 in Number) who have a common interest, forming the core of a Farmer Field School.

The Field: The field is the teacher. It provides most of the training materials like plants, pests and other facilities. In most cases, communities provide a study site with a shaded area for follow-up discussions.

The Facilitator: The facilitator is a technically competent person who leads group members through the hands-on exercises. The facilitator can be an extension agent or a Farmer Field School graduate.

Curriculum: The curriculum follows the natural cycle of the subject, be it crop, animal, soil, or handicrafts. This allows all aspects of the subject to be covered in parallel with what is happening in the FFS field.

Approach: Farmers field school (FFS) is the key activity for transfer of technology and sharing of best practices. Farmers upgrade knowledge by sharing, observations and experiments. 20-25 farm families formed into a group known as "Sasyamithra Sanghas" and these sanghas are assisted by a community activist.

In this paradigm, the farmers are encouraged to experiment, innovate and their innovations are shared among other farmers. Respect is accorded to farmers own initiatives. This approach is different from the mainstream attitude where the farmer is a passive recipient of 'knowledge' produced in formal agriculture research stations or universities. It is a very liberating approach and the momentum in our programme is fuelled by countless innovations of farmers and the pride they take in their 'research' efforts.

Characteristics of FFS approach:

Farmers: Farmers are experts conducting their own field studies. Training is based on comparison of activities that they conduct.

The Field: The field is the learning place where farmers working in small groups collect data, analyze and make decisions based on their analyses then present the decisions to other farmers for refinement.

Extension workers: They are facilitators not teachers. Once the farmers know what to do the extension workers takes a back seat only offering guidance when need be.

The Curriculum: This is integrated to include crop husbandry, animal husbandry, land husbandry and other areas in relation to ecology, economics, sociology and education.

Training: Training is related to the seasonal cycle of the practice being investigated such as land preparation, cropping, harvesting, livestock feeds and so on.

Meetings: These are held at regular intervals depending on what activities need to be done.

Learning materials: These are generated by farmers and are consistent with local conditions. Even illiterate farmers can prepare and fuse simple diagrams to illustrate the points they want to make and actions to be taken

Group dynamics: Training includes communication skills building, problem solving and leadership and discussion methods. Farmers implement their own decisions in their own fields.




Module-1: Natural Resource Management

Session —1: Weather and climate
Duration - 60 mts

Introduction:

Climate of a country, region, and state determines what are the crops can be grown, when and what soil type. Weather determines the effect of rainfall, temperature, humidity, sunshine etc the crop growth on a farmers field. This is the reason we need to understand the difference between climate and weather. Since Indian agriculture is predominantly dependent on Monsoon it is imperative to understand the phenomena of Monsoon and its effect on crop production. Further depending on weather, soil type India has been divided into homogenous agro climatic zones to facilitate planning for crop production.

Learning outcomes:

At the end of the session participants will be able to;

3. Know the difference between weather and climate
4. The elements of weather that influence farming
5. How Monsoon impact cropping systems and crop production
6. What are Agro-climatic zones and Agro-ecological zones- their significance
7. What are the basic natural resources of any country?
8. Identify the soil types in the state/region that you work and its characteristics

Difference between weather and climate:

Weather is the state of the atmosphere, to the degree that it is hot or cold, wet or dry, calm or stormy, clear or cloudy. Therefore weather is something people often communicate about.

Weather generally refers to day-to-day temperature and precipitation activity, whereas climate is the term for the statistics of atmospheric conditions over longer periods of time

Weather is driven by air pressure (temperature and moisture) differences between one place and another. These pressure and temperature differences can occur due to the sun angle at any particular spot, which varies by latitude from the tropics.. Weather systems in the mid-latitudes, such as extra tropical cyclones, are caused by instabilities of the jet stream flow. Because the Earth's axis is tilted relative to its orbital plane, sunlight is incident at different angles at different times of the year. On Earth's surface, temperatures usually range ±40 °C (−40 °F to 100 °F) annually. Over thousands of years, changes in Earth's orbit can affect the amount and distribution of solar energy received by the Earth, thus influencing long-term climate and global climate change.

Surface temperature differences in turn cause pressure differences. Higher altitudes are cooler than lower altitudes due to differences in compressional heating.

Weather forecasting is the application of science and technology to predict the state of the atmosphere for a future time and a given location. Human attempts to control the weather have occurred throughout human history, and there is evidence that human activities such as agriculture and industry have modified weather patterns.

Monsoon phenomena in India

Monsoon in India is among the several geographically distributed observations of the global monsoons. In the subcontinent, it is one of oldest weather observations, an economically important weather pattern and the most anticipated weather event and unique weather phenomenon. Yet it is only partially understood and notoriously difficult to predict. Due to its effect on agriculture, flora and fauna and the general weather of India, Bangladesh, Pakistan, Sri Lanka, etc., among other economic, social and environmental effects, a Monsoon is one of the most anticipated, followed and studied weather phenomenon of the Indian subcontinent. It has significant impact on the overall well-being of sub-continent residents and has even been dubbed the "real finance minister of India"

Definition

Monsoon, is generally defined as a system of winds characterized by a seasonal reversal of its direction, lacks a consistent detailed definition. Some examples are given below:

Indian Meteorological Department defines it as the seasonal reversals of the wind direction along the shores of the Indian Ocean, especially in the Arabian Sea, that blow from the southwest during one half of the year and from the northeast during the other half.[6]
Observed initially by sailors in the Arabian sea travelling between Africa, India and South-East Asia, Monsoon is a major weather phenomenon in India (and the subcontinent) for the influence it casts on the lives of its inhabitants since centuries. Monsoon in India can be categorized into *two branches* based on their spatial spread over the sub-continent:

- Arabian Sea Branch
- Bay of Bengal Branch

Alternatively, it can be categorized into *two segments* based on the direction of rain bearing winds:

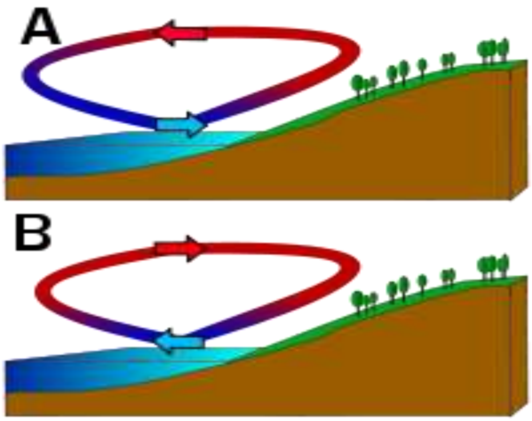
- **South-West Monsoon (SW Monsoon)**
- **North-East Monsoon (NE Monsoon)**

Based on the time of the year that these winds bring rain to India, they can also be categorised in *two rain periods* called:

- the *Summer monsoon* (June to September)
- the *Winter monsoon,* (October to December)

The complexity of Monsoon as a weather phenomenon of India is not yet completely understood, making it difficult to accurately predict its behaviour in terms of quantity, temporal and spatial distribution of the accompanying precipitation. These are the most monitored components of Monsoon determining the water availability in India for any given year.

Process of Monsoon creation



A: Sea breeze, B: Land breeze

- Data analysis important for agriculture
- Forecasting services
- Satellite imagery
- It is global science
- Data modeling

What are essential weather elements?

- Temperature – recorded twice every day Min and Max
- Wind direction
- Wind speed
- Sun shine hours – important for crop growth
- Relative humidity
- Rainfall in past 24 hours

How these are useful to farmers' daily weather forecast

- Plan field operations – tillage, seedbed preparation
- Sowing
- Fertilizer application
- Spraying
- Harvesting
- Threshing, drying
- Irrigation

India exhibits a variety of landscapes and climatic conditions those are reflected in the evolution of different soils and vegetation. There also exists a significant relationship among the soils, land form and climate.

Session-2: Climate change
Duration 45 mts

Introduction:

Climate change is the variation in global or regional climates over time. It reflects changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes can be caused by processes internal to the Earth, external forces (e.g. variations in sunlight intensity) or, more recently, human activities.

- In recent usage, especially in the context of environmental policy, the term "climate change" often refers only to changes in modern climate, including the rise in average surface temperature known as global warming.
- Climatic vulnerabilities are drought, flood, cyclone, heat wave, cold wave etc.
- Interventions include resource conservation practices and technologies for natural resource management.
- Efficient use of resources and inputs for improved crop, livestock and fisheries production. Enhancing resilience is the key to achieve sustainability in agriculture especially in the context of climate vulnerability.

Learning outcomes:

At the end of this session participants will be able to:

1. What is climate change
2. Understand the effects of climate change on agriculture
3. How it affects the livelihood of farmers
4. What are effect of change parameters
5. What are the resilient farming practices to mitigate the effect of climate change

Background:

What is climate change and how it affects farmer's livelihood

- Unusual weather conditions and its effect on farming
- Unseasonal rainfall, hail storm, drought, flooding all are climate change effects
- Sudden high temperature during growing period
- Sudden drought during critical period of growth

Climate resilient Agriculture:

- Scientists are working all over the world to tackle climate change which is real
- New varieties which are drought resistant,
- Mature even in high temperature during crop growth
- Resistant to pests and diseases
- Shorter duration crops to escape mid-season drought
- Selecting crops which are climate resilient

community mat nursery (Sahbhagi dhan 2012-13)

Some of the best practices to mitigate effects of climate change

Rejuvenation of farming in cyclone and flood prone coastal

- Agro-ecosystems through land shaping
- Community paddy nursery as a
- contingency measure for delayed planting
- Direct seeded rice for promoting
- water use efficiency
- Drum seeding of rice for water and timeliness in planting
- Drought tolerant paddy cultivars to tackle deficit rainfall situations
- Short duration finger millet varieties for delayed monsoon/deficit rainfall districts.
- Short duration crop varieties suitable for late sowing
- Crop diversification for livelihoods security and resilience to climate variability
- Community tanks/ponds as a means of augmentation and management of village level water resources

Some of the best practices to mitigate effects of climate change:

- Rejuvenation of farming in cyclone and flood prone coastal area
- Agro-ecosystems through land shaping

- Community paddy nursery as a contingency measure for delayed planting
- Direct seeded rice for promoting water use efficiency
- Drum seeding of rice for water and timeliness in planting
- Drought tolerant paddy cultivars to tackle defiit rainfall situations
- Individual farm ponds for small and marginal farmers
- Jalkund- low cost rainwater harvesting structures
- Check dam-Storing excess runoff in streams
- Recharge of wells to improve shallow aquifers
  Integrated farming system modules
- Improved planting methods for enhancing water use efficiency and crop productivity
- Zero till drill wheat to escape terminal heat stress
- In situ incorporation of biomass and crop residues for improving soil health
- Village level seed banks to combat seed shortages
- Fodder cultivars to tackle fodder scarcity

Session-3: Cropping systems
Duration 45 mts

Introduction:

Cropping systems and crop rotation have developed over time immemorial by farmers for food security and marketable surplus depending on **weather, soil, food needs (quantity and quality) and many other factors**. Research on the subject also has been quite wide and guided farmers for profitable cropping systems which gives maximum yield from a piece of land at the same time protect natural resources.

Cropping system: is an important component of a farming system. It represents cropping pattern used on a farm and their interaction with farm resources, other farm enterprises and available technology which determine their makeup.

Learning outcome:

At the end of session participants will be able to;

1. Review the various cropping systems that are followed in India depending on Agro climatic zones.
2. Employ the principles of crop rotation for Agro ecological Farming and maintenance of natural resources
3. Practice crop rotation
4. Factors that influence cropping system; Climate change, food and nutritional security

Polyculture practices:

Replacing a natural ecosystem with a few specifically chosen plant varieties reduces the genetic diversity found in wildlife and makes the organisms susceptible to widespread disease. The Great Irish Famine (1845–1849) is a well-known example of the dangers of monoculture. In practice, there is no single approach to sustainable agriculture, as the precise goals and methods must be adapted to each individual case. There may be some techniques of farming that are inherently in conflict with the concept of sustainability, but there is widespread misunderstanding on impacts of some practices. Today the growth of local farmers' markets offer small farms the ability to sell the products that they have grown back to the cities that they got the recycled compost from. By using local recycling this will help move people away from the slash-and-burn techniques that are the characteristic feature of shifting cultivators are often cited as inherently destructive, yet slash-and-burn cultivation has been practiced in the Amazon for at least 6000 years of the system without degradation of the natural resources.

What are the benefits of cropping systems?

1. Maintain and enhance soil fertility. Some crops are soil exhausting while others help restore soil fertility. However, a diversity of crops will maintain soil fertility and keep production level high.

2. Enhanced crop growth. Crops may provide mutual benefits to each other for. for example, reducing lodging, improving winter survival, or even acting as windbreaks to improve growth.

3. Minimize spread of disease. The more divers the species of plants and the longer period before the soil is reseeded with the same crop, the more likely disease problems will be avoided.

4. Control weeds. Crops planted at different times of the year have different weed species associated with them. Rotating crops helps prevent build up of any one serious weed species. The more different growth cycles the crops have in your rotation, the fewer weeds will be able to adapt to the field conditions.

5. Inhibit pest and insect growth. Changing crops each year to unrelated species can dramatically reduce the population of pests and insects. Corp, crop rotation frequently eliminates their food source and changes the habitat available to them.

6. Increase soil cover. Growing a diversity of crops helps keep field sizes smaller, which increases soil cover, improves solar radiation capture and reduces erosion.

7. Use resources more efficiently. Having a diverse group of crops helps to more efficiently use the available resources, natural resources, such as nutrients, sunlight and water in the soil, are evenly shared by plants over the growing period, minimizing the risk for nutrient deficiencies and drought. Other resources, such as labor, animal draft power, and machinery are also utilized more efficiently as the time and effort spent planting and harvesting crops are more spread out over the harvesting period.

8. Reduce risk for crop failure. Having a diverse group of corps helps prevent total crops equally. It also reduces food security concerns, as well as the amount of money required to finance production.

9. Improved food and financial security. Choosing an appropriate and diverse number of crops will lead to a moue regular food production throughout the year. With a lower risk for crop failure, there is a greater reliability on feed production and income generation.

Organic farming is the form of agriculture that relies on techniques such as crop rotation, green manure, compost and biological pest control to maintain soil productivity and control pests on a farm.

Organic farming excludes or strictly limits the use of manufactured fertilizers, pesticides (which include herbicides, insecticides and fungicides), plant growth regulators such as hormones, livestock antibiotics, food additives, and genetically modified organisms.

"Organic Agriculture" is a production system that sustains the health of soils, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

Seasons of India and cropping system:

1. Kharif/Rainy season- Main cropping season depending on monsoon rainfall and /or irrigation
2. Rabi/winter season: Either on residual soil moisture or irrigated conditions. Example-rabi sorghum in peninsular India.
3. Zaid or Summer season: Has to be irrigated, large tracts under summer rice where water is available

   CS: Depends on seasonal variations with temperature, day length , humidity rainfall etc.

Factors for selection of a CS

- CS depends on seasonal variations with temperature, day length, humidity, rainfall etc
- Crops to be chosen where pests and disease incidents are ecologically controllable (without chemical)
- Rotation of selected crops to be followed
- Infrastructure requirement supporting a system
- Which crop will yield maximum- yield, input required, pest control, suit local land type, weather ,income security, market
- Household food and nutrition
- Is the CS compatible with farmer's skill,
- Farming system compatibility
- Input level affordability
- Farmer's economic viability
- Access to Market, infrastructure such as road transport etc

Some of the cropping systems in India

- Rice based cropping systems
- Kharif cereals other than rice
- Maize based cropping systems
- Sorghum based cropping systems
- Millet based systems
- Groundnut based systems
- Winter cropping systems wheat- cow pea
- Rabi sorghum based cropping systems

Session-4: Soil physical properties
-Duration 60 mt

Introduction:

What is soil?

Life-supporting upper surface of earth that is the basis of all agriculture. It contains minerals and gravel from the chemical and physical weathering of rocks, decaying organic matter (humus), microorganism, insects, nutrients, water, and air.

Soils differ according to the climate, geological structure, and rainfall of the area and are constantly being formed and removed by natural, animal, and human activity

Composition of soil:

Soil composition is an important aspect of nutrient management. While soil minerals and organic matter hold and store nutrients, soil water is what readily provides nutrients for plant uptake. Soil air, too, plays an integral role since many of the microorganisms that live in the soil need air to undergo the biological processes that release additional nutrients into the soil.The basic components of soil are minerals, organic matter, water and air.

Learning outcome:

At the end of this session the participants will be able to;

1. List basic textural classes of soil, definition of texture and structure and why they are important
2. Recall how they influence water holding capacity, erosion, infiltration ease of cultivation
3. Influence texture and structure formation of a soil, what are structures found in a soil
4. A soil profile – why it is important
5. How to get a crumb structure- what is needed , role of organic matter
6. Tillage and structure – role of moisture
7. How texture influence structure formation of a soil, what are structures found in a soil

Mineral matter obtained by the disintegration and decomposition of rocks

A. **Organic matter** obtained by the decay of plant residues, animal remains and microbial tissues
B. **Water** obtained from the atmosphere and the reactions in soil (chemical, physical and microbial)
C. **Air or gases** from atmosphere, reactions of roots, microbes and chemicals in the soil
D. **Organisms** both big (worms, insects) and small (microbes)

Soil Minerals:

Soil minerals play a vital role in soil fertility since mineral surfaces serve as potential sites for nutrient storage. However, different types of soil minerals hold and retain differing amounts of nutrients. The mineral portion of soil is divided into three particle-size classes: sand, silt, and clay.

	Texture	Characteristics
Sand	Gritty	Sand is visible to the naked eye, consists of particles with low surface area, and permits excessive drainage.
Silt	Buttery	Silt is not visible to the naked eye and increases the water holding capacity of soil.
Clay	Sticky	Clay has a high surface area, high water holding capacity, many small pores, and possesses charged surfaces to attract and hold nutrients.

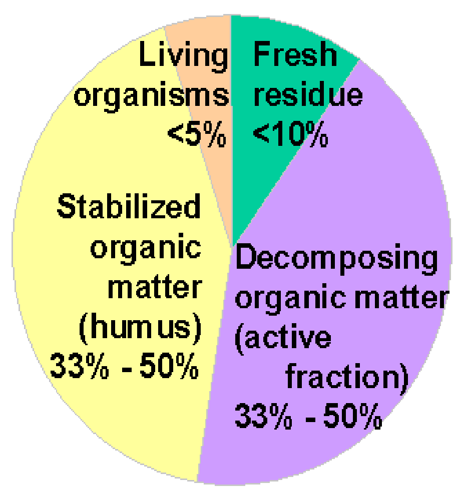
Soil organic matter includes:

- Living organisms (soil biomass)
- The remains of microorganisms that once inhabited the soil
- The remains of plants and animals

Organic compounds that have been decomposed within the soil and, over thousands of years, reduced to complex and relatively stable substances

Functions of organic matter:

1. Act as binding agent for mineral particles
2. Producing friable surface soils
3. Increase the amount of water that a soil may hold
4. Provides food for organisms that inhibits the soil
5. Humus is an integral component of organic matter



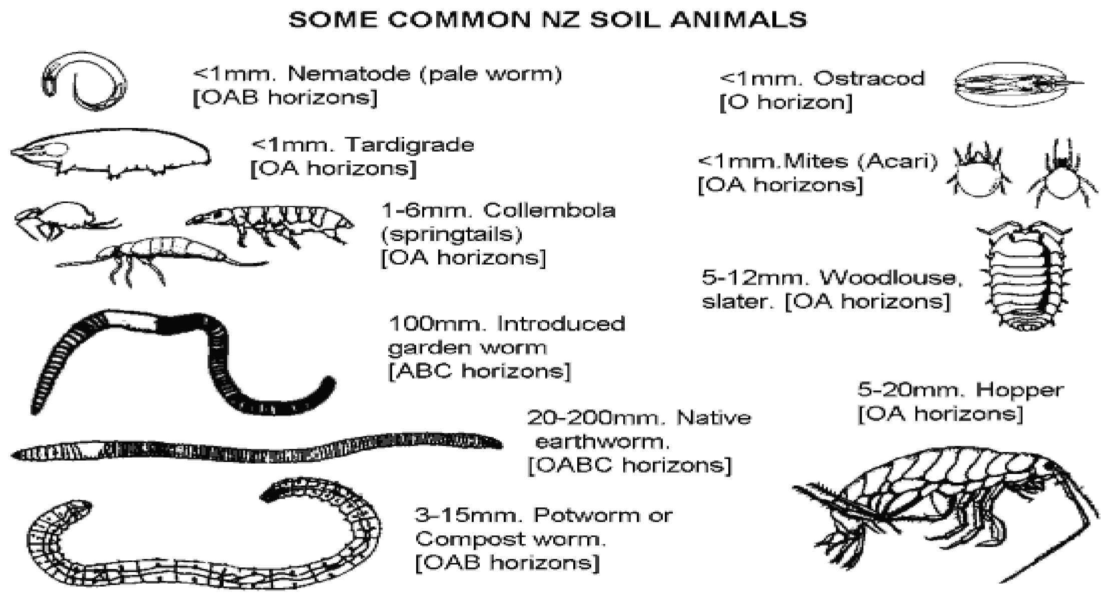
Colour of soil:

- Soil colour gives an indication of the various processes going-on in the soil as well as the type of minerals in the soil.
- **Red colour** in the soil is due to the abundance of iron oxide under oxidised conditions (well-drainage) in the soil
- **Dark colour** is generally due to the accumulation of highly decayed organic matter
- **Yellow colour** is due to hydrated iron oxides and hydroxide
- **Black nodules** are due to manganese oxides
- **Gray hues** indicate poor aeration

Soil organisms:

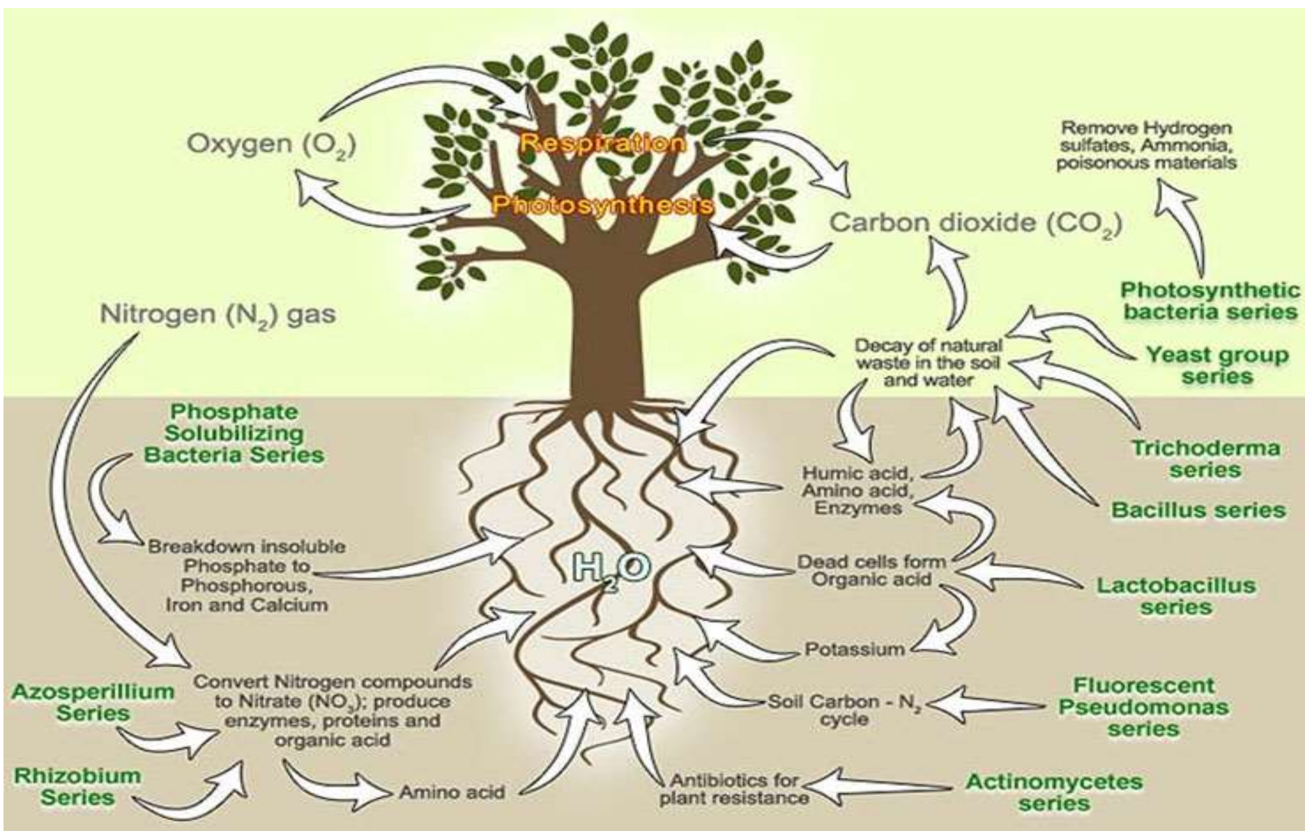
Any organism inhabiting the soil during part or all of its life. Soil organisms, which range in size from microscopic cells that digest decaying organic material to small mammals that live primarily on other soil organisms, play an important role in maintaining fertility, structure, drainage, and aeration of soil. They also break down plant and animal tissues, releasing stored nutrients and converting them into forms usable by plants. Some soil organisms are pests. Among the soil organisms that are pests of crops are nematodes, slugs and snails, symphylids, beetle larvae, fly larvae, caterpillars, and root aphids. Some soil organisms cause rots, some release substances that inhibit plant growth, and others are hosts for organisms that cause animal diseases. Since most of the functions of soil organisms are beneficial, earth with large numbers of organisms in it tends to be fertile; one square metre of rich **soil can harbour as many as 1,000,000,000 organisms.**

Type	Nutrient Cycling	Soil structure
Microflora (bacteria + fungi)	Catabolise organic matter. Mineralise and immobilise nutrients.	Produce organic compounds that bind aggregates. Hyphae entangle particles onto aggregates.
Microfauna (Pot worms, snails, slugs, millipedes)	Regulate bacterial and fungal populations. Alter nutrient turnover.	May affect aggregate structure through interactions with microflora.
Mesofauna (nemotodes, mites, spring tails)	Regulate fungal and micro faunal populations. Alter nutrient turnover. Fragment plant residues.	Produce faecal pellets. Create biopores. Promote humification.
Macro fauna (burrowing animals, such as snakes, lizards, gophers, badgers, rabbits, hares, mice, and moles)	Fragment plant residues. Stimulate microbial activity.	Mix organic and mineral particles. Redistribute organic matter and microorganisms. Create biopores. Promote humification. Produce faecal pellets.



Functions of soil organisms:

Soil organisms are responsible for performing vital functions in the soil. Soil organisms make up the diversity of life in the soil. This soil biodiversity is an important but poorly understood component of terrestrial ecosystems. Soil biodiversity is comprised of the organisms that spend all or a portion of their life cycles within the soil or on its immediate surface (including surface litter and decaying logs)



Humus formation:

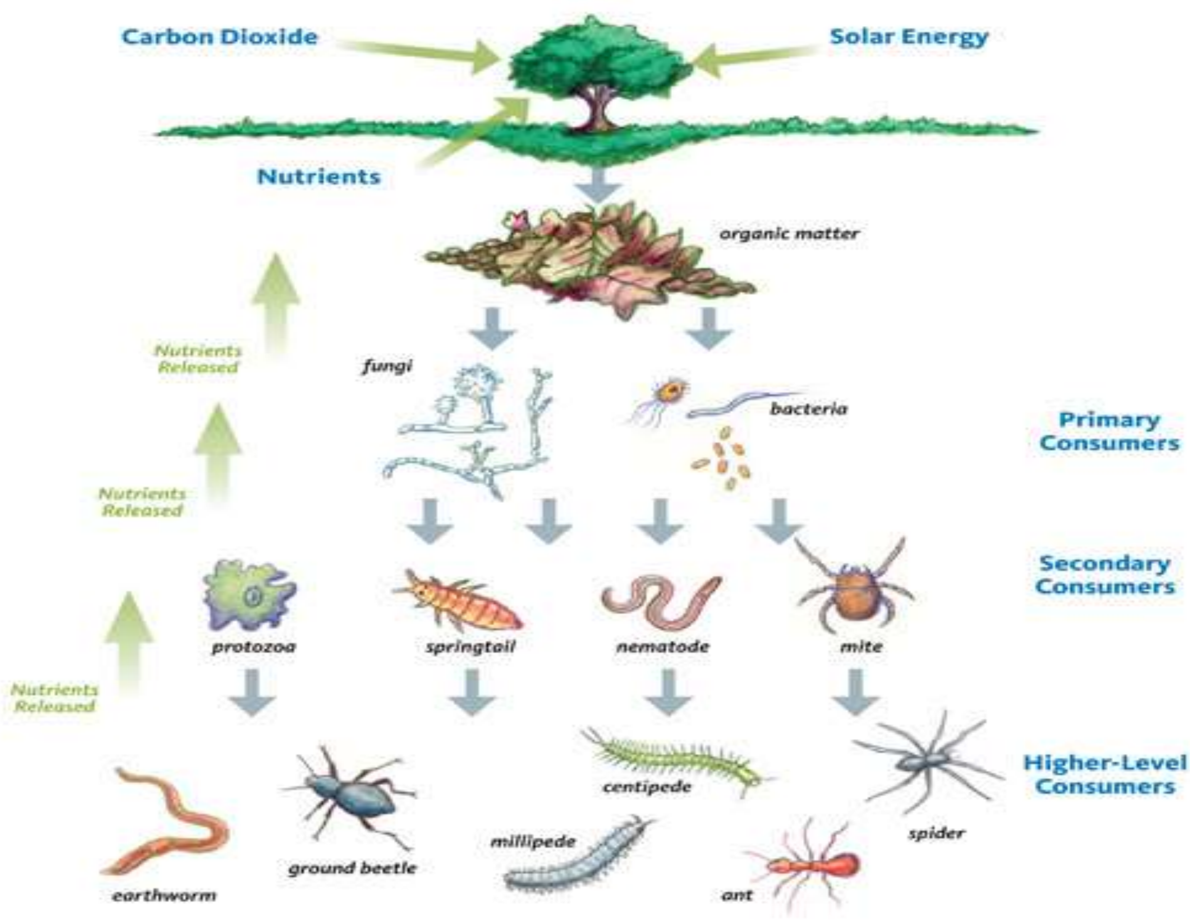
When a leaf falls it cannot be eaten by most animals. After the water-soluble components of the leaf are leached out, fungi and other microflora attack its structure, making it soft and pliable. Now the litter is palatable to a wide variety of invertebrates, which fragment it into a mulch.

The multipedes, wood lice, fly larvae, springtails, and earthworms leave the litter relatively unchanged organically, but they create a suitable substrate for the growth of the primary decomposers that break it into simpler chemical compounds. There is also a group called secondary decomposers (some creatures, such as the springtails, are in both groups), which break it down even further.

So the organic matter of leaves is constantly being digested and redigested by waves of increasingly smaller organisms. Eventually the humic substance that remains may be as little as one-fourth of the original organic matter of the litter. Gradually this humus is mixed into the soil by burrowing animals (such as moles, rabbits, etc.) and by the action of the earthworms.

Soil food web:

The soil food web is the community of organisms living all or part of their lives in the soil. A food web is a series of conversions (represented by arrows) of energy and nutrients as one organism eats another



All food webs are fuelled by the primary producers:

The plants, lichens, moss, photosynthetic bacteria, and algae that use the sun's energy to fix carbon dioxide from the atmosphere. Most other soil organisms get energy and carbon by consuming the organic compounds found in plants, other organisms, and waste by-products. A few bacteria, called chemoautotroph, get energy from nitrogen, sulphur, or iron compounds rather than carbon compounds or the sun.

As organisms decompose complex materials, or consume other organisms, nutrients are converted from one form to another, and are made available to plants and to other soil organisms. All plants – grass, trees, shrubs, agricultural crops – depend on the food web for their nutrition.

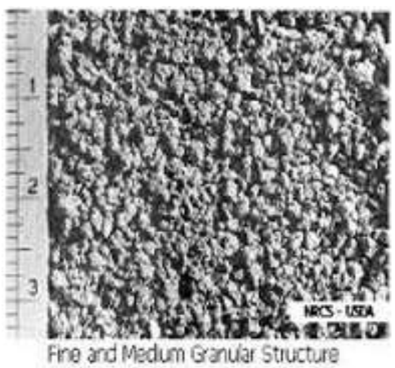
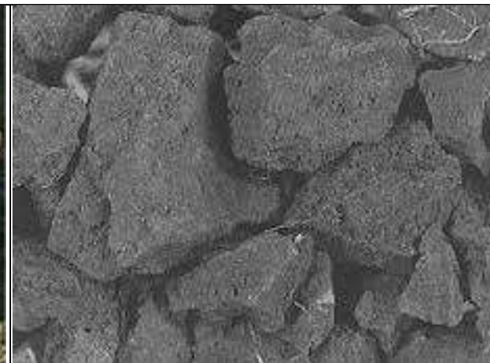
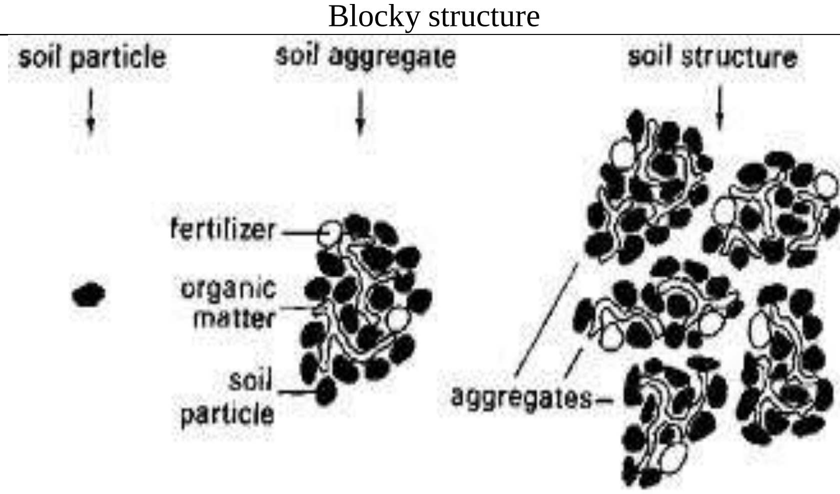
Strategies for protecting and encouraging soil organisms include:

- Limiting soil disturbance and tillage
- Restoring overly compacted soils to allow air and water movement
- Covering soil with plants or mulch
- Regularly apply layers of compost or organic mulch such as tree leaves or bark to the top of the soil
- Avoiding pesticides that may harm soil biota
- Maintaining crop diversity
- Returning weeds and crop residues to the soils
- Allowing leaves and other plant materials to decompose

Session -5: Soil structure
Duration – 45 mts

Soil structure:

Describes the arrangement of the solid parts of the soil and of the pore space located between them. It is determined by how individual soil granules clump or bind together and aggregate, and therefore, the arrangement of soil pores between them. Soil structure has a major influence on water and air movement, biological activity, root growth and seedling emergence.

		
Granular structure		Massive structure
		
Blocky structure		
		

Soils of India:		
Sr. No.	Soil types (Indian nomenclature)	States
1	Red loamy soils	A.P, T.N, Karnataka, Kerala, M.P., Orissa
2.	Red sandy soils	T.N., Karnataka, A.P.
3.	Lateritic soils	T.N, Kerala, Karnataka, A.P, Orissa, MH, Goa, Assam
4	Red and yellow soils	M.P, Orissa
5	Shallow black soils	MH, M.P, Gujarat
6.	Medium black soils	MH, M. , Gujarat
7	Deep black soils	MH, A.P, Karnataka, M.P, Gujarat
8	Mixed red and black soils	Karnataka, T.N, MH, M.P
9	Coastal alluvial soils	T.N, Kerala, A.P, MH, Gujarat
10	Coastal sands	Orissa
11	Deltaic alluvium soils	T.N, A.P, Orissa, W.B
12	Alluvial soils- old and new	U.P, Punjab, Bihar, W.B, Assam
13	Alluvium soils (calcareous)	N.E, U.P, Bihar
14	Calcareous soils	Punjab
15	Grey brown soils	Gujarat, Rajasthan
16	Dessert soil	Rajasthan
17	Terai soils	U.P, Bihar, W.B
18	Brown hill soils	U.P, Bhutan, Sikkim, H.P
19	Sub-mountain soils	U.P, J&K
20	Mountain meadow soils	Kashmir and Ladakh
21	Saline and alkali	U.P, Punjab, MH, Karnataka, T.N
22	Peaty and saline soils	Kerala
23	Skeletal soils	M.P
24	Glaciers and eternal snow	U.P, Kashmir

Session -6: Tillage and Tilth
Duration 30 mts

Learning outcome:

At the end of this session the participants will be able to;

1. Tillage and tilth definition
2. Tillage and structure – role of moisture
3. How texture influence structure formation of a soil, what are structures found in a soil
4. Optimum tillage and tilth for farming

Tillage and tilth:

Objectives of tillage:

1. To loosen the soil, granulate for plant growth
2. Kill weeds and incorporate plant residues
3. Incorporate fertilizers
4. Conserve moisture and prevent soil erosion.

Primary tillage break the massive soil structure
Secondary tillage is to prepare the seedbed
Granulate the soil
Main aim is to modify the structure for conducive to root growth
To get the granular or crumb structure

What is tilth?

Tilth is the condition of a soil which favors good contact of the seed to come with soil particles.
This will happen when a granular structure is obtained after tillage.
Tilth can be impaired if the tillage is done on too wet soil or very dry soil
Therefore moisture content of soil at a given time is very important to achieve a good tilth.

Tillage Implements:

Choice of implements will depend upon the depth and texture of the soil-

Ploughs
Harrows
Sub-soiler
Rotavators
Ridgers
BBF implements etc.

Tractor drawn tillage implements




Bullock drawn tillage implements




Why we need to know the depth of the soil and know the soil Horizon:

Depth of the top soil may vary from few centimetres to few meters depending on the type of soil. For example black soils generally are deep soil, where as red soils are shallow soils. The depth of the top layer which supports the root growth, anchorage etc will determine what sort of implements can be used for primary tillage and seedbed preparation and how much water a soil can hold. Water holding Capacity will be determined by depth as well as texture of soil. Study of soil profile will show the development of different layers of soil formation and the depth of the top soil. Therefore it is important to know the soil profile in a farmers field.

Soil horizon: cross-section of soil top, revealing horizons

Session -7: Soil chemical properties
Duration 15 mts

Learning outcome:

At the end of session participants will be able to;

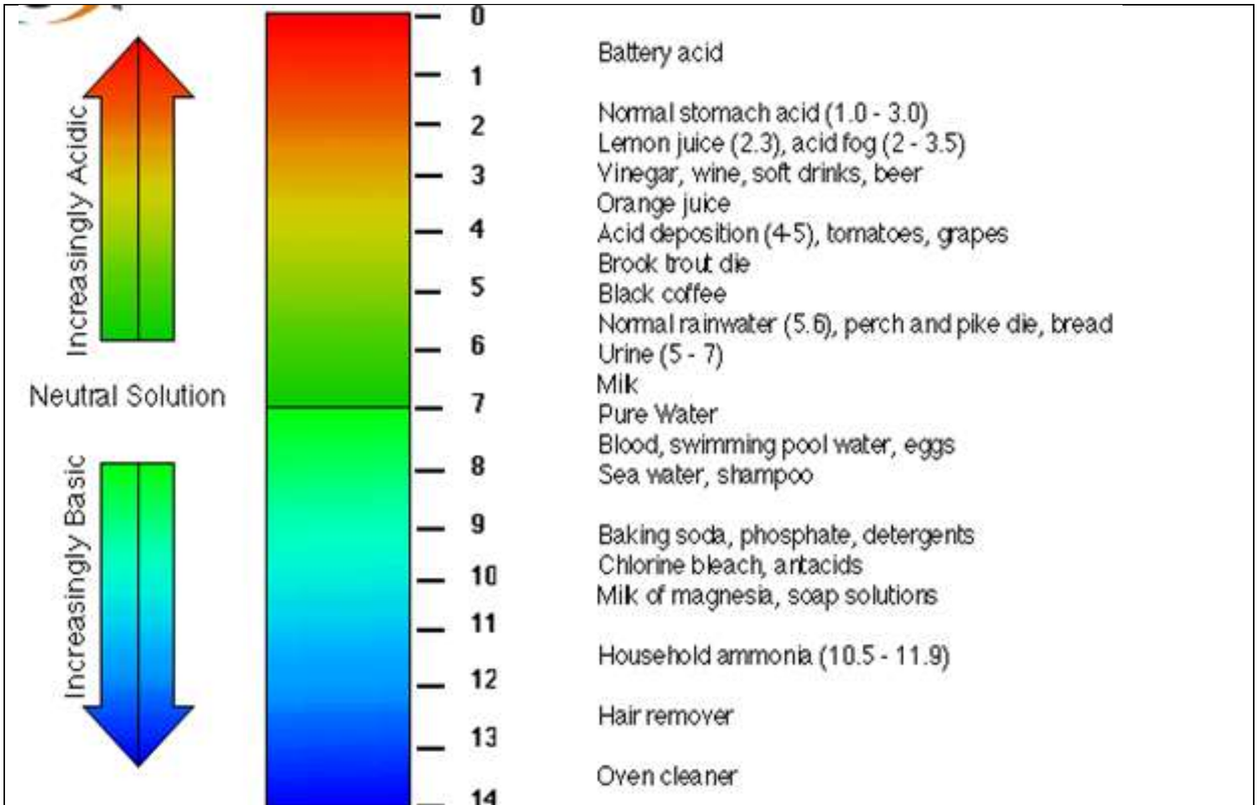
1. What is pH
2. Factors that contributes to soil pH wrt to inputs used
(a) Manures and inorganic Fertilizers, (b) water/irrigation
3. Optimum pH for mineral absorption by plants and crop growth

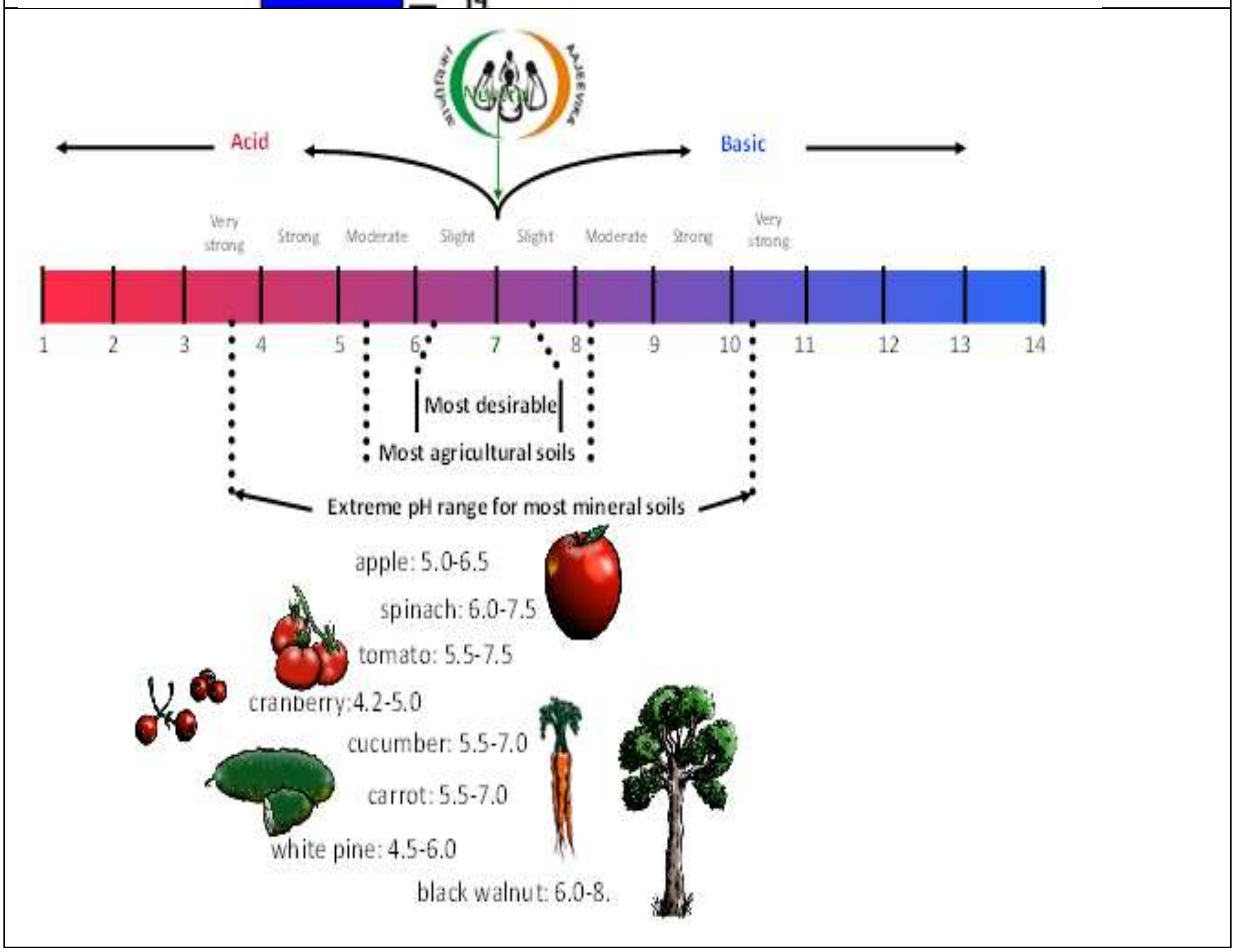
What is pH?	• It's simply a measure of the relative amount of H^+ ions • In the soil, it is driven by the ionization of water: $H_2O \rightarrow H^+ + OH^-$ • We us pH to measure the acidity or the alkalinity (basicity) of a solution (a soil solution)

The most important effect of pH in the soil is on ion solubility, which in turn affects microbial and plant growth. A pH range of 6.0 to 6.8 is ideal for most crops because it coincides with optimum solubility of the most important plant nutrients. Some minor elements (e.g., iron) and most heavy metals are more soluble at lower pH. This makes pH management important in controlling movement of heavy metals (and potential groundwater contamination) in soil.

Factors that affect soil pH:

- Some rocks and sediments produce soils that are more acidic than others: quartz-rich sandstone is acidic; limestone is alkaline
- Some types of vegetation, particularly conifers, produce organic acids, which can contribute to lower soil pH values
- In humid areas such as the eastern US, soils tend to become more acidic over time because rainfall washes away basic cations and replaces them with hydrogen
- Addition of certain fertilizers to soil can also produce hydrogen ions. Liming the soil adds calcium, which replaces exchangeable and solution H+ and raises soil pH.


Increasingly Acidic
Neutral Solution
Increasingly Basic
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Battery acid
Normal stomach acid (1.0 - 3.0)
Lemon juice (2.3), acid fog (2 - 3.5)
Vinegar, wine, soft drinks, beer
Orange juice
Acid deposition (4-5), tomatoes, grapes
Brook trout die
Black coffee
Normal rainwater (5.6), perch and pike die, bread
Urine (5 - 7)
Milk
Pure Water
Blood, swimming pool water, eggs
Sea water, shampoo
Baking soda, phosphate, detergents
Chlorine bleach, antacids
Milk of magnesia, soap solutions
Household ammonia (10.5 - 11.9)
Hair remover
Oven cleaner


Acid
Basic
Very strong
Strong
Moderate
Slight
Slight
Moderate
Strong
Very strong
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Most desirable
Most agricultural soils
Extreme pH range for most mineral soils
apple: 5.0-6.5
spinach: 6.0-7.5
tomato: 5.5-7.5
cranberry:4.2-5.0
cucumber: 5.5-7.0
carrot: 5.5-7.0
white pine: 4.5-6.0
black walnut: 6.0-8.

Session -8: Moisture requirement of crops
Duration – 45 mts

Learning outcomes:

At the this session the participants will be able to;

1. List some of the soil moisture definitions
2. Relate the importance of crop cover
3. Distinguish between transpiration and evapotranspiration
4. What are suitable soils for irrigation
5. How to conserve moisture
6. Tillage practices for moisture conservation
7. Mulching to conserve moisture
8. Vegetative barriers for conserving water

Introduction:

Crops need water for transpiration and evaporation

The plant roots suck or extract water from the soil to live and grow. The main part of this water does not remain in the plant, but escapes to the atmosphere as vapour through the plant's leaves and stem. This process is called **transpiration.** Transpiration happens mainly during the day time.

Water from an open water surface escapes as vapour to the atmosphere during the day. The same happens to water on the soil surface and to water on the leaves and stem of a plant. This process is called **evaporation**. The water need of a crop thus consists of transpiration plus evaporation. Therefore, the crop water need is also called **"evapotranspiration".**

The water need of a crop is usually expressed in mm/day, mm/month or mm/season

Suppose the water need of a certain crop in a very hot, dry climate is 10 mm/day. This means that each day the crop needs a water layer of 10 mm over the whole area on which the crop is grown . It does **not** mean that this 10 mm has to indeed be supplied by rain or irrigation every day.

It is, of course, still possible to supply, for example, 50 mm of irrigation water every 5 days. The irrigation water will then be stored in the root zone and gradually be used by the plants: every day 10 mm.

Importance of crop cover

- Initial stage – germination to early crop growth- soil has less than 10% cover
- Crop development stage – 70-80% cover
- Mid -season stage – from Crop development to flowering
- Soil moisture level has to be above the critical level which may lower yield
- Irrigation applied to field capacity
- This should take care of the net return

Some soil- moisture definitions- to understand moisture availability

- Saturation – When all the pores are filled with water
- Field capacity- when the maximum of water that is retained after allowing free drainage
- Permanent wilting points (PWP)- When a crop permanently wilts even when water is applied – symptoms of PWP…….
- Available water capacity (AWC)- Moisture content between field capacity and wilting point
- Crop rooting behavior is important- greater the root growth lesser is the sensitivity to soil

Suitable soil for irrigation

- Ideal soil would be a deep soil, without any water table, high water holding capacity
- such a s alluvial soils, black soils
- High infiltration rate (light soils)
- Low salt content
- Loam and clay soils are best
- Certain soils irrigation may not be economic all sandy soils where water drains out fast
- Heavy soil will require surface and soil drainage- drainage is also important with irrigation
- Light soils may waste water
- In rice field – 60-70% is lost due to deep percolation(half of all water goes to rice in India)
- Selection of proper soil is therefore important
- Water is lost due to evaporation and transpiration (Evapo-transpiration)

Conservation of water

- Agronomic measure – 1-6% slope
- Conserve in-situ rainfall – some are…
- Contour farming- operations such as tillage, sowing , intercultural along the contour creates barriers across slope
- Creating ridges and furrows
- Reduce run-off, soil erosion, absorb more water

Other methods are

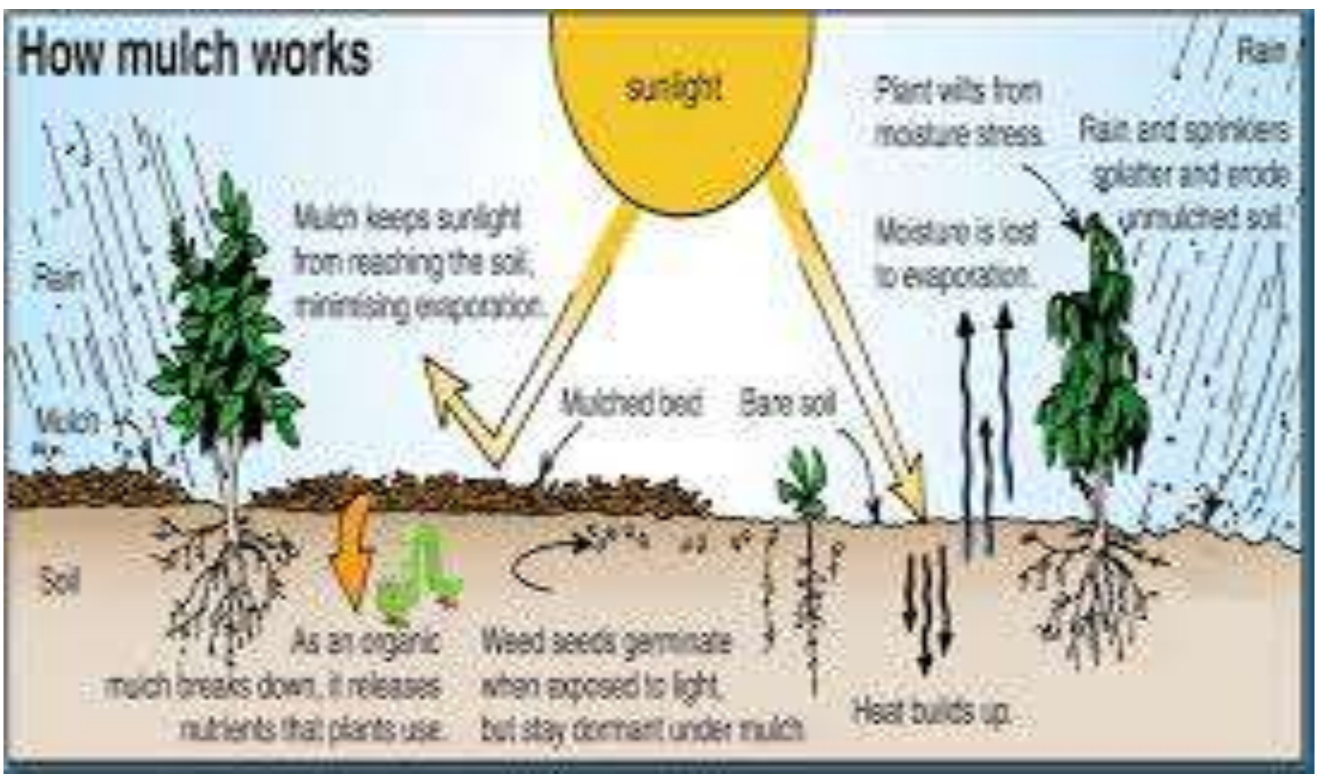
- Intercropping – legume with cereals cover the soil, reduce erosion, increase productivity
- Strip cropping- accepted all over the world towards soil erosion
- Contour strip cropping- maintain fertility, shortens length of the slope, reduce velocity
- Biological barriers – increase absorption of water
- Main crop with erosion resistant strips – maize with lantana, maize with cowpea 2:1 ratio

Mulching

- Important agronomic practice to prevent soil erosion
- Reduces evaporation, improve soil structure
- Conserve moisture
- Organic mulch @ 4 t/ha reduces run-off 37-15% and 18-5.4 ton soil loss
- Example – 2 t/ha mulch material
- Crop mulch in hilly areas – ginger, colocasia, turmeric, lantana camera
- Grass mulch in rabi
- Recycling sunhemp in situ one moth after sowing increased yield of wheat as next crop
- Weed cover, pruning of agro-forestry plants , thinned crop after planting over-population

- Leucaena – 2t/ha incorporate after 30 days of maize
- Timely sowing,
- Quick crop canopy development and manipulation to cover the bare soil as quickly as possible
- Not leaving a bare soil when monsoon comes
- Try to have a crop canopy cover soon
- Dry seeding techniques before rains (ICRISAT experience in black soil)

	
Mulch	**Inter-row mulch**



Session -9: Soil and water conservation
Duration – 45 mts

Introduction:

Learning outcome

At the end of this session the participants will be able to;

1. Define soil and water conservation
2. Conservation of water and soil by various means
3. Relate conservation tillage
4. Techniques to reduce erosion

The Extent of Erosion

The lower rainfall in semi-arid areas compared with that in humid climates does not mean a corresponding low level of soil erosion by water. Indeed rainfall erosion can be higher in semi-arid areas than in any other climatic zone. This is partly because the rainfall of semi-arid areas has a high proportion of convective thunderstorm rain of high intensity and high erosive power. It is also because there is poor protective vegetative cover, especially at the beginning of the rainy season.

Some of the soils common in semi-arid areas are particularly vulnerable, either because they have poor resistance to erosion (high erodibility), or because of their chemical and physical properties). Gully erosion can be severe in semi-arid climates and the benefit/cost of gully control needs to be considered.

There are always strong links between measures for soil conservation and measures for water conservation, and this applies equally in semi-arid areas. Many measures are directed primarily to one or the other, but most contain an element of both. Reduction of surface run-off by structures or by changes in land management will also help to reduce erosion. Similarly, reducing erosion will usually involve preventing splash erosion, or formation of crusts, or breakdown of structure, all of which will increase infiltration, and so help the water conservation.

Integrated Programmes

The subsistence farmer cannot afford to respond to philosophical or emotional appeals to care for the soil, and this means that conservation measures must have visible short-term benefits to the farmer. For the subsistence farmer the benefit he would most appreciate might be increased yields per unit of land, or perhaps better production per unit of labour, or perhaps improved reliability of yield.

The advantages are:

- A village group can tackle jobs too big for an individual or family;
- it generates a sense of community care for the land
- work groups are a good forum for extension workers to encourage improve farming

BIOLOGICAL SOIL CONSERVATION

Conservation Tillage

This umbrella term can include reduced tillage, minimum tillage, no-till, direct drill, mulch tillage, stubble-mulch farming, trash farming, strip tillage, plough-plant (for details see Mannering and Fenster 1983). In countries with advanced soil conservation programmes, particularly the USA and Australia, the concept of conservation tillage is the main theme. It is less applicable to low input level crop production, or subsistence agriculture.

The principles are equally effective in any conditions - to maximize cover by returning crop residues and not inverting the top soil, and by using a high crop density of vigorous crops. Conservation tillage also has the advantage of reducing the need for terraces or other permanent structures. However there are several disadvantages which hinder the application of conservation tillage in semi-arid conditions:

- dense plant covers may be incompatible with the well-tested strategy of using low plant populations to suit low moisture availability;
- crop residues may be of value as feed for livestock;
- planting through surface mulches is not easy for ox-drawn planters although there may be no problem with hand jab planters.

Deep Tillage

One of the reasons for low yields in semi-arid areas is the limited amount of moisture available to crop roots. The available moisture will be increased if the rooting depth is increased and it has been shown that in some cases deep tillage can help, deep tillage is beneficial for some crops but not all, and on some soils but not all. Also deep tillage requires greater draught power which is usually in short supply in semi-arid areas.

Ripping or subsoiling can be beneficial, either to increase the porosity of the soil, or to break a pan which is reducing permeability.

Conservation Farming

Like conservation tillage, this title covers many different farming techniques. It includes any farming practice which improves yield, or reliability, or decreases the inputs of labour or fertilizer, or anything else leading towards improved land husbandry, which we have defined as the foundation of good soil conservation.

Sometimes there is a long history of traditional farming and soil conservation practices which have been tested and developed over periods of time which are long enough to include all the likely variations of climate. These traditional practices should give the best long-term result, bearing in mind that the farmer's interpretation of 'best' may be based on reliability rather than maximum yield. But the semi-arid areas are changing rapidly, and the traditional patterns may be no longer relevant. As Jones (1985) says "while tradition may incorporate the wisdom of centuries of practical experience, it may also be inappropriate where recent demographic pressures have already compelled changes - for instance, the abandonment of bush fallowing or migration onto different types of soil or into more arid areas. There is also the point that the agricultural scientist very often still lacks the recipe for certain success; and you cannot require farmers to adopt new practices that are only 50 percent successful." Possible new techniques should have the same basic characteristics as traditional practices, they should be easy to understand, simple to apply, have low inputs of labour or cash, and must show a high success rate i.e. a high rate of return.

Some of the techniques are:

Farming on a grade is well established in India (Swaminathan 1982).Cultivations and planting are done on a gentle gradient, sometimes together with graded channel terraces. This encourages infiltration but permits surplus run-off at low velocities. Sometimes this may be combined with simple practices to encourage infiltration such as returning crop residues. This seldom provides a complete solution because of the problem of disposal of the surface run-off when it does occur.

Strip cropping is most useful on gentle slopes, where it may reduce erosion to acceptable levels without any banks or drains.

Rotations are another well established and simple practice. The object may be to improve fertility by the use of legumes or to help control pest or disease.

Mixed cropping and inter planting are widely applied traditional techniques. A combination of crops with different planting times and different length of growth periods spreads the labour requirement of planting and of harvesting, and also allows mid-season change of plan according to the rain in the early part of the season. Another possible advantage may arise from the use of legumes to improve the nitrogen status for the cereal crop. Variations on the theme of mixed cropping, intercropping, and relay cropping are being investigated in the Farming Systems Programme at ICRISAT (1986).

Surface mulching has the advantage of providing protective cover at a time when crop cover is not practical. It improves infiltration, and may also beneficially reduce soil temperature. Possible dis-advantages are:

- the amount of crop residue required may be more than is available from low-level production;
- problems of pest, disease, or nitrogen lock-up;
- the lack of implements which can plant or drill through the mulch;
- organic mulches are liable to be rapidly oxidized in high temperatures.

Timeliness of farming operations is always important, particularly where the rainfall is erratic, and yields can be dramatically affected by planting or cultivating at the right time. Common problems are having to wait for rain to soften the ground because it is too hard to plough when dry, and perhaps then not being able to plant because the ground is too wet. Or a family with only one ox having to wait to borrow another one - hence the interest in the one-ox plough shown in Plate 4.4. Or having to wait for a month after the rains start to get the oxen back into condition for ploughing after a hard dry season. The essence of Farming Systems Research is to look at the whole farming operation to identify the constraints or bottle-necks before starting component research on parts of the system.

Some other techniques should be mentioned, but are beyond the scope of this book, so references are given for the interested reader.

- Deep planting of varieties which can germinate from 15 cm deep, and so delay germination until good rains have fallen. Alternatively, soaking seed before planting when it is desirable to accelerate germination.

- Dry seeding where the onset of rains can be predicted.
- Improved ox-drawn implements.

Improved Water Use Efficiency

Other desirable characteristics are a short growing season, drought resistance, and drought avoidance. The latter means the ability of the plant to adjust its growth habit according to the available moisture, for example, by tillering when moisture is available or going dormant when moisture is short, or only carrying through to ripening a proportion of the seed heads available.

Supplementary irrigation can be important because the provision of small quantities of water at critical times can have good results, for example to allow earlier planting, life-saving irrigation to carry crops through dry periods, or to increase the availability of soluble plant nutrients.

In high rainfall areas a common objective is to lead unavoidable surface run-off safely off the land using drains and ditches. In semi-arid regions the objective is more likely to be to slow down the run-off to non-scouring velocities and to encourage infiltration or deposition of silt, without diverting the run-off. This requires simple low-cost structures quite different from the classical system of diversion drains, graded channel terraces, and disposal waterways. That is a high-technology layout of carefully designed structures, and the design procedures are set out in Hudson (1981). The approach is not suitable for semi-arid regions where it is unlikely that there will be suitably trained staff. Simpler techniques are required which can be laid out by village extension workers, or the farmers themselves.

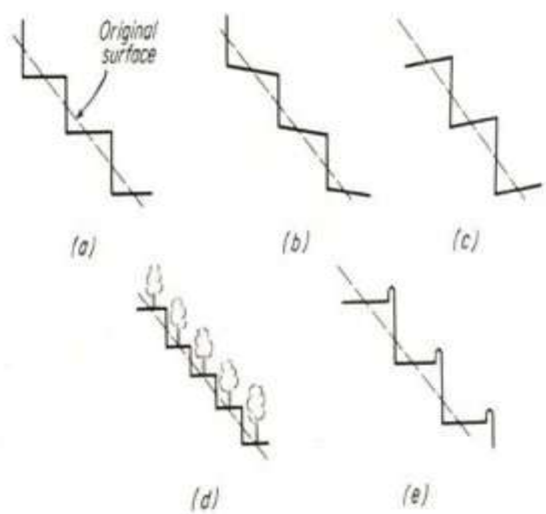
There are several well-tested methods for laying out lines either on a level contour or on a predetermined gradient. The A-frame has been widely and successfully used in Africa and in South America, and so has the water tube. In Kenya the line level is preferred. These and other simple levelling devices have been compared by Collett and Boyd (1977). Where large areas of gently sloping land are to be laid out, a simple pendulum device can be mounted on a tractor and this has been successfully used in Northern Territory of Australia (Fitzgerald 1977). Whatever method is used to lay out the lines, it is a good idea to make a permanent mark if a tractor or oxen are available. The temporary markers used when laying out the lines are easily lost or disturbed if there is a delay between surveying and construction. Also if channels or earth banks are going to be made by hand, the labour requirement can be reduced by ripping or ploughing by tractor or animals.

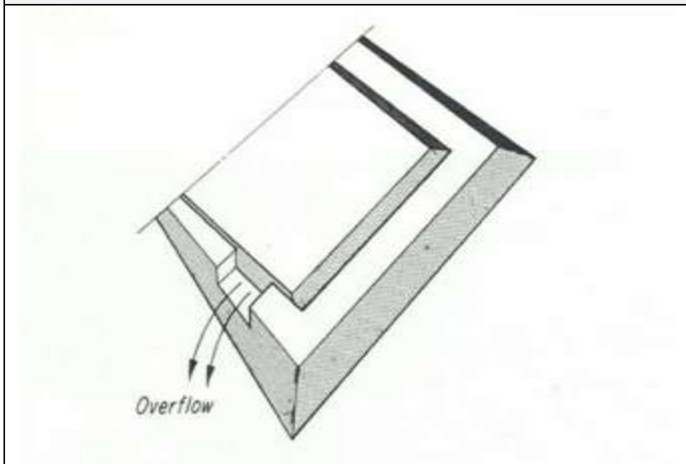
Any system of lines, banks, or bunds on the contour has the import- ant by-product of encouraging cultivation on the contour. This alone can result in a reduction of run-off and soil loss of up to 50 percent.

Low-cost Measures

The discussion of terracing and conventional conservation works clearly points to the use of simple and easily applied measures. The first of these should always be farming on the contour. This alone can reduce soil loss to approximately half of what it would be with cultivation up and down the slope. We have already seen that although rainfall in semi-arid areas will be less in total, it can still include very damaging storms, and so it will usually be beneficial to have some form of structure which will slow down the surface run-off, encourage the deposition of suspended material, and reduce the concentration of surface run-off in minor depressions.

Some applications of stone lines have the primary objective of water harvesting rather than soil conservation. Run-off from uncropped land higher up the slope runs down onto the cropland, and is spread by the permeable stone lines along with the run-off which starts on the cropland.

Before	After one season later after battering and chisel seeding
	 Plate 4.2 An example of expensive gully control from Australia (R.J. Noonan, Soil Conservation Authority, Victoria)
 Level Irrigation terraces in BHUTAN	 Figure 4.1 Types of bench terraces (a) Level bench (Plate 4.6) (b) Outward-sloping bench (c) Inward-sloping (or reverse slope) bench (d) Step terraces (Plate 4.7 (e) Irrigation terraces (Plate 4.5)

Sketch of a contour bund to retain both soil and water	Graded channel terraces
	
Live hedges of draught–resisting species to contain livestock-KENYA	A newly planted barrier to slow down run-off in Southern MALI
	
Stone lines set out on the contour	Increased moisture and deposited soil improves the grass growth near stone lines
	

Session-10: WATER HARVESTING

Duration – 60 mts

Introduction:
This section describes methods where surface run-off is collected and stored in dams, tanks, or cisterns, for later use.

Learning outcome

At the end of this session the participants will be able to;

1. Know about different water harvesting
2. Know about common water storage structures
3. Design capacity of the tank with soil structure, slope
4. Familiarity to common terms used in water harvesting and watersheds
5. Convergence-MGNREGA for land and water improvement measures

HARVESTING METHODS

The subject may be considered in terms of:

a. the purpose of the stored water, whether for domestic use, stock watering, supplementary or full irrigation;
b. the type and quantity of storage; small amounts for domestic use or stock watering; below ground in cisterns or lined ponds or above ground in tank structures; larger quantities for irrigation, usually in ponds or reservoirs;
c. whether the catchment is in its natural state or treated in some way to increase the run-off.

Stored systems nearly always modify the natural situation in some way, so there must therefore be some element of design. Factors to be considered in the design are:

· the amount of required water, which can be calculated from estimates of the numbers of people or stock and their daily requirements, or from the area and requirement of crop;
· rainfall, its frequency probability, and intensity, which combined with surface conditions will determine the run-off, and hence some change is required to increase the run-off.
· losses of the stored water through evaporation, seepage, or' leakage.

TREATMENT OF CATCHMENTS

WATER STORAGE

The harvesting and use of water by storing it in dams, tanks, and other constructed containers is too big a subject for detailed treatment here. This section reviews the principles of the more common types of storage, and for more detail readers are referred to manuals listed with the references.

Small Earth Dams

Small earth dams are probably the most common type of man-made storage, and on favourable sites are effective and economical. They do require some care in design and construction, and they need regular maintenance, but there is a wealth of information and advice available in books and manuals at all levels (Hudson 1975).

Planning earth dams

The first step in planning a dam is to define quite clearly the purpose of the dam, so that design requirements can be identified. For example, if a cattle-watering point is required in order to make use of grazing in a particular area, this means there is no point in looking for a site outside the defined area. If the water has to be available throughout the year, this means there must be a minimum depth so that water is always available after allowing for evaporation, but, on the other hand, the amount of water required for stock-watering will be much less than for an irrigation storage dam. When the purpose is irrigation this means the required amount of storage is defined, and also the period when the water must be available. When the purpose is clear, the consideration of the other following factors will be easy.

Site location

This is usually dictated by the purpose, as in the above example of providing water in a particular grazing area. When the purpose is irrigation, the location will be dictated by the answers to questions such as:

- "Can the scheme be anywhere in the district, or is there a particular piece of land to be irrigated, and which the dam has to be near?"
- "Is it a gravity scheme where the dam must be above the land? or can we pump from below?"
- "Could we have the dam site upstream and bring the water down in the stream?"
- "If the dam is at some distance from the scheme, would the supply canal have to be lined?"

Capacity

In order to plan the capacity of the dam, we need to ask "How much water will be used from the dam, and how much will the demand fluctuate through the year? What is the maximum demand? What are the consequences if the supply dries up? Is a carry-over from one year to the next necessary or desirable? What will the losses be from evaporation and from seepage?"

The shape of the valley influences how much will be stored for a given height of dam wall. The ideal site has a long throwback, that is the surface of the stored water goes a long way back upstream giving a big capacity. It will also have steep valley sides at the dam site so that the earth wall is short. A valley with gently sloping sides means a long and expensive wall. If evaporation is high, it is better to have deep water and a small surface area rather than a large surface area of shallow water. Sites with a good basin storage are often found where the stream passes from a wide valley through a narrow gorge, or where the streambed changes from a flat to a steeper gradient, or at the confluence of two streams so that there are two storage basins for one wall.

Soils

The site must have suitable soil conditions for constructing an earth dam. The soil of the basin should not be porous, and the site for the wall should be free from boulders and termite mounds. Suitable soil for constructing the wall should be available nearby. The best kinds of soil for different parts of the wall are discussed under The Embankment or Dam Wall, and Construction Sequence. Certain soils are unsuitable for the construction of dams; these include:

- saline, alkaline, or sodic soils, or any soils with abnormal chemistry;
- peat or other soils high in organic matter;
- heavy clays subject to swelling, shrinking, and cracking;
- light sands;
- soils containing a high proportion of fine silt.

Spillways

Few dams on streams and rivers can be built big enough to store all the run-off, and some provision is required to pass on the surplus flood water after the dam has filled. The spillway is the channel or pipe or waste-weir designed to do this. The cost of small earth dams is greatly increased if spillways have to be built of concrete or similar materials, so a major factor in site selection is looking for sites where the overflow can be safely discharged over grass-covered spillways.

Cut spillways

For small conservation dams one solution is open channel spillways cut into the bank at the side of the dam wall These are cheap and effective, but there is a risk of erosion if the water flows too quickly. If it is possible to maintain a good grass cover, this greatly reduces the required size of spillway, but grassed channels do require careful design and construction and may be difficult to establish and maintain in areas of poor rainfall. It is wise to limit the maximum size of catchments for dams with grassed spillways to 500 ha in semi-arid areas.

The most vulnerable point on cut spillways is where the water rejoins the stream. To prevent erosion at this point the stream bank must be cut back to a gentle slope and planted with grass like the rest of the spillway. Alternatively, a concrete or masonry drop structure may be provided at this point.

It is undesirable for grass spillways to be constantly saturated. This makes them more vulnerable to erosion because the types of grass which are best for spillways do not like continually wet conditions. So if a stream is likely to have a small constant flow, or one which continues a considerable time after each storm, a trickle flow outlet should be provided. This can take the form of a small brick-lined or concrete channel set in the spillway, or it can be a small diameter pipe going through the dam wall, preferably on the opposite side of the stream from the spillway.

If it is not practical to protect a cut spillway with grass, it may be necessary to protect it, or perhaps the most vulnerable parts, with stone pitching or concrete.

Mechanical spillways

These use pipes to pass the flood through the embankment. It would not be practical to have the pipe large enough to pass the maximum peak flow, so temporary flood storage is provided above the pipe outlet.

This fills up during the height of the flood, and discharges through the pipe after the peak flow has passed . An emergency spillway is also provided for the exceptional floods. Drop inlets are often used at the entry to pipe spillways, partly to ensure a good discharge through the pipe and partly so that the pipe can be buried below the dam wall ,

The embankment or dam wall

Impermeable core

Seepage through or under the dam wall must be prevented, or reduced to the point where it is not important. Unless the whole wall can be built of impervious material, a central impermeable core of compacted clay is required as shown in Figure 6.6. The width can suit the method of construction. If the trench is excavated by hand, and the core material is placed by hand, the core can be as little as 1 m wide, but if done by machine it will have to be at least as wide as the machine. The excavated material from the trench can be used in the downstream side of the wall. The important points in constructing the core are as follows:

it must be taken down to, and bedded into, an impervious layer so that there is no risk of seepage below it;

· it must be continued up to slightly above the full supply level along the whole length of the wall and at both ends;

the material used for the core must have enough clay so that it is plastic and workable when wet. For dams which will remain full for most of the time, so the core will not dry out, a pure clay can be used, but for smaller dams which may dry up, a pure clay might shrink and crack, so a sandy clay will be better;

the material must be properly placed and compacted. The best way is to place the clay in thin layers, add enough water to make it plastic and to 'puddle' it, that is, to compact it by labourers ramming it with poles. Another good method is to drive cattle, oxen, or buffaloes up and down over each layer of clay. When using earth-moving machinery, the soil should be placed by a scraper in thin layers, and compacted when wet by wheeled tractors or by sheepfoot rollers. Placing the soil by bulldozer is not satisfactory, nor is compaction by tracked tractors.

Side slopes

The embankment walls must slope inwards at an angle which will be stable at all times. Saturated soil is less stable than dry soil, so the water side of the wall has to be flatter than the downstream side. For most soils the slopes should be not steeper than 3:1 on the upstream side and 2:1 on the downstream. For soils approaching the ideal mixture of grain sizes and which are carefully placed and well compacted, the slopes could be increased to 2:1 upstream and 11/2:1 downstream. Soils which will be difficult to compact should have slopes of 3:1 or 4:1. For small dams the slope does not make much difference to the total costs, so if there is any doubt a flatter slope should be used.

Crest width

The top of the dam wall must be wide enough for both the construction equipment and for any traffic if the wall is going to be used as a bridge. Unnecessary width will add to the volume of earth-work required. If the wall will only carry foot traffic and bicycles, 2 m will be enough, but for vehicles a minimum of 3 m should be allowed.

Settlement

No matter how carefully the earth is placed and compacted, there will be settlement over the years, and an allowance must be made for this. For average soils with reasonable compaction 10 percent should be added to the finally required height. This means that the newly built wall will be convex along the top as the allowance for settlement will be greater in the middle than at the ends. Embankments built without consolidation, for example those built by bulldozers, are not recommended, but if this method of construction is unavoidable the allowance for settlement should be 20 percent.

Construction sequence

a. Site preparation

The limits of the wall at ground level should be staked out, and all trees, shrubs, and roots removed. Next the grass, grass roots, and topsoil should be dozed off to a depth of about 100 mm. This material should be stockpiled just clear of the site on the down stream side as it will be used at the end of the job to give a dressing of topsoil over the whole wall.

b. Borrow areas

The areas from which soil is to be taken for the embankment should be within the area to be flooded as this increases the capacity, and also avoids bare areas which would be liable to erosion. The borrow area should be near the wall to reduce the haul distance, but not closer than 10 m or seepage under the wall may be increased. The topsoil should be bulldozed off the borrow areas, and stockpiled like the topsoil from the dam wall site.

c. Outlet pipes

It is always difficult to consolidate earth placed around a pipe already in position. The best method is to put the pipe in undisturbed soil under the dam wall. The joints in the pipes must be made carefully and checked for water tightness as leakage would threaten the security of the dam. The staunching rings both hold the pipe in place and also prevent seepage along the pipe. They are cast directly against undisturbed earth, that is without using formwork. If the wall is to have a clay core, the pipe can pass through the core trench, with a concrete curtain wall as shown in Figure 6.5.

d. Building the embankment

The rules for placing the soil of the embankment are the same as for the core, that is, it should be placed in thin layers, and well compacted. Adding water may assist the compaction, but this is a refinement not usually necessary on small dams. Placing soil by bulldozer is always undesirable, because it will not be properly compacted.

e. Finishing works

The embankment should be given a thin cover of the topsoil removed from the site of the embankment and from the borrow pits, and then planted or sown with a suitable grass. The crest and the downstream slope should have a good tough dryland creeping grass, and the upstream side one which will tolerate occasional drowning. The spillway and training wall should also be carefully grassed, and given other protection as required, such as stone pitching. It is always sound practice to fence off the embankment and spillway, and if cattle will water at the dam it is preferable to fence off the whole dam and to pipe water to a drinking trough below the dam wall.

Small Weirs

Weirs are structures of concrete, brick, or masonry, where the water flows over the top when the storage is full. They may be more suitable than earth dams in some situations, for example:

- when the permanent flow is too big to pass through a spillway;
- when the object is to raise the water level so that part of the flow can be diverted into a canal, but storage is not required;
- when the object is gully control, or to trap sediment.

The main types of weir are shown in Figure 6.7. Gravity weirs depend solely on weight for their stability. A symmetrical section (Figure 6.7a) can be used, but the section in Figure 6.7b gives the same height with less material and . For weirs not built in steps (Figure 6.7c), the back slope is at 2 horizontal to 3 vertical. The crest width depends on the wall height as follows:

· wall height up to 1 m, crest width 0.3 m;

· wall height 1-1.5 m, crest width 0.4 m;

· wall height 1.5-2 m, crest width 0.5 m.

The weir can be entirely concrete, as in Figure 6.7c, formed by pouring concrete into wooden shuttering. Alternatively, masonry can be used to form the outside layer and act as the shuttering. Brickwork can also be used as shuttering . Another kind of gravity weir is the rock-fill dam, in which a pile of rocks and boulders gives the stability, and a concrete skin makes it watertight.

The large amount of material necessary for gravity weirs can be reduced by slab-and-buttress weirs , or arch weirs . In the slab-and-buttress, the vertical slab is held up against the pressure of water by the buttress, and in the arch weir the pressure of water is resisted by the buttresses at each end. Both these kinds of weir can be built of concrete, brick, or masonry, and can be built up to a height of about lm without design calculations. An engineer should be called in for larger weirs, or in cases where failure would cause serious damage.

Construction

The essential requirement for all weirs is a solid rock foundation extending the full width of the stream channel. Building weirs on poor foundations or on a rock bar which only goes halfway across may be possible, but should be left to engineers.

The first step is to clean off thoroughly all dirt and soil, chip off any loose or cracked rock, and if the surface is worn smooth by the water it should be roughened by chipping. To get a good bond between the foundation and the concrete, a grout (cement and water mixed to the consistency of thick cream) is brushed into the rock surface. Brick masonry shuttering is built using a mortar mix of six sand to one cement (by volume) and all joints should be completely filled with mortar. The concrete of a gravity weir does not require great strength, but this should be obtained by the use of an economical mix of good materials, rather than the use of poor materials. The cement should be fresh, and the sand should be clean and free from soil, dirt, and organic matter. River sand is quite suitable if clean; if not, it should be washed. Coarse stone aggregate must be clean and free from soil and dirt. Ideally, it should be a graded mixture of stones from 2 mm to 50 mm. River washed pebbles and gravel are suitable if clean.

A suitable mix is 1 part cement by volume, 3 parts sand, 6 parts stone. The quantities required per cubic metre of concrete are 0.15 m^3 cement, 0.5 m^3 sand, 1 m^3 stone, and 70 l of water. The order of mixing is not the same for mechanical mixers and mixing by hand. For mechanical mixers the stone is put in first, then the sand, then the cement, and then the water. For hand mixing, the cement and sand are thoroughly mixed dry, then the stone, and finally the water.

New concrete should not be allowed to dry out too quickly as this causes shrinkage, cracking, and loss of strength. It should be 'cured' for at least seven days, that is, kept moist by covering with wet sacks. The most common causes of poor quality concrete are:

- using sand or stone contaminated with soil,
- using too much water, and
- not curing properly.

Sand Dams

It is not necessary for water storage to be in the form of free water open to the atmosphere. Sand can store substantial quantities of water in the voids between the particles if they are not filled by smaller particles. A coarse sand of uniform size could store up to 45 percent of its volume as water within the sand. The sand in river beds usually has a mixture of grain sizes but may hold up to 30 percent water, of which about half would drain under gravity. The fact that apparently dry sand river beds contain water at accessible depths is known and exploited by all dwellers of the deserts, both human and animal.

The volume of sand trapped behind a weir will depend on choosing a suitable site, and the storage capacity can be increased over a period of time. If the weir is built progressively in stages of about one metre, the flood will deposit coarse sand behind the weir, but the silt and clay will be carried over the weir by the flood. A second stage can then be added to the weir to trap a second layer and so on progressively to the required height

There are a number of advantages to storage in this manner:

- once the water level has sunk to 1 m below the sand surface the evaporation loss is negligible;
- the risk of waterborne diseases such as malaria and bilharzia, or contamination by animals, is greatly reduced;

- by installing a pipe through the weir, a supply of clean piped water can be supplied downstream from the weir.

In India, the use of off-stream storage is widespread in what are called 'tanks'. It is quite common for them to have sophisticated water control as in the inundation tanks and khadins , and the tanks are frequently multi-purpose, being for combinations of domestic use, stock consumption, fish production, and irrigation. Deep water pools are sometimes provided within the tank so that fish can survive between rainy seasons, with no fishing permitted in these sanctuary pools.

ii. Rectangular tanks

This is the best shape for gently sloping land and can give S/E ratios of 1.5 to 2.5 . Catch drains pick up surface run-off, and when the reservoir is full any surplus is spilled safely through overflows in the catch drains. These are also called tank-dams. Small sizes for stock watering can be built economically using either a drag-line excavator, or a small farm tractor and scoop, or by hand.

iii. Ring tanks

On flat, or nearly flat ground, better S/E ratios are obtained from round tanks rather than square tanks. Because of the geometry of this shape, the S/E ratio increases with size, being about 1.5 for a 50 m diameter tank holding about 35 000 m^3 to 4.5 for 200 m diameter holding 200 000 m^3 .

iv. Turkeys nest tank

· if the surface soil is relatively impermeable, but overlies a more porous material, or

· where it is convenient to be able to distribute the water by gravity.

The S/E ratio is poor, from 0.2 at 200 m^3 to 0.4 at about 5000 m^3, and the main use is as an alternative to corrugated-iron storage tanks for small quantities of pumped water used for stock watering.

LOSSES OF STORED WATER

The main causes of loss of stored water are seepage through a leaking basin or dam wall, and evaporation from the surface. Many methods have been developed for controlling both, but few are economically attractive.

Seepage Losses

Losses from seepage can, to some extent, be reduced by site selection, avoiding sands and gravels. The Australian experience suggests that it is often cheaper to build a new storage tank on another site than to try to correct seepage in an existing tank .

Other chemical additives are used. One type relies on deflocculation to disperse the aggregates and seal the pores. Sodium salts or polyphosphates are used. A colloidal clay marketed under the trade name 'Bentonite' has a flocculating effect from its sodium salt content, and also disperses to fine particles which have a sealing effect. Chemical additives are usually only economic if cheap local supplies are available. The amount required varies according to the soil and should be determined from soil tests for example a well-graded soil will require about 5 kg of Bentonite per m^2 up to 20 kg on sandy soils.

The surface membranes, discussed in Section 6.3, for improving run-off from catchments are all possible solutions to reducing seepage from dams, with the same general conclusion. Thin cheap membranes like the polyethylene are not sufficiently robust or long lasting, while the stronger and more durable materials like butyl rubber are too expensive.

Evaporation Losses

To some extent evaporation losses can be reduced by management. If the surface area can be reduced by increasing the depth, this will both reduce the evaporating surface and also lower the incoming radiation and the heating effect. The surface area can also be reduced by storing the water in a compartmented reservoir, and pumping the water from one compartment to another as the water is used, so that there are some full compartments and some empty, instead of a single shallow sheet when the reservoir is partly full.

Shading the water surface can substantially reduce the evaporation. Crow and Manges (1967) showed that a plastic mesh which gave only 6 percent shade reduced the evaporation by 26 percent, while a mesh which gave a 47 percent shade reduced evaporation by 44 percent. However, suspending nets or branches over the water surface is expensive, and no floating mesh has yet been successful.

DEVELOPING GROUNDWATER

Storage of water within the soil profile was discussed in Chapter 5, and storage using structures and in sand rivers was discussed in Section 6.3. This section is about deep storage and extraction.

Groundwater Recharge

The possible sources of water for recharge are spate flows in streams and rivers, run-off collected by furrows or channels, and run-off stored in tanks or dams.

The conditions required for recharge to be practical are:

· adequate surface infiltration for the water to be absorbed, and permeability so that it can move below the surface;

· good water storage capacity. For rock this is defined as the specific yield, or the volume of water which drains from the rock under gravity. It is expressed as a percentage of the total rock volume, and is similar to the porosity of soils. In rocks it depends on the amount of weathering, joints, cracks, and fissures;

· good hydraulic conductivity is required: the rate at which water can be abstracted from or recharged into the rock depends upon its hydraulic conductivity.

Two problems which may occur with recharge are salinity and silting. Storm run-off and flood water in streams and rivers are usually low in salts because of the dilution, although there are cases of semi-arid saline soils where even the flood run-off is saline. The more common problem of salinity is where raising the water table brings up saline groundwater to within the reach of wells or plant roots.

Silting may be a problem because the flash run-off in semi-arid areas usually carries a heavy sediment load which is likely to block the soil surface and reduce infiltration. Siltation tanks are commonly used to reduce this problem, for example, in the systems of recharging groundwater in the San Joaquin Valley in California.

Methods of recharge

The methods of water spreading for groundwater recharge, either by carrying run-off to an infiltration zone, or it may happen almost accidently by seepage through the bottom of canal. Accidental seepage from canals may be beneficial where a rise in the water table is helpful, but it can also lead to undesirable results by causing water logging or salinity problems.

If there are aquifers, such as gravel beds, at moderate depth below the soil surface the basin method may be employed. This consists of excavating basins to a depth which extends into the aquifer, so that the basin may be filled from a canal and then left to seep into the aquifer, and then filled again. The inundation tanks or khadins are primarily intended for wetting the soil profile in the floor of the tank, but they have a subsidiary recharge effect, which improves the yield of shallow wells downstream from the tank. When the basins are specially built for groundwater recharge, it will be necessary to avoid them being choked by sediment in the water. Silt-trap tanks may be used, or another method is periodically to remove a shallow layer from the soil surface in the basin.

Another variation, when the aquifer is too far below the surface for the basin system, is to discharge the water into shafts or wells excavated into the aquifer. In this case it is more difficult to correct the effects of choking by sediment, although it can be done by back-wash pumping. A better solution is to use water which is free from sediment.

Shallow wells are a very common way of using groundwater. In India a common design is a stone-lined circular well up to 10 or 15 metres in diameter and similar depth, or rectangular wells of similar capacity. This large capacity is required because both the clay soil and the underlying rock have a low hydraulic conductivity. The well is emptied each day by domestic use, stock watering, and small-scale irrigation, and is replenished overnight. This traditional method has been successfully operated for centuries when the water was lifted by hand or ox-power, but in some districts the widespread introduction of first diesel-engined pumps and more recently electric motors has meant that the water can be removed much more quickly. This has led to searches for increased capacity and delivery. In the Deccan Plateau, a common device is to drill small bores (30-50 mm) radially and horizontally outwards in an attempt to tap more faults and fissures in the rock. The same technique of increasing the yield of wells is used in Iran where the horizontal collectors are shafts or galleries driven by hand labour.

Rain fed sustainable Agriculture (RFSA)

RFSA refers to radical soil and moisture conservation works which include Conservation furrows for every four m, trenches all around the field, farm pond, trees on conservation furrows etc. The main objective is to harvest rain water in-situ. Mounting cropping pattern in these fields with 5:1 and 7:1 ratio, including perennial Red gram, Castor, leafy vegetables, fruit plants and trees on conservation furrows. Following are the major components in RFSA

- Conservative or deep furrows for every four meters.
- Trench around the field.
- Farm ponds.

What is the conservative furrow?

Any furrow which is made deep across the slope at a distance of every four metres is called a conservation or deep furrow. It should be measured as 1.0 metres width at the surface 0.3 metres width at the bottom and 0.5 metres depth.

Importance of a Conservative furrows:

As there is a conservative furrow in the agriculture field, every drop of rain water is **n**ot wasted and the entire rain water sinks in the soil. This results in increasing the level of **g**round water. Though there is much gap between one rain and the other, plants grow healthy due to the wet condition of the soil. It protects from erosion of fertile soil. Since different varieties of crops are grown in the middle of the conservative furrow, there is a lot of possibility for food security.

Formation of a conservative furrows:

Some gradient should be given to the conservation furrows if it black soil. Removal of soil must be done after digging from the upper measurement to the bottom of the pit till certain slope is formed Below the slope the removed soil should be pounded in the shape of trapezium leaving the burn equal to the depth of the pit. Measurements should be taken to the pit that is dug instead the bund.

What kind of crops are to be grown?

Small farmers in our state mostly depend on Rain fed Agriculture. Most of the small Farmers grow crops like Maize, Sorghum and Bazra as single crops and they incur heavy loss when the conditions are unfavourable. Hence there should be rapid changes in the field of agriculture. Farmers should focus on poly crops instead of mono crops. Mixed crops means growing pulses like deep rooted red grams between two main crops like Maize and Sorghum. If we grow mixed crops like this at least one crop yields good though the Climatic conditions are unfavourable between every two conservative furrows for every four meters three furrows of Green or black grams, one furrow of Red gram, 2 furrows Sesame, 2 furrows of Maize etc are to be grown as mixed crops. The fertility of soil increases due to these pulses. Deep rooted crops like Redgram (Pulses) can easily resist the conditions of famine. Maize and sesame cause a lot of food security. The Budget for conservative furrows in one acre of land.

Planting of trees on Conservative furrows:

Shadow giving plants like Glyrisidin, Subabul, Kanuga, Munaga may be planted if the slope of the soil is in the east-west direction. If the slope of the soil is in the North-South direction plants which give less shadow (i.e casuarinas, Teak and custard) may be grown. On the swellings of the conservative furrow plants like papaya, Karivepa (Curry leaf tree)may be planted for every 3 metres distance. Between these 3 metres length for every 1.5metres length the seeds of either perennial red gram or castor must be sown. Between every 12 to 12 metres length plants like Mango, Jack tree, wood apple tree etc. may be grown.

Digging a Trench around the field:

Digging trenches (ditch) around the agricultural field is useful for preserving the rain water. Trenches that are dug along the agricultural fields are known as ditches or trenches. The soil that comes out by digging of the trenches. The soil that comes out by digging of the trenches is used to build banks of trench. A trench also helps in sinking water into the soil. Like this a trench yields good results. If more water is accumulated in a trench or ditch, it should be directed to a soak pit. Soak pits should be built at the end of the trenches (ditches) according to the nature of the slope

Plantation on the banks of trenches:

On the banks of the trenches thorny plants like Teak, Aloe, wood apple, plum tree, Soap-nut, Kalimi, Gorintaku, Gatchakaya, Chillakampa, Mangala Girikampa, Boganvillia may be planted. In addition to the above plants. Glyricydia, and Subabul also may be planted. Besides the above plants serve as living fence they can prevent the speed of the wind. These plants are useful to protect the mixed crops from cattle. After 4 or 5 years these plants give us more income by selling timber and wood.

Advantages:

- To prevent soil from erosion.
- After filling the trench (ditch) rain water is not allowed to flow out of the bund of the clay (soil) removed from the ditch
- It helps water to sink
- As fruit bearing plants are planted in and around the ditch (trench), they grow well and they are used for the protection of natural fertility of soil and conservation water. Develops greenery
- It increasing ground water, and developing moisture.

Construction of the side trenches:

- We must dig the trenches as per the measurements already fixed. Width and depth also must be as per norms.
- Removed soil must be poured under the slope / beyond the boundary.
- While digging the trench and making the bank the same depth and height should be maintained along the ditch. (Trench).
- In every pit that is dug we must leave clay flacks (Thandlu) at a distance of 15 to 20metres with a width of 30 cm.
- The clay balls of the bundle must be broken and smashed and we must make a base of the bund with the clay.
- On the clay bundles (banks) the seeds of stylo Hemata, local grass seeds, perennial Red gram, seeds of caster, and creepers of vegetables may be sown. This can prevent erosion of the clay bank (clay bundle)
- Per one acre of land the length of the ditch / trench will be 280 metres.
- We must utilize the trench / ditch as a live fence. Thorny plants and famine resistant plant and drought resistant plants must be planted on the trench.

Farm pond:

Small water ponds used for storing excessive rain water coming out of their fields.

Advantages:

- Used as drinking water for cattle and labourers in summer.
- Providing essential water for fruit bearing plants and Kanuga plants.

- Decreasing the speed of the flowing water and eradicating erosion of soil.
- Providing essential water to the vegetable plants in Rain fed region.
- Providing water for spraying kernels
- Helps in developing fish culture or Aqua culture in farm ponds.

Formation of farm ponds:

- Basing on the physical conditions these ponds may be constructed in the shape of a square or cube
- Pond must be dug in the required length and depth as per the measurement of the bottom.
- After words measurement from upper surface to the bottom of the farm pond it should be dug by removing soil till certain slope is formed.
- Leaving inlet and outlet, putting apart the of the pond equally deep, the removed soil should be placed in the shape of trapezium and sectioning must be done with the soil.
- According to the types of soil side slope may be from 1 ½ :1 to 1:1.
- There should be no hindrance for water either by removing soil from the farm pond or flowing of excess water after the pond is filled.
- The clay balls of the bank should be broken and smashed to form a smooth base or to make base like structure.
- In the direction of water of the farm pond at the bottom of a trench should be constructed with pebble stones measuring 9".
- The slope through which water comes into the pond and the slope through which water goes out from the pond should be constructed as revetment with pebble stones
- If the pond is constructed for drinking water facility for cattle the inlet side slope(inlet) should be 4:1

Tank Silt:

- Removal of Tank Silt and shifting of the tank silt to the lands cultivated by S.C, S.T, small farmers.
- Where there is possibility for removing silt from tanks and shifting of the silt to the lands cultivates by farmers. Tractors be used for the transport of silt. Transport charges will be paid in case of the silt is shifted to the lands of SC / ST, small farmers.
- Machines like JCB, should not be used.
- We must register day wise reports on tractor usage. We must register the names of the benefited farmers and drivers and take their signature at an appropriate place.
- Labourers will be paid for removing the tank silt and the driver of the vehicle will be paid for shifting the silt.

Fruit Gardens:

- The main aim of the scheme is to show income resources to scheduled castes, scheduled tribe and the farmers below poverty line by planting fruit bearing trees.
- It is to conserve Environment in draught prone areas by growing fruit bearing trees on permanent basis.
- Improving health security.

Size of pits: 0.6 X 0.6 X 0.6 metres pits – 25 per one acre.

Selection of Seedlings:

- Primary root and scion should be thickly attached.
- There should be no new twigs on the top the primary root.
- Grafting should be done above 15 to 20 cms height above the stalk
- Grafting should be done only on healthy plants which are free from diseases.

Distance between plants: Multi storied fields Measuring 36 X 36

12 meters	**6 meters**	**3 meters**
Mango	Orange	Custard apple
Sapota	Lemon	Drum stick
Muk berry	Guava	Papaya
	Cashew	Plantain

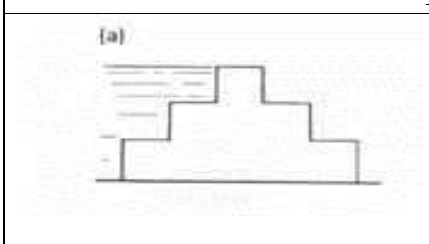
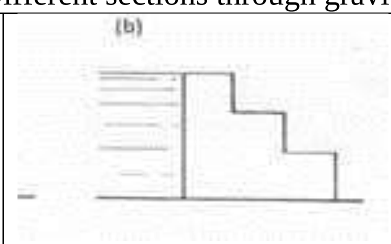
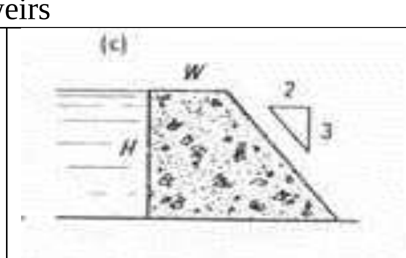
Soak Pits: The pits dug in the cultivated land to store water are called soak pits. The soak pit should be dug at the end of the field in the direction of the slope. The excessive rainwater should be diverted to the soak pit to prevent wastage of water.

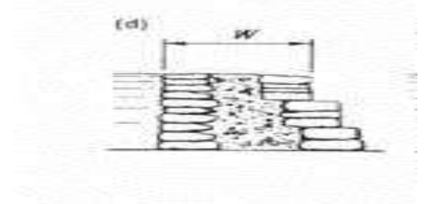
How to dig the Pit?

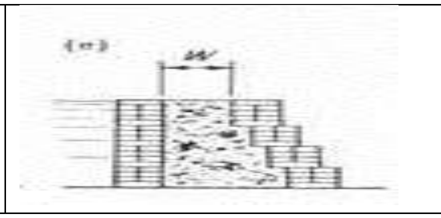
The soak pit should be dug as per the following measurements. Upper surface: 8 X 8 metres length and width 2, metre depth. Bottom: 4 X 2 metres length and width. The soak pit enables to increase ground water levels. The water in the soak pit can be used to save the crops under the conditions of drought or famine.

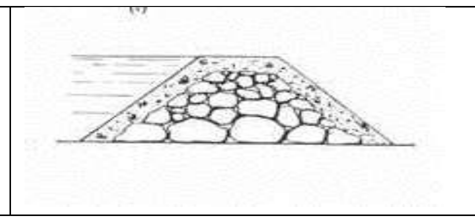
Advantages:

Small soak pits are needed in rain fed agricultural lands, drought prone areas and the places where moderate rain fall is common. If silt is removed every year, the water storage capacity will not be decreased. The fertility of the soil increased if the silted soil is spread as a layer in the same field. Farmers may be benefited by planting creepers like ridge (angular) gourd, snake gourds pumpkins, cucumbers etc on the bank of the soak(water) pits.

Example of small weirs		
Different sections through gravity weirs		
		
Masonry used as shuttering for a concrete weir	Brickwork used as shuttering for a concrete weir	Rock fill dam with a concrete skin







Different water harvesting structures

Land and water resource development under NREGA and other government schemes:
MGNREGA came into force on September 7, 2005 and its implementation was notified in a phased manner. In phase I, it was introduced in 200 most backward districts of the country on February 2, 2006. 130 districts were further included under MGNREGS in phase II with effect from April 1, 2007. The scheme was extended to the remaining 274 districts of India from April 1, 2008.

The objective of the act is to enhance livelihood security in rural areas by providing at least 100 days of guaranteed wage employment in a financial year to every household whose adult members volunteer to do unskilled manual work.

The primary objective of the Act is augmenting wage employment.
Its auxiliary objective is strengthening natural resource management through works that address causes of chronic poverty, like drought, and so encourage sustainable development.

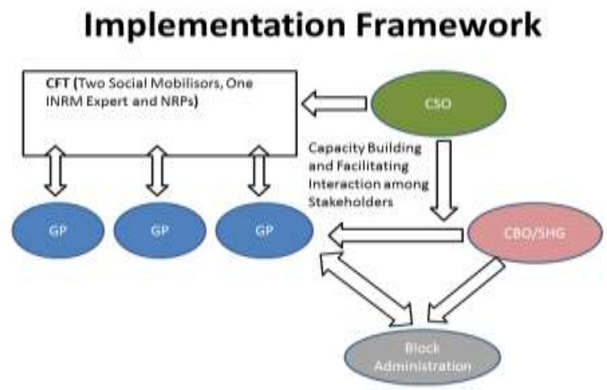
Permissible works includes: (i) water conservation and water harvesting; (ii) drought proofing (including afforestation and tree plantation); (iii) irrigation canal including micro and minor irrigation works; (iv) provision of irrigation facility to land owned by households belonging to the Scheduled Castes and Scheduled Tribes or to land of beneficiaries of land reforms or that of the beneficiaries under the Indira Awas Yojana of the Government of India; (v) renovation of traditional water bodies including desilting of tanks; (vi) land development; (vii) flood control and protection works including drainage in water logged areas; (viii) rural connectivity to provide all-weather access; and (ix) any other work which may be notified by the Central Government in consultation with the State Government.

There is special provision of works on individual land "provision of irrigation facility to land owned by households belonging to the Scheduled Castes and Scheduled Tribes or to land of beneficiaries of land reforms or that of the beneficiaries under the Indira Awas Yojana of the Government of India". This was amended to include horticulture plantation, land development and Below Poverty Line families vide Notification dated March 6, 2007 i.e. "provision of irrigation facility, horticulture plantation and land development facilities on land owned by households belonging to the Scheduled Castes and the Scheduled

Tribes or to Below Poverty Line families or to beneficiaries of land reforms or to the beneficiaries under the Indira Awas Yojana of the Government of India". This was further amended vide Notification dated July 24, 2009 to add small and marginal farmers i.e. "provision of irrigation facility, horticulture plantation and land development facilities to land owned by households belonging to the Scheduled Castes and the Scheduled Tribes or below poverty line families or to beneficiaries of land reforms or to the beneficiaries under the Indira Awas Yojana of the Government of India or that of the small farmers or marginal farmers as defined in the Agriculture Debt Waiver and Debt Relief Scheme, 2008".

NREGS thus provides an opportunity for the households from SC/ST/ BPL families, beneficiaries of land reforms /IAY and of SF/ MF to take up land development, irrigation facility, and horticulture plantation on their land to mitigate drought, enhance agricultural productivity and generate steady income.

MGNREGA in most states have been streamlined and land and water resources development in private land and community land taken up. In some places some facilitation might be required to do the intensive planning popularly known as IPPE (Intensive participatory planning process) where village level planning is done using various Participatory resource Appraisal (PRA). Facilitation could be any team working in the area for farm livelihoods promotion. The team is referred a Facilitation Team (FT). The FT however need to coordinate with existing MGNREGA machinery, at GPs, Block and District. The FT's role starts from the planning at village level, to sanctions and approval, quality control of works and ensuring the utilisation of created asset.

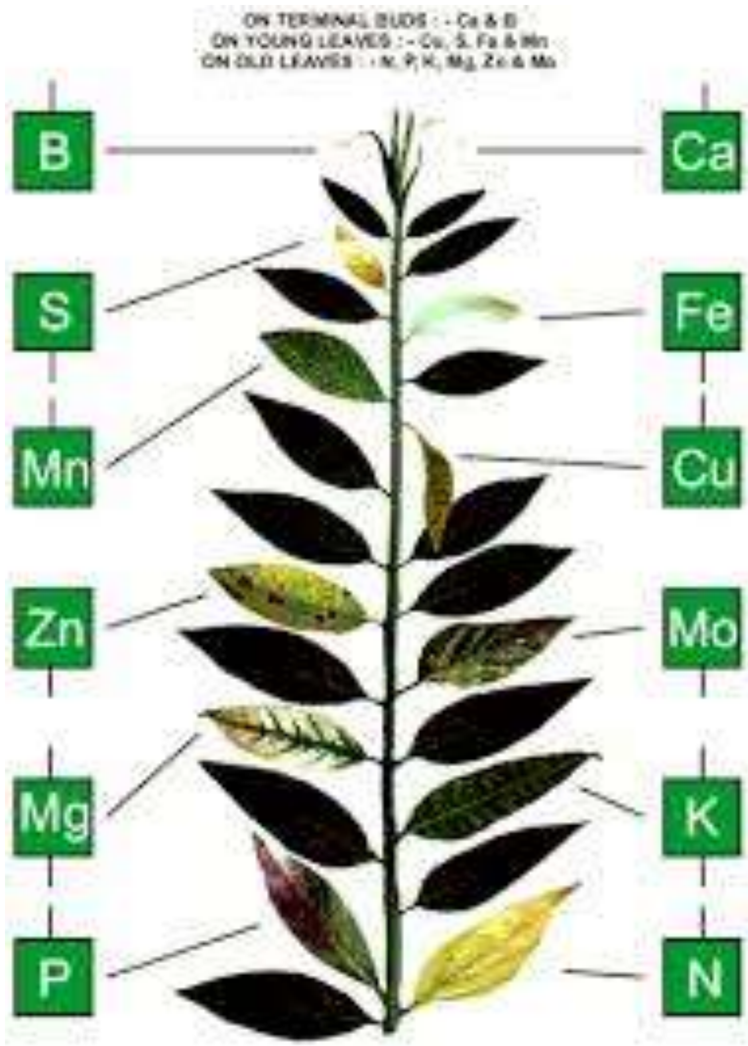


In this regard an exhaustive outline is presented to do land and water resource development under MGNREGA.

Village wise planning process	
Mobilisation on 1st day of planning exercise publicising meeting venue and time	The FTs are to participate in the GP planning process. In GPs were FTs have already prepared plans, they are to revisit the plan from a livelihood perspective. In GPs where plans have not been prepared, FTs will oversee the role of the Block Planning Team in facilitating planning exercise in each hamlet/village with the support of the ward members and the SHG representatives.
Village level meeting to discuss objectives and outcomes of planning exercise	
Discussion on overall livelihood planning for village	
Preparation of social map to identify persons for livelihood planning	
Seasonality Map to assess demand for work	

Revenue map to assess types of works	
Transect Walk for site selection	
Identification of Works	
Filling formats for convergent planning including household livelihood plans, NSAP, IAY, DDU-GKY	
Collation of all hamlet plans in specified format for Gram Sabha.	
Discussion and prioritisation of plan in Gram Sabha.	
Department desks at Gram Sabha for applications	FTs to inform workers about the purpose of desks and assist them in the filling of forms.
Post Planning Exercise	
Collation of Gram Sabha plans at the Gram Panchayat	FTs to assist the Block Planning Team in compiling the plan.
Preparation and approval of annual action plan of Gram Panchayat in Gram Sabha	Ensure Gram Sabha attended by SHGs
Submission of MGNREGA plan to block	This meeting will also be attended by FT members, SHG representatives and Block Planning Team.

MODULE 2- Plant Nutrition



Session -1: Major and minor plant nutrients
Duration – 60 mts

Learning outcome:

At the end of the session participants will be able to :

1. Know about essential elements required by plants
2. Know the status of supply and availability of essential elements in the soil
3. Distinguish between macro and micro elements
4. Role of essential elements in plant growth

Introduction:

Plant nutrition is the study of the chemical elements and compounds that are necessary for plant growth, and also of their external supply and internal metabolism. In 1972, E. Epstein defined two criteria for an element to be essential for plant growth:

- in its absence the plant is unable to complete a normal life cycle; or that the element is part of some essential plant constituent or metabolite.

There are 14 essential plant nutrients which plants take from soil. Recent studies indicate that more thirty elements are absorbed by plants. Carbon hydrogen and oxygen are absorbed from the air and water, while other nutrients l. Plants must obtain the following mineral nutrients from the growing media: The nutrients must be in a available form to be taken up by plants. Therefore the supply and availability is important criteria for plants to uptake essential nutrients from soil.

- the primary macronutrients are : nitrogen (N), phosphorus (P), potassium (K)
- the three secondary macronutrients: calcium (Ca), sulphur (S), magnesium (Mg)
- the micronutrients/trace minerals are : boron (B), chlorine (Cl), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), molybdenum (Mo), nickel (Ni)

The macronutrients are consumed in larger quantities and are present in plant tissue in quantities from 0.2% to 4.0% (on a dry matter weight basis). Micro nutrients are present in plant tissue in quantities measured in parts per million, ranging from 5 to 200 ppm, or less than 0.02% dry weight.[3]

Most soil conditions across the world can provide plants with adequate nutrition and do not require fertilizer for a complete life cycle. However, humans can artificially modify soil through the addition of fertilizer to promote vigorous growth and increase yield. The plants are able to obtain their required nutrients from the fertilizer added to the soil. A colloidal carbonaceous residue, known as humus, can serve as a nutrient reservoir. Even with adequate water and sunshine, nutrient deficiency can limit growth.

Nutrient uptake from the soil is achieved by cation exchange, where root hairs pump hydrogen ions (H^+) into the soil through proton pumps. These hydrogen ions displace cations attached to negatively charged soil particles so that the cations are available for uptake by the root.

The root, especially the root hair, is the most essential organ for the uptake of nutrients. The structure and architecture of the root can alter the rate of nutrient uptake. Nutrient ions are transported to the center of the root, the stele in order for the nutrients to reach the conducting tissues, xylem and phloem. The Casparian strip, a cell wall outside of the stele but within the root, prevents passive flow of water and nutrients, helping to regulate the uptake of nutrients and water. Xylem moves water and inorganic molecules within the plant and phloem accounts for organic molecule transportation. Water potential plays a key role in a plants nutrient uptake. If the water potential is more negative within the plant than the surrounding soils, the nutrients will move from the region of higher solute concentration--in the soil--to the area of lower solute concentration: in the plant.

Nutrients are moved inside a plant to where they are most needed. For example, a plant will try to supply more nutrients to its younger leaves than to its older ones. When nutrients are mobile, symptoms of any deficiency become apparent first on the older leaves. However, not all nutrients are equally mobile. Nitrogen, phosphorus, and potassium are mobile nutrients, while the others have varying degrees of mobility. When a less mobile nutrient is deficient, the younger leaves suffer because the nutrient does not move up to them but stays in the older leaves. This phenomenon is helpful in determining which nutrients a plant may be lacking.

Many plants engage in symbiosis with microorganisms. Two important types of these relationship are 1.) with bacteria such as rhizobia, that carry out biological nitrogen fixation, in which atmospheric nitrogen (N_2) is converted into ammonium (NH_4); and 2.) with mycorrhizal fungi, which through their association with the plant roots help to create a larger effective root surface area. Both of these mutualistic relationships enhance nutrient uptake.[4]

Though nitrogen is plentiful in the Earth's atmosphere, relatively few plants harbour nitrogen fixing bacteria, so most plants rely on nitrogen compounds present in the soil to support their growth. These can be supplied by mineralization of soil organic matter or added plant residues, nitrogen fixing bacteria, animal waste, or through the application of fertilizers.

Macro Nutrient	
Carbon (C):	Carbon forms the backbone of many plants biomolecules
Hydrogen (H2)	Hydrogen also is necessary for building sugars and building the plant
Oxygen (O2)	Oxygen by itself or in the molecules of H_2O or CO_2 are necessary for plant cellular respiration.
Nitrogen (N)	Plant convert Nitrogen to make proteins essential to new cell growth
Phosphorus (P)	Necessary for photosynthesis and works as catalyst for energy transfer within the plant. Phosphorus helps build strong roots and is vital for flower and seed production.
Potassium (K)	Activates the manufacture and movement of sugars and starches, as well as growth by cell division
Magnesium (Mg)	K is found as a central atom in the chlorophyll molecule and is essential to the absorption of light energy. Magnesium aids in the utilization of nutrients, neutralizes acids and toxic compounds produced by the plant.
Calcium (Ca)	Ca is fundamental to cell manufacture and growth
Sulphur(S)	Component of plant proteins and plays a role in root growth and chlorophyll supply
Micronutrients	
Iron (Fe)	Key catalyst in chlorophyll production and is used in photosynthesis
Manganese (Mg)	Works with plant enzymes to reduce nitrates before producing proteins.
Zinc (Zn)	Is a catalyst and must be present in minute amounts for plant growth
Copper (C)	Catalyst for several enzymes
Boron (B)	Necessary for cells to divide and protein formation
Molybdenum (Mn)	Helps in forming proteins and aids the plant's ability to fix nitrogen from the air
Chlorine (Cl2)	Necessary for osmosis and ionic balance

Session -2: Soil fertility management without chemical fertilizer

Duration 60 mts

Learning outcomes :

At the end of this session participants will be able to:

1. List the bio fertilizers and inoculants
2. How to prepare NADEP
3. And various other organic manures for plant nutrition

Introduction:

Rampant misuse of chemical fertilizers have brought serious problems of water pollution and soil degradation. The philosophy of CMSA is to totally shun use of chemical plant nutrients replacing with organic manures, bio mass incorporation, aerobic farm compost such as NADEP and use of bio inoculants for **meeting the need of crops.**

Soil fertility Management without chemicals:

Soil is a living systems and soil fertility is the key to agriculture productivity. Soil fertility management is a package of complex practices that should act upon three aspects: Soil, Microbes in the soil and plants. Following are the broad ecological principles of soil fertility management:

Supply of organic matter:

Each type of soil organism occupies a different niche in the web of life and favours a different substrata and nutrient source. Most soil organisms relay on organic matter for food; thus a rich supply and varied source of organic matter will generally support a wider variety of organisms

Increase plant varieties:

Crops should be mixed and their spatial – temporal distribution varied to create a greater diversity of niches and resources that stimulate soil bio diversity. Wider variety of organisms, improve nutrient cycling and natural process of pest and disease control

Protect the habitat of soil organisms:

The activity of soil biodiversity can be stimulated by improving soil living conditions such as aeration, temperature, moisture, and nutrient quantity and quality

Following are different practices for managing soil fertility:

- Composting
- Green manuring
- Green leaf manuring
- Dabholkar method of green manuring

- Inoculants
- Bio fertilisers
- Azolla
- Tank silt application
- Mulching
- Mixed cropping

Composting:

Composting is a process where microorganisms break down organic matter to produce humus like substance called compost. Supplies organic matter and nutrient content. Controlled process ensure organic material is broken down and nutrients mineralized into plants available form

- Destruction of pathogens
- Small particles for easier application

NADEP method of composting:

The process basically involves placing select layers of different in a simple, mud sealed structure designed with brick and mud water. This system permits conversion of approximately one Kg of animal dung into 40 Kg of rich compost.

Construction of NADEP compost pit:

This method requires construction of a tank admeasuring 3m x 1.8 m or 3.6 m x 1.5 internally with 25 cm thick perforated brick wall all around in mud or cement mortar to a height of 0.9 m above ground. The above ground-perforated structure facilitates passage of air for aerobic decomposition. The floor of the tank is laid with bricks. The tank is covered above with a thatched roof. This prevents loss of nutrients by seepage or evaporation and the contents are not exposed to sun and rain.

Filling of NADEP compost pit:

The ingredients for making compost are agro-wastes, animal dung and soil in the ratio of 45:5:50 by weight.

The ingredients are added in layers starting with vegetable matter followed by dung and soil in that order.

Each layer can be about 45 kg vegetable matter, 5 kg of dung mixed in 70 l of water and 50 kg of soil so that 15 layers will fill the tank.

Tree loppings and green manure crops can also be used to fill up the tank if sufficient farm wastes are not available at time. The nutrients produced in the manure are absorbed by the soil layers thus preventing their loss.

About 22-50 l of water is to be sprinkled twice a week after the tank is loaded.

The material loaded has to be left in the tank for about 100 to 120 days for complete decomposition of the material. One tank can be used three times a year. With production of 3 tons to 3.5 tons of compost produced per cycle about 9 to 10 tons of compost can be made annually from one tank.

The compost can be stored for future use, preferably in a thatched shed after air drying and maintaining it at about 20% moisture level by sprinkling water when ever needed. By following the procedures suggested above, the compost could be preserved for about 6 to 8 months. It is advisable to sprinkle cultures like Trichoderma, Azatobacter and PSB in layers to enhance the speed of composting process.

A NADEP

Green manuring: Green manuring is the plowing under or soil incorporation of any green manure crops while they are green or soon after they flower. Green manures are forage or leguminous crops that are grown for their leafy materials needed for soil conservation. The most important green manure crops are sunnhemp, dhaincha, clusterbeans and *Sesbania rostrata.*

Green manure crops and addition of Nitrogen to soil:

Crop	Sowing months	Seed rate kg/ha	Nitrogen to soil (kg/Acre)
Black gram	June-July	8-9	27-28
Cow pea	April-July	18-22	30-35
Dhanchia	April-July	32-40	33-42
Green gram	June- July	12-16	27-34
Horse gram	June -July	10-12	48-54

Biomass production and N accumulation of green manure crops

Crop	Age (Days)	Dry matter (t/ha)	N accumulated
Sesbania aculeata	60	23.2	133
Sunnhemp	60	30.6	134
Cow pea	60	23.2	74
Pillipesara	60	25.0	102
Cluster bean	50	3.2	91
Sesbania rostrata	50	5.0	96

Nutrient content of green manure crops

Plant	Scientific name	Nutrient content (%) on air dry basis		
		N	P2O5	K
Sunhemp	*Crotalaria juncea*	2.30	0.50	1.80
Dhaincha	*Sesbania aculeata*	3.50	0.60	1.20
Sesbania	*Sesbania speciosa*	2.71	0.53	2.21

Green leaf manuring: Application of green leaves and twigs of trees, shrubs and herbs collected from elsewhere is known as green leaf manuring. Forest tree leaves are the main sources for green leaf manure. Plants growing in wastelands, field bunds etc., are another source of green leaf manure. The important plant species useful for green leaf manure are neem, mahua, wild indigo, Glyricidia, Karanji *(Pongamia glabra)* calotropis, avise*(Sesbania grandiflora)*, subabul and other shrubs.

Nutrient content of green leaf manure:

Plant	Nutrient content (%) on air dry basis		
	N	**P**	**K**
Gliricidia	2.76	0.28	4.6
Pongamia	3.31	0.44	2.39
Neem	2.83	0.28	0.35
Gulmohur	2.76	0.46	0.50
Calotrophis	2.06	0.54	0.31

Dhabolkar method of Green manuring:

This method was developed by Sri Dabholkar of Maharashtra to convert unproductive lands.
In this method, 20-25 kg of mixed seed from 5 categories (4 crops in each category i.e total 20-21 crops) mentioned below are sown:

1. Cereals (Coarse cereals and millets)
2. **Pulses** (Black gram, Green gram, Chickpea, Bean)
3. **Oilseeds** (Sesame, Groundnut, Sunflower, Castor)
4. **Legumes** (Sesbania, Sunhemp, Horse gram etc.)
5. **Spices** (Mustard, Coriander, Methi, Ajwain)

In this mix, pulses, oilseeds, cereals/millets, green manure crop seeds are added @ 6kg each whereas spices are added @ ½ kg each. After 40-45 days of sowing, the entire biomass is incorporated into the soil. This has to be repeated two more times for best results. In this way, the top soil gets replenished with all plant nutrients and also help in buildup of humus. It is essential that enough moisture is ensured for the growth and decomposition of green manure crops

Inoculants:

Drava Jeevamrutham: Can be used as a fertilizer for each plant for every week, which boosts the plant growth and gives good yield. We need to use the prepared one within one week of preparation. Please note that once we use Jeevamrutham, we shouldn't water the plants for 12 hrs.

How to Prepare:

Requirements for 10liters of jeevamrutham

1. 1/2 litre Cow Urine
2. 1/2 K.g Cow Dung
3. 100 gms Jaggery

4. 100 gms Basin Powder/ Black-eyed peas or cow peas Powder
5. 2 tb spn of Top soil

Procedure:

1. In 2 and 1/2 litre water mix cow dung, urine Jaggery and basin powder. Stir the contents with stick. Make sure no lumps are there in the liquid.
2. In this add 7 litres of water so that will get 10 litres of liquid.
3. Keep this container outside under the shade/ under the tree. place some cotton cloth over it.
4. Stir the liquid in the container every day in morning and evening for about 15 minutes.
5. Jeevamrutham will be prepared in 48 hrs, Can use directly to plants.

Ghana Jeevamrutham:

Required material:

- Dung – 100 Kgs
- Cattle urine – required amount
- Dung – 2Kgs
- Pulse flour – 2 Kgs
- Virgin soil - fistful

Preparation: Mix all materials by adding urine. Keep this mixture under shade for seven days. After drying store in gunny bags up to six months.

Application:

Take 20 Kg of Ghana jeevamrutham and add 100kgs of dried compost grind it and apply in the field.

VERMIWASH:

Take 10 lit of mud pot or plastic container for preparation of vermiwash. Arrange a tap for it at the bottom. Then place 10 cm gravel or broken bricks at the bottom. Spread coconut husk upto 4 cm. on this. Place partially decomposed agricultural waste material and dung and moisten the material with water. After wetting the material for 2 days, release two dozen earthworms. In 2 weeks the wastes get transformed into black compost. At this stage pour 3 litres of water. After 24 hrs, 2 lit vermiwash can be collected through the tap. Continue this method for one week, remove the compost from the container and it can be used as manure. Again refill the container as explained above and prepare vermiwash.

Method of application:

- 10 lit. Vermiwash is mixed in 100 litres of water and sprayed on an acre of crop.
- Vermiwash can be used on all crops, nurseries and fruit crops.
- Can be sprayed 1-2 times during crop duration to get good results.
- By spraying Vermiwash controls micronutrient deficiencies to some extent.

Bio fertilisers:

Bio fertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants' uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants

Group	Examples
N2 fixing bio fertilizers	
Free living	*Azatobactor , Nostoc*
Symbiotic	*Rhyzobium, Anabena*
Associative symbiotic	*Azospirillum*
P solubilising bio fertilisers	
Bacteria	*Bacillus, Psudomonas*
Fungi	*Pencillium, Aspergillus*
P mobilizing bio fertilisers	
Arbuscular mycoryzha	*Glomus*
Ectomycoryzha	*Laccaria*
Orchid mycoryzha	*Pezizella*
Plant growth promoting ryzho bactria	
Pseudomonas	Pseudomonas

Application of bio fertilisers:

Seed treatment: One packet of the inoculants is mixed with 200 ml of rice kanji to make a slurry. The seeds required for an acre are mixed in the slurry so as to have a uniform coating of the inoculants over the seeds and then shade dried for 30 minutes. The shade dried seeds should be sown within 24 hours. One packet of the inoculants (200 g) is sufficient to treat 10 kg of seeds.

Seedling root dip: This method is used for transplanted crops. Two packets of the inoculants is mixed in 40 litres of water. The root portion of the seedlings required for an acre is dipped in the mixture for 5 to 10 minutes and then transplanted.

Main field application: Four packets of the inoculants is mixed with 20 kgs of dried and powdered farm yard manure and then broadcasted in one acre of main field just before transplanting.

Rhizobium: For all legumes *Rhizobium* is applied as seed inoculants.

Az*ospirillum/Azotobacter*: In the transplanted crops, *Azospirillum* is inoculated through seed, seedling root dip and soil application methods. For direct sown crops, *Azospirillum* is applied through seed treatment and soil application.

Phosphobacteria: Inoculated through seed, seedling root dip and soil application methods as in the case of *Azospirillum*.

Combined application of bacterial bio fertilizers: Phosphobacteria can be mixed with *Azospirillum* and *Rhizobium*. The inoculants should be mixed in equal quantities and applied as mentioned above.

Azolla:

Azolla is a free-floating water fern that floats in water and fixes atmospheric nitrogen in association with nitrogen fixing blue green alga *Anabaena azollae*. *Azolla* fronds consist of sporophyte with a floating rhizome and small overlapping bi-lobed leaves and roots. *Azolla* is used as bio fertilizer for wetland rice and it is known to contribute 40-60 kg N ha-1 per rice crop.

The important factor in using *Azolla* as a bio fertilizer for rice crop is its quick decomposition in soil and efficient availability of its nitrogen to rice. In tropical rice soils the applied *Azolla* mineralizes rapidly and its nitrogen is available to the rice crop in very short period. The common species of *Azolla* are *A. microphylla, A. filiculoides, A. pinnata, A. caroliniana, A. nilotica, A. rubra*and *A. mexicana*.

Method of inoculation of *Azolla* to rice crop:

The *Azolla* biofertilizer may be applied in two ways for the wetland paddy.

In the first method, fresh *Azolla* biomass is inoculated in the paddy field before transplanting and incorporated as green manure. This method requires huge quantity of fresh *Azolla*.

In the other method, *Azolla* may be inoculated after transplanting rice and grown as dual culture with rice and incorporated subsequently.

A. *Azolla* biomass incorporation as green manure for rice crop

- Collect the fresh *Azolla* biomass from the *Azolla* nursery plot.
- Prepare the wetland well and maintain water just enough for easy incorporation.
- Apply fresh *Azolla* biomass (15 t ha-1) to the main field and incorporate the *Azolla* by using implements or tractor.

***B. Azolla* inoculation as dual crop for rice**

- Select a transplanted rice field.
- Collect fresh *Azolla* inoculum from *Azolla* nursery.
- Broadcast the fresh *Azolla* in the transplanted rice field on 7th day after planting (500 kg / ha).
- Maintain water level at 5-7.5cm.

- A second bloom of *Azolla* will develop 8 weeks after transplanting which may be incorporated again.
- By the two incorporations, 20-25 tonnes of *Azolla* can be incorporated in one hectare rice field.

Mulching:

The principle requires the farmer to cover the land under cultivation with a mulching material. Mulching protects soil from evaporation of surface moisture, preserve and add to organic matter in soils in addition to improving soil properties.

Tank silt application:

10-20 cartloads of tank silt is applied per acre during last plough**.**Following are the advantages of tank silt:

- Silt and clay particles due to their smaller size provide the nutrients to soil
- Microorganisms are also high in number
- Helps in forming small pores and retain water

***Note*:** If the tanks are saline then the soil should not be used. Tank silt should be used based on the availability in the last ploughing.

Mixed cropping:

Growing two or more crops together on the same field (grain and bean). Direct production increase compared to mono cropping, due to better ground cover, optimum use of sunlight, more efficient root growth and extra nitrogen (when using N fixers)

Session -3: Plant nutrient deficiency symptoms

Duration – 45 mts

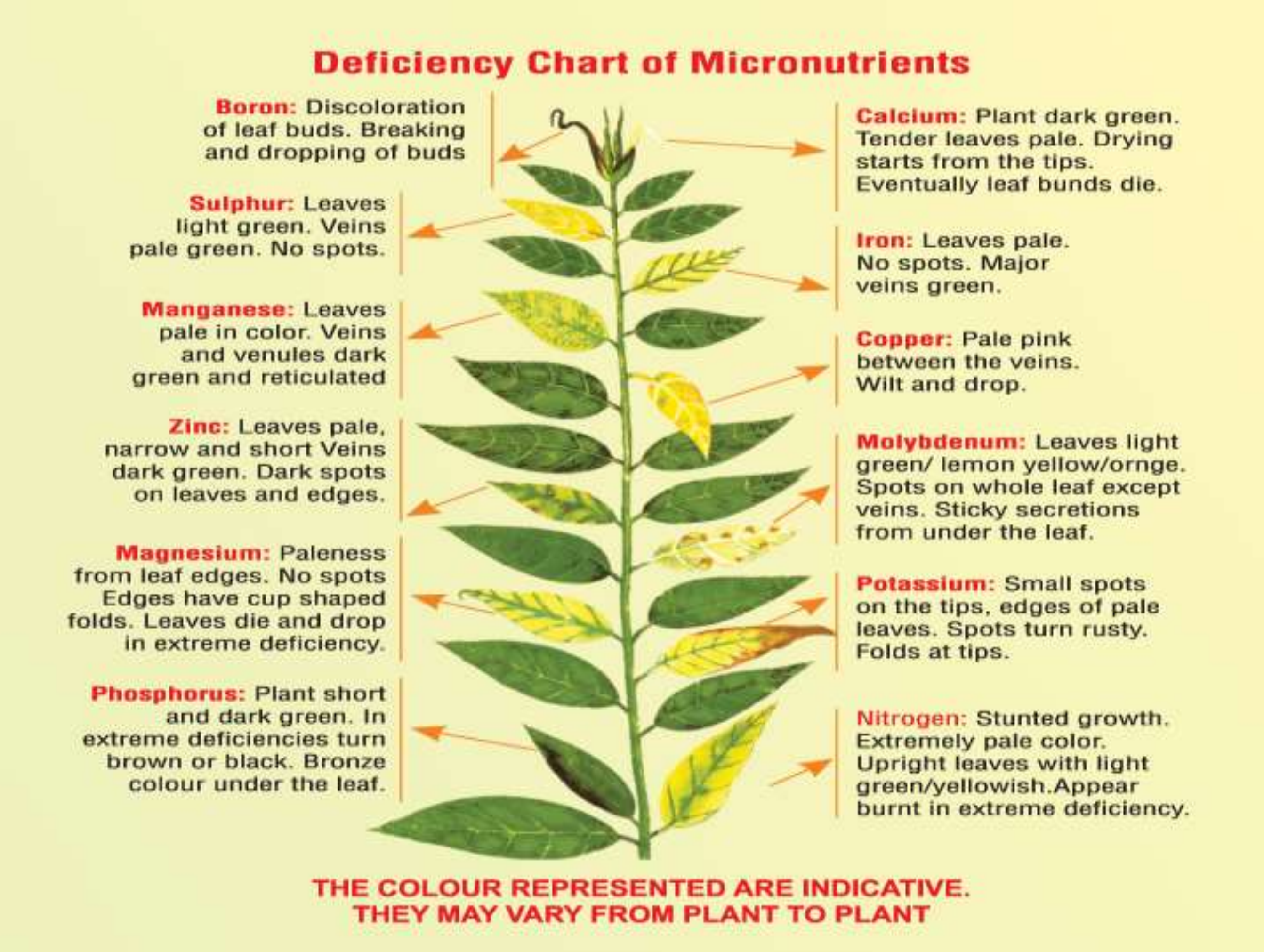
Introduction:

Plants, like all other living things, need food for their growth and development. Plants require 16 essential elements. Carbon, hydrogen, and oxygen are de- rived from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, zinc, manganese- their function in plants, symptoms of their deficiencies, and recommended nutrient levels in plant tissues of selected crops.

Learning outcome:

At the end of this session participants will be able to;

- Identify the deficiency symptoms of an element



Deficiency Symptoms of major and minor elements

Plants, like all other living things, need food for their growth and development. Plants require 16 essential elements. Carbon, hydrogen, and oxygen are de- rived from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, zinc, man-their function in plants, symptoms of their deficiencies, and recommended nutrient levels in plant tissues of selected crops.

Nitrogen:

1. Stunted growth may occur because of reduction in cell division.
2. Pale green to light yellow color (chlorosis) appearing first on older leaves, usually starting at the tips. Depending on the severity of deficiency, the chlorosis could result in the death and/or dropping of the older leaves. This is caused by the translocation of N from older tissues
3. Reduced N lowers the protein content of seeds and vegetative parts. In severe cases, flowering is greatly reduced.
4. N deficiency causes early maturity in some crops, which results in a significant reduction in yield and quality.

		
Nitrogen deficient potato plant (left) is chlorotic; plant at right is normal.	Nitrogen deficient corn; yellowing proceeds down the midrib of older leaves	Nitrogen deficient soybean; lower leaves turn uniformly pale green, then yellow.

Phosphorus:

- Because P is needed in large quantities during the early stages of cell division, the initial overall symptom is slow, weak, and stunted growth.

- P is relatively mobile in plants and can be transferred to sites of new growth, causing symptoms of dark to blue-green coloration to appear on older leaves of some plants. Under severe deficiency, purpling of leaves and stems may appear.

- Lack of P can cause delayed maturity and poor seed and fruit development.

	
Phosphorus deficient sugar beet plants are stunted, with dark green leaves	Phosphorus deficient tomato leaves have purple interveinal tissue on their undersides

Potassium:

- The most common symptom is chlorosis along the edges of leaves (leaf margin scorching). This occurs first in older leaves, because K is very mobile in the plant.
- Because K is needed in photosynthesis and the synthesis of proteins, plants lacking K will have slow and stunted growth.
- In some crops, stems are weak and lodging is common if K is deficient.
- The size of seeds and fruits and the quantity of their production is reduced

Deficiency symptoms of other elements

Calcium:

	
Calcium deficient celery; young leaves are necrotic and the growing point dies	Calcium deficient corn leaves fail to unfold.

Magnesium

- Because Mg is a mobile element and part of the chlorophyll molecule, 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. Corn leaves appear yel- low-striped with green veins, while crops such as potatoes, tomatoes, soybeans, and cabbage show orange-yellow color with green veins.
- 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.

		
Magnesium deficient soybean; interveinal chlorosis of older leaves.	Magnesium deficient corn; interveinal chlorosis of older leaves.	Magnesium deficient tomato; interveinal chlorosis of older leaves.

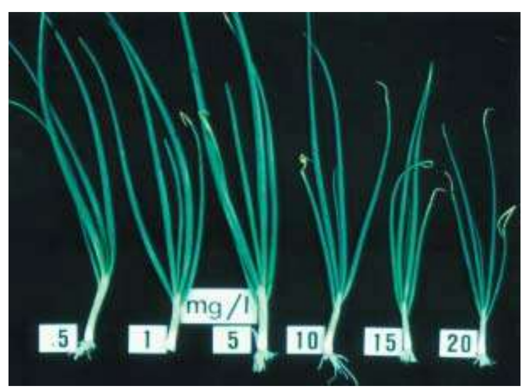
Sulphur

- Younger leaves are chlorotic with evenly, lightly colored veins. In some plants (e.g., citrus) the older leaves may show symptoms first. However, deficiency is not commonly found in most plants.
- Growth rate is retarded and maturity is delayed.
- Plant stems are stiff, thin, and woody.
- Symptoms may be similar to N deficiency and are most often found in sandy soils that are low in organic matter and receive moderate to heavy rainfall.

		
Sulphur deficient banana; young leaves are uniformly chlorotic.	Sulphur deficient tomato; young leaves are uniformly chlorotic.	Sulphur deficient sorghum; young leaves are uniformly chlorotic

Boron:

Boron deficiency symptoms are related to its main role in plants, cell wall expansion and structure. Typical deficiency symptoms include: impaired cell expansion in rapidly growing organs (leaves, roots, pollen tube), impaired growth of the plant meristems in roots and shoots causing malformation and thick and shorter roots, flower abortion, male and female flowers sterility, and reduced seed set due to inhibition of pollen growth. Reproductive organs, which have a high concentration of pectins rich in B, are frequently most sensitive to B deficiency because of their high B demand. . These organs also have low transpiration rates which limit the movement of B to these tissues.



Leaf symptoms of B deficiency develop in young leaves of plants that cannot mobilize B. Under severe B deficiency, stunted growth and death of growing tissue commonly occur. Inhibition of root elongation, failure of flowers to set seeds and fruit abortion are also common effects of B deficiency. However, these negative effects may occur without any visible leaf symptoms of B deficiency. Additional characteristic symptoms of B deficiency include the internal breakdown of tissues, especially in root crops (e.g., sugarbeet, turnip, potatoes) and fruit cracking (e.g. apple).

Leaf chlorosis (loss of green color) and nechrosis (leaf death) occur only in a few species and very rarely as a first symptom. The practical implication is that when B deficiency symptoms are observed in leaves, it is already too late and yield has been reduced. Consequently, the best strategy for B is to prevent deficiency with soil application of B.

Boron uptake

Boron uptake is also very unique. Boron reaches roots mainly by mass flow and is absorbed as boric acid, which is uncharged. In contrast to other nutrients, most crop species exhibit very little control of B uptake when its availability is in the adequate to toxic range. This response is a direct consequence of the passive uptake of B through plant membranes, in contrast to other nutrients that have specific transporters that regulate uptake. Consequently, plant B accumulation is directly related to transpiration and soil B concentration. Boron exhibits a very narrow range between deficient and toxic availability; therefore, uniform B availability through soil applied fertilizer is critical to ensure optimum nutrition.

Potassium and phosphorus nutrition is enhanced by boron.

By maintaining proper functioning (through ATPase activity) and structure of root cell membranes, B has a positive impact on root uptake of P and K, particularly. Boron also plays an important role in the colonization of mycorrhizal fungi in roots, which is a contributing factor to root uptake of P. In short term experiments with corn, the root uptake of P and K were shown to be severely reduced under low B conditions. However, root uptake was restored very rapidly (within 1 hour) after B was added to the growth medium. There is also some experimental evidence showing that an adequate B supply is needed for mitigation of aluminum toxicity in plants grown in low pH soils.

- Generally, B deficiency causes stunted growth, first showing symptoms on the growing point and younger leaves. The leaves tend to be thickened and may curl and become brittle.
- In many crops, the symptoms are well defined and crop-specific, such as:
  - *peanuts: hollow hearts*
  - *celery: crooked and cracked stem*
  - *beets: black hearts*
  - *papaya: distorted and lumpy fruit*
  - *carnation: splitting of calyx*
  - *Chinese cabbage: midribs crack, turn brown*
  - *cabbage, broccoli, and cauliflower: pith in hollow stem*

	
Boron deficient potato leaves have light brown edges; crinkling around the centre of the leaf blade causes an -cupped shape; the plant's growing point dies.	Boron deficient papaya fruits develop bumps.

Copper:

- Reduced growth, distortion of the younger leaves, and possible necrosis of the apical meristem.
- In trees, multiple sprouts occur at growing points, resulting in a bushy appearance. Young leaves becomes bleached, and eventually there is defoliation and dieback of twigs.
- In forage grasses, young leaf tips and growing points are affected first. The plant is stunted and chlorotic.

	
Copper deficient corn leaf tips bend and droop.	Copper deficient onion leaves have white tips and twist in spirals or right angles.

Chlorine:

- Chlorosis of younger leaves and wilting of the plant. Atmosphere and rain water.

	
Chlorine deficient tomato; leaf edges roll upward.	**Chlorine deficient sugar beet; young leaves are chlorotic.**

Iron:

Deficiency symptoms

Interveinal chlorosis in younger leaves.
The youngest leaves maybe white, because Fe, like Mg, is involved in chlorophyll production.
Usually observed in alkaline or over-limed soils.

Iron deficient soybean; young leaves have interveinal chlorosis.

Manganese

- Symptoms first appear as chlorosis in young tissues. Unlike Fe chlorosis symptoms, in dicots Mn chlorosis shows up as tiny yellow spots.
- In monocots, greenish-grey specks appear at the lower base of younger leaves.

The specks may eventually become yellowish to yellow-orange. In legumes, necrotic areas develop on the cotyledons, a symptom known as marsh spots.

Manganese deficient tomato; expanded young leaves have green veins with. Interveinal chlorosis Manganese deficient corn; young leaves are olive-green and slightly streaked.

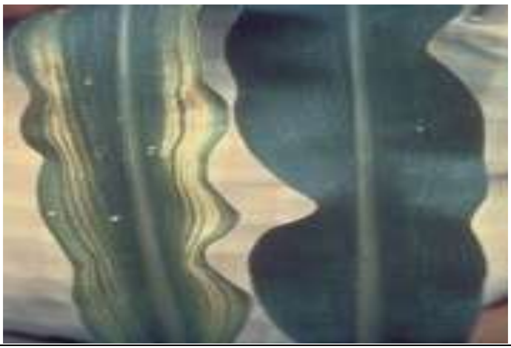
Molybdenum

1. Deficiency symptoms resemble those of N be- cause the function of Mo is to assimilate N in the plant. Older and middle leaves become chlorotic, and the leaf margins roll inwards.
2. In contrast to N deficiency, necrotic spots appear at the leaf margins because of nitrate accumulation.
3. Deficient plants are stunted, and flower formation may be restricted.
4. Mo deficiency can be common in nitrogen-fixing legumes.

	
Molybdenum deficient grapefruit leaves have interveinal chlorosis	Molybdenum deficient tomato leaves have interveinal chlorosis.

Zinc

- Interveinal chlorosis occurs on younger leaves, similar to Fe deficiency. However, Zn deficiency
- Is more defined, appearing as banding at the basal part of the leaf, whereas Fe deficiency results in interveinal chlorosis along the entire length of the leaf.
- In vegetable crops, color change appears in the younger leaves first. The new leaves are usually
- Abnormally small, mottled, and chlorotic.
- In citrus, irregular interveinal chlorosis occurs with small, pointed, mottled leaves. Fruit formation is
- Significantly reduced.
- In legumes, stunted growth with interveinal chlorosis appears on the older, lower leaves. Dead
- Tissue drops out of the chlorotic spots.

	
Zinc-mango shoots have shortened internodes, resulting in leaf rosetting.	Zinc deficient corn. Young leaves have interveinal, chlorotic stripes on both sides of the midrib

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Session -1: Seed and food crop

Duration – 60 mts

Learning outcomes

At the end of this session the participants will be able to :

1. Differentiate between a crop for seed and food
2. How to select seed for planting
3. Quality aspects of seed
4. What is seed replacement ratio
5. Seed treatment before sowing
6. Seed storage at farm level
7. Seed production systems
8. Some of the basic facts of seed laws

Introduction:

Seeds and planting materials are the fundamental ingredients for agriculture to happen; research shows that in general productivity of any crop would be effectively increased by 20 – 25% using quality seeds alone keeping other cultural and management practices the same. The price of seed is always substantially higher than the grains; therefore seed based economy has a special relevance in rural development

There exists a huge gap between the supply and demand of high quality, disease free seeds and other biological planting materials in the country as a whole.

The seed replacement ratio in India is on the lower side resulting in declining productivity, which is conspicuously evident in case of paddy.

The science related technology of seed production has marched ahead considerably but the reach of knowledge to the farmers, is still unfortunately inadequate; the knowledge dissemination process still by and large is dominated by the dealers and traders who are associated with agri-input business.

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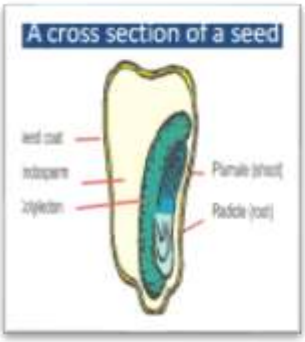
What is a seed?



Botanically 'seed' is a fertilized ovule in a plant, which when mature can be planted to advance the generation. In simple term 'seed' is a planting material for growing a crop. Hence any seed which is planted (in soil mostly) germinates to grow into another plant. Not always seed is planted to grow a crop. For example potato tuber which is planted to grow a potato crop is not a 'true' seed – it is the modified stem which is planted and is a vegetative way to take a crop. True potato seed can be obtained for planting but needs specific climatic requirement and cannot be produced everywhere. Tissue culture is one sophisticated laboratory and green housed based system which gives vegetative propagation of disease and virus free planting material for plantation crop and floriculture – such as flower seedlings, banana, spices etc. Therefore there are various ways of propagating a crop depending on the crop type, climate, agro-ecological zone. For our purpose we will confine to true seed as it is called, such as, paddy, wheat, mustard, maize, vegetables, cotton, millets to name a few.

Functional meaning of a seed

Is a unit of dissemination

Angiosperms-double fertilization within an ovary

Gymnosperms-Single fertilization, no seed cover (ex. cone of conifer plant)

- Monocots –family of gramineae- rice, wheat, maize all are our major food
- Dicots – are from leguminoceae family, - soyabean, chickpea, pigeon pea etc
- Most of our food comes from these two families

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Difference between a crop grown for seed and crop grown for food

One must understand the major difference between a seed crop and food crop. For example paddy grown for food (which we consume as a major staple) will not qualify as a seed, which goes to the market for growing a crop. Though scientifically seed from paddy grown for food can be planted again and it will give crop.

The major difference is that a seed crop by law has to be genetically pure with characteristics described for a particular variety. This require the seed to be a class called `Foundation seed' to be obtained from designated public research institutions such as Agricultural Universities, State Research Centres, ICAR, etc. and the crop should be grown with specified quality control with regular inspection from authorized certified agencies – such as State Seed Certification Department . Only when a crop grown for Foundation seed gets a certificate, it can be sold as certified seed to the market with a `Tag' stamped by Seed Certification Agency. Therefore the prime concern is genetic purity which a crop for food may not be maintained and usually have a mixture of other varieties. This is an elaborate process during the production of seed. A seed company must ensure this purity if it wants the stamp of authorized certification. Majority of seed sold in the market is treated with chemicals to prevent insect damage, hence cannot be used for food if the seed is not sold (exception is paddy as it can be sold without chemical treatment and if a lot is not sold can be sold as food). Seeds are also sold with polymer coating which makes it unfit as food.

Factors influencing seed development:

1. Dormancy: a few days to several years of sleeping to preserve a species of desirable characters.
2. Sometimes dormancy has to be broken for cultivation
3. Viability- ability to grow, viable, remain viable for long time, lotus – 3000 years
4. Vigor- Seed vogor to grow to a crop
5. A seed may germinate but not be viable or vigorous

Analytical purity • Intact seed of a specific species • No contamination • Pure seed – analytical laboratory • Normally expressed as % of pure seed • Germination • Vigour • Viability • Seed size – actual, uniformity test weight, 1000/100 seed mass • Seed health – disease pest • Moisture content at harvesting, at germination	**Factor that affect seed quality** • Seed lot planted • Agronomical practices • Plant protection • Isolation distance – why ? • Roguing during growth stages • Weed control • Method and time of harvest • Regular inspection • Verify genetic purity • GOT – standard practice, sample etc • Population density • Pollinating agent
Post harvest quality control	
• Moisture level and its importance • Seed drying temperature • Cleaning, sorting • Seed treatment	• Seed storage, at godowns, standard laid out • Sampling methods for testing and analysis • Seed testing Lab a must • Proper labeling • Follow up test for germination – when it is done

Basic principles and concepts of seed quality control

Seed is the basic input for agriculture and quality seed is the key to boost production of crops. It is important genetic purity is maintained in the full seed chain – from breeders seed to certified seed which is sold to the farmers.

The concept of seed quality

Seed quality is the sum of all the attributes which makes a seed different from grain (see the first chapter).

The main attributes are – genetic purity, physical purity, germination, dormancy, moisture, seed health, vigour, should be of uniform size and lustrous /color.

Genetic purity

This is the most important attribute which must be at least 98% stipulated under seed law. This governs the yield potential as well as resistant disease, pests, drought, etc. The standards at each stage has been prescribed. The genetic purity of breeder seed must be 100% and maintained through generation.

Physical purity

The seed lot after harvesting is not fit for sowing as it has lot of impurities. There will be soil, stones, inert material, chaff, broken seed, leaves, husks, other foreign material, weed seed, other crop seeds, etc. No amount of clean and sanitized cultivation can totally avoid these impurities. Therefore seeds after harvest must be cleaned and processed before it can be sold. The standards for physical purity is also stipulated.

Germination

This is one attribute can play havoc when the seed is planted by the farmer and often can be the cause for dispute. This is affected by various factors and hence seeds to be monitored on a regular basis with prescribed standard procedures.

Moisture

The viability of a seed revolves round the moisture content. Should not be too high or too low. It should be at desirable level (10-14%) which can be attained by drying. This also determines type of packing material and storage.

Seed health

Mainly pertains to infections by fungi or pest affected. This will affect germination, seed color, seed size and carry forward the disease to next generation (with seed borne fungus). Therefore at the time of harvest seed must be inspected thoroughly for any such disease or pest. During storage disease or pest will affect the seed quality – specially when the seed is not sold and is carried forward to next season.

Seed vigour

This is an attribute which determines how well a seed will grown after germination. 100% germination does not mean all the seeds will grow in to plant. If the seed is less vigorous many seeds will die after germination. Seed vigour is tested at the laboratory before a seed lot is approved for final packing.

Factors affecting seed quality

Can be broadly grouped in four categories. 1. Genetical factor, 2. Ecological factor, 3. Agronomic practices, 4. Harvesting and post-harvesting handling.

Genetic purity may decline over years specially when the same source of seed is used continuously over the years. The growth of the plant and seed quality is strongly influenced by environmental factors. Similarly Agronomic practices are of utmost important when raising a crop. Post harvest handling is equally important to get rid of all the physical impurities ensure clean, genetically pure quality seed for certification and final dispatch to market. Even in improper storage seed quality can deteriorate fast making it unsuitable for sale. In every step of drying, handling, processing the stipulated parameters must be followed to ensure top quality seed.

Parameters of a quality seed

- Improved variety/hybrid
- High genetic purity
- High physical purity
- High germination
- High vigour
- Free from seed-borne pathogens
- Safe moisture content

Pilot scheme for seed crop insurance

- Initiated in rabi – 1999-2000 as a pilot in 12 States, 10 crops (pp 155)
- To provide financial security
- To estimate new undertakings
- To bring modern seed production techniques

Plant protection of Variety and Farmers Right Act (PPV & FRA)

This important legislation came by parliament 30 Oct 2001. Features are:

- Stimulate investment in research and development – both public and private sector
- To facilitate the growth of seed industries through domestic and foreign investment to ensure high quality seeds and planting materials to Indian farmers.

Salient features are:

- Extends to all categories of plants
- In order to have legislative protection a variety must be new distinct uniform and stable.

- Period of protection shall be 18 years for trees and vines, 15 years for other crops
- Compulsory licensing in the public interest
- Farmers will have their traditional variety to save, use, exchange, share and sell their products of the protected variety. Farmer cannot sell any branded seed of the protected variety.
- A PPV & FRA authority has been set up with necessary executive powers.

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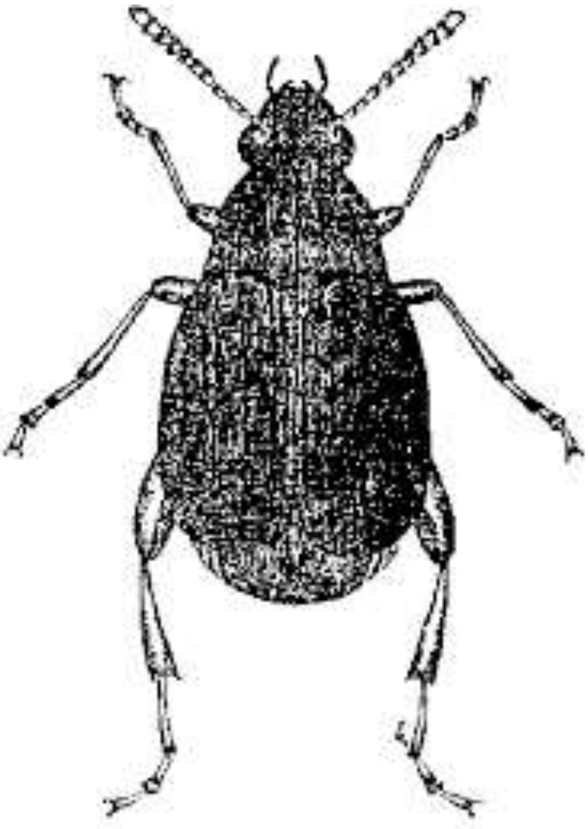

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Module-4: Stored grain pests and their control

Session-1:- Storing grains and seed

Duration – 45 mts

Learning outcome

At the end of this session participants will be able to;

1. Storing Seeds and Grains - Principles of Preventive Storage Protection
2. Additives are useful to protect stored produce from pest attack
3. Pests that attack stored grain
4. How to preserve grains in villages without chemicals

Introduction:

Grains, dry legume seeds and tubers are excellent food not only to humans but also to lots of other creatures. Food stores are excellent breeding sites for all those pests. A farmer has to take adequate measures about food storage to conserve his/her crops to be able to feed the family even during longer droughts.

The main storage pests, apart from rodents, are beetles and moths. Some pests such as grain borers, weevils and Angoumois grain moths are able to feed on whole, healthy grains, they are considered primary pests. Secondary pests such as flour beetles can attack only broken grain, moist and thus soft grain, grain damaged by primary pests or processed products such as flour.

STORED GRAIN PESTS

In India, post-harvest losses caused by unscientific storage, insects, rodents, micro-organisms etc., account for about 10 per cent of total food grains. The major economic loss caused by grain infesting insects is not always the actual material they consume, but also the amount contaminated by them and their excreta which make food unfit for human consumption. About 500 species of insects have been associated with stored grain products. Nearly 100 species of insect pests of stored products cause economic losses

Storage insect pests are categorized into two types viz.

- Primary storage pests : Internal and External feeders
- Secondary storage pests

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Primary storage pests: Insects that damages sound grains are primary storage pests

Common name	Pest	Family	Order
		Internal	
Rice weevil	*Sitophilus oryzae,*	Curculionidae	Coleoptera
Lesser grain borer	*Rhyzopertha dominica*	Bostrychidae	Coleoptera
Angoumois grain moth	*Sitotroga cerealella*	Gelechiidae	Lepidopter
Pulse beetle	*Callosobruchus chinensis, C. maculatus*	Bruchidae	Coleoptera
Cigarette beetle	*Lasioderma sericorne*	Anobiidae	Coleoptera
Drug store beetle	*Stegobium paniceum*	Anobiidae	Coleoptera
Tamarind Beetle	*Pachymeres gonagra*	Bruchidae	Coleoptera
Sweet Potato weevil	*Cylas formicarius*	Apionidae	Coleoptera
Potato tuber moth	*Phthorimoea*	Gelechiidae	Lepidopter
Arecanut beetle	*Araecerus fasciculatus*	Anthribidae	Coleoptera
		External	
Red flour beetle	*Tribolium castaneum,*	Tenebrionidae	Coleoptera
Indian meal moth	*Plodia interpunctella*	Phycitidae	Lepidopter
Fig moth or almond	*Ephestia cautella*	Phycitidae	Lepidopter
Rice moth	*Corcyra cephalonica*	Galleriidae	Lepidopter
Khapra beetle	*Trogoderma granarium*	Dermestidae	Coleoptera

Secondary storage pest: Insects that damage broken or already damaged grains secondary

Common name	Pest	Family	Order
Saw toothed grain	*Oryzaephillis*	Silvanidae:	Coleoptera
Long headed flour	*Latheticus oryzae*	Tenebrionid	Coleoptera
Flat grain beetle	*Cryptolestus minutas,*	Cucujidae	Coleoptera
Grain lice	*Liposcelis divinitorius*	Liposcelidae	Psocoptera
Grain mite	*Acarus siro*		Acari

Contamination by fungi also causes direct losses and poses a threat to human and animal health by producing poisons known as mycotoxins, which contaminate food and feed.

Beetles: Weevils, Grain Borers, Bruchids, Khapra Beetles

The main beetle pests of storage are bruchids (e.g. cowpea seed beetles and bean bruchid), grain borers (e.g. the larger and the lesser grain borers), weevils (e.g. grain weevils), flour beetles, Khapra beetles beetles and dried fruit. The larvae and some adult beetles feed in the seeds and grain, leaving them full of small holes. Sometimes a fine dust is found around the holes, being the excrements of these beetles. Beetle damage renders grains and seeds unsuitable for human and, in case of heavy attack, even for animal consumption.

Cowpea bruchids (*Callosobruchus spp.***)**

Cowpea seed beetle (Callosobruchus maculatus). Adult female on cowpea (***Vigna unguiculata)*** seeds.

Cowpea bruchids (Callosobruchus spp.) are the most common and widespread insect pests in storage. Adults are 2 to 3.5 mm long. They are major pests of pulses (cowpeas, pigeon peas, soybean, geen gram and lentils). They attack both pods in the field and seeds in storage. They attack nearly mature and dried pods. Infested stored seeds can be recognised by the round exit holes and the white eggs on the seed surface. Post-harvest losses are highly variable, but losses can be over 90%.

What to do:

Pods should be harvested as soon as they mature and the seeds sun dried before stored in clean beetle-proof containers. A coating of edible oils or of inert clay can prevent further development of bruchids in the stored seeds. Some farmers in East Africa use wood ash in grain stored for food or seed for planting, or chillies or smoke from cooking fire to preserve seeds for planting. Other farmers store unthreshed pods as a strategy to minimise grain damage by bruchids (Minja et al. 1999).

The bean bruchid (*Acanthoscelides obtectus*)

This beetle, also known as the dry bean weevil, is about 3 to 5 mm long, oval in shape, grey and reddish brown with yellowish and dark patches of hairs on the wing cases. The wing cases are short and do not cover completely the abdomen. This beetle is a major pest of beans. Attack by this beetle often starts in the field. Female beetles lay eggs on the ripening pods on the crop or among stored beans. The larvae bore the way into the seed and feed inside. The presence of mature larvae or pupae can be recognised by the small circular windows on the bean seeds. The life cycle is completed inside the seed and the adult beetle emerges by pushing the window, which falls off leaving a neat round hole about 2 mm in diameter.

What to do:

Intercropping maize with cowpeas, and not harvesting crops late significantly reduced infestation by the bean bruchid (Acanthoscelides obtectus) and cowpea bruchids in Kenya).

The larger grain borer (*Prostephanus truncatus*)

The adult beetle is 3 to 4.5 mm long.

The larger grain borer is a serious pest of stored maize and dried cassava roots, and will attack maize on the cob, both before and after harvest.

What to do:

Use botanicals or plant parts to protect stored cassava. There are reports in Kenya, that the larger grain borer can be effectively repelled by storing cassava or grains with a fairly large amount of dried lantana or eucalyptus leaves (Personal communication, field officer of Meru herbs). Neem is also reported to be effective.

Lesser grain borer (*Rhyzopertha dominica*)..

This is a tiny beetle (2-3 mm long) with a slim and cylindrical shape and red-brown to black in colour. Adults are 2 to 3 mm in length and reddish-brown in colour (shown on wheat grains).The thorax bears rows of teeth on its upper front edge and the head is turned down underneath the thorax so that it cannot be seen from above. Eggs are laid loose among the cereal grains. The larvae are mobile. Both larvae and adult bore through the stored produce usually causing characteristic round tunnels (up to 1 mm diameter).

In later stages of infestation these beetles may also hollow out the grains. Pupation usually takes place within the eaten grain. The lesser grain borer is primarily a pest of cereal grains, other seeds, cereal products and dried cassava. It will be controlled by any method that controls the larger grain borer.

Grain weevils (*Sitophilus spp.*)

The adults are small (2.5 to 4.0 mm long), brown weevils with a long, narrow snout. Female lays eggs inside the grain. The larva (grub) lives and feeds inside the grain hollowing it out. The adult attacks whole or damaged grains causing irregularly shaped holes. Grain weevils attack grains either in the field before harvest or in the store.

Rice weevil (Sitophilus oryzae)

The rice weevil (Sitophilus oryzae) is a major pest of rice, maize and other cereals in store.

Flour beetles (*Tribolium castaneum, T. confusum*)

The adults are elongated beetles, 3 to 4 mm long, red brown to dark brown in colour. The wing cases are marked with finely punctured lines. Larvae and adults are secondary pests and attack cereals and cereals products, groundnuts, nuts, spices, coffee, cocoa, dried fruits and occasionally pulses. Infestation leads to persistent unpleasant odours of the products.

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Khapra beetle (*Trogoderma granarium)*

The adults are oval beetles, 2 to 3 mm long, dark brown in colour often with blurry reddish markings. The larvae are very hairy. They are common in hot dry areas. Damage is done only by larvae feeding on cereal grains and products, groundnuts, oilseed cakes, nuts, pulses, etc.

Dried fruit beetles (*Carpophilus spp.*)

They are slightly flattened ovate to oblong beetles, 2 to 5 mm in length. The wing cases are short, leaving part of the abdomen exposed. They are light brown to black in colour, but several species have yellow or red markings on the wing cases. They are secondary pests; presence of these beetles is an indicator of damp, mouldy conditions. Adults and larvae cause damage on poorly dried cereal grains, cocoa, copra, oilseeds, dried fruit, vegetables, herbs and mouldy produce.

Moths

The potato tuber moth (Phthorimaea operculell

Pupae of the potato tuber moth on potato tuber.

This moth is the most serious pest of potatoes in the region. It occurs in Africa wherever potatoes are grown, and it also attacks tobacco, eggplants and tomatoes.

Caterpillars of the potato tuber moth are up to 12 mm long and feed as leafminers, causing silver blotches on leaves, and bore into the petiole or a young shoot or main leaf vein and later into the tuber. This causes wilting of plants. When eggs are laid on tubers, caterpillars begin feeding on the tubers immediately upon hatching making long irregular black tunnels, which are filled with excreta (faeces), where disease-causing microorganisms grow.

Potato tubers damaged by the potato tuber moth.

Major damage is caused by caterpillars burrowing in the tubers. Infestations start in the field. The pest is transferred with the harvested tubers to the potato store, where it can reproduce and infest other tubers. This may lead to total destruction of the stored crop.

Parasitic wasp (*Copidosoma khoeleri*), a natural enemy of potato tuber moth.

Natural enemies are important for natural control of the potato tuber moth. However, in many cases control by local natural enemies is not satisfactory. Therefore, several parasitic wasps, native from South America, the area of origin of the pest, have been introduced to several countries in Africa. These wasps have provided effective control of the pests in several countries in Southern and Eastern Africa.

Cultural methods (e.g. ridging, use of healthy seed tubers) and biopesticides (e.g. Bt, neem, lantana) as described below are also important for managing this pest.

What to do:

- Farmer experience: Meru Ministry of Agriculture Field Officer Mr Mwai (2007) had tested mixing dried lantana leaves with stored maize and beans - his samples had stayed for over a year without getting attacked by storage pests.

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Lantana leaves protect maize and cowpeas from storage pests

- Use healthy, clean seed, since infested seed tubers are the main cause of re-infestation in the field.
- Avoid planting in rough soil. Plant as deeply as possible (10 cm deep) and ridge at least 3 times during the growing season. Experiments in Sudan showed that increasing the sowing depth from 2.5 cm practiced by farmers to 7.6 cm, significantly reduced damage by the cutworms and the potato tuber moth and resulted in an increase of 3.7 t/ha in marketable yield (Siddig, 1987).
- Compact hilling is very important to prevent moths reaching the tubers to lay eggs. For caterpillars it would also be difficult to reach the tubers, and emerging moths from infested tubers will be killed, since they are not able to penetrate so deep into the soil.
- Provide enough water to prevent soil cracks.
- Mulch the plants with rice straw and/or with leaves. Mulching with neem leaves during the last 4 weeks before harvest significantly reduced insect damage in Sudan (Ali, 1993).
- Intercrop potatoes with hot pepper, onions or peas.
- Harvest the crop immediately as it matures, as tubers left in fields for longer periods are highly infested.
- At harvesting, ensure that the tubers are not exposed to moths before they are properly protected in the store. All harvested tubers have to be bagged and removed before late afternoon every day.
- Destroy all infested potatoes immediately and remove all plant residues from the field. Caterpillars pupate in the tubers and dry stems left in the field.
- Destroy all volunteer potato plants before planting new potato crops.

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Grain moths

Angoumois grain moth (*Sitotroga cerealella)*

The moths of the Angoumois grain moth are small (about 1 cm long with a wing span of 10 to 18 mm), yellowish or straw-coloured, and have a fringe along the posterior margins of the wings. They can be observed flying around infested stores. Female moths lay ovoid and pinkish eggs at night in clumps on the outside of cereal grains, in cracks, grooves or holes made by other insects. Eggs are initially white turning red near hatching. The larvae are caterpillars of dirty white colour and about 8 mm long when fully grown. Caterpillars penetrate into and feed inside whole grains. They prepare a round exit hole for the moth, leaving the outer seed wall only partially cut as a flap over the hole, resembling a trap door.

The adult pushes its way out through this "window" leaving the trap door hinged to the grain. Infested grains can be recognised by the presence of these small windows. The adult lifespan may be up to 15 days, and one female can lay over 100 eggs. They are pests of whole cereal grains like paddy, sorghum, maize and wheat. Damage is similar to that caused by weevils. This moth may also infest the crop in the field prior to harvest, and damage can reach serious levels, before the grains are stored.

Storage moths or tropical warehouse moth *(Ephestia cautella, Corcyra cephalonica, Plodia interpunctella)* The main storage moths are the tropical warehouse moth *(Ephestia cautella*), the rice moth (*Corcyra cephalonica*), and the Indian meal moth (*Plodia interpunctella*). These storage moths are small (15 to 20 mm wingspan), greyish brown in colour with an indistinct pattern.

The moth of the Indian meal moth is distinctive with the outer half of the forewings a coppery-red separate from the creamy inner half by dark grey bands. Female moths lay eggs through holes in the bags. Larvae are elongated whitish caterpillars about 2 cm long. They feed on the seed germ, moving about freely in the stored foodstuff. They cause extensive damage in cereal flowers and other milled products, but also in whole grains, mainly feeding on the germ. They also attack nuts, groundnuts, dry fruit, cocoa, copra and other foodstuff. The dense white cocoons of the pupae are often seen attached to the bag surfaces. Infestations are characterised by aggregations of kernels, frass, cocoon and dirt caused by webbing, which contaminates the foodstuff reducing its quality.

Fungi
Storage fungi include species of Aspergillus and Penicilium. Storage fungi require a relative humidity of at least 65%, which is equivalent to equilibrium moisture content of 13% in cereal grain. Storage fungi grow at temperatures of between 10°C to 40°C. Infection with certain species of fungi may already occur in the field, reducing considerably the storage life of grains. Infection with storage fungi can cause:

- Loss of nutrients.
- Discolouration of the grain.
- Reduction of germination capacity.
- Caking of grains.
- Increase in the temperature of the stored goods up to spontaneous combustion.
- Mouldy smell and taste.
- Production of mycotoxins. These are toxic substances produced by various fungi under certain conditions, which remain in the stored product as residues. They are highly poisonous to both human and animals. The best-known mycotoxins are aflatoxin, ochratoxin, patulin and citrin. Aflatoxins, which are produced by Aspergilum flavus are regarded as very dangerous substance causing liver cancer.

Damage caused by fungi is often neglected until it has reached an advanced stage. However, it is very important to prevent growth of fungi, since it is the only way of avoiding mycotoxins. Mycotoxins are very stable and cannot be destroyed by boiling, pressing and processing. This means that infected produce has to be destroyed. Mycotoxins can be found in the stored product as soon as 24 hours after infection with fungus.

To prevent contamination by fungi, the produce must be properly dried, and any source of moisture in the store should be avoided.

Storing Seeds and Grains - Principles of Preventive Storage Protection

Choice of variety and selection of healthy seeds
Select the most suitable seeds for planting. Indigenous seeds have been developed for hundreds of generations and are well adapted to the areas where they are grown, whereas some modern varieties are higher yielding but may be more susceptible to pests. There is a widespread perception that modern, high-yielding varieties of maize may be more susceptible to storage pests. These varieties often have open cob husks, allowing insects and birds to easily attack maize in the field, whereas some of the traditional varieties have closed husks, thus effectively protecting the crop from insect attack. The same have been observed with some sorghum varieties. Therefore, the increased yield offered by some varieties should be weighed against the susceptibility to storage pests, the expected period of storage and the price to be expected for grain of a particular damage level. Efforts are going on to develop high yielding varieties with resistance to storage pests

Select the best seeds for next years planting avoiding damaged and sick looking seeds.

Choosing harvest time

If planting and harvesting is planned so that harvest falls in the dry season, there are no special problems with drying the crop. Care should be taken when cultivating new high yielding and early ripening varieties, since the harvest may fall in the wetter part of the year, and this may create problems of storage.
Some storage pests (e.g. bean beetles, cowpea bruchids, the larger grain borer and some moths) infest beans and grains in the field only when the crop is almost dry. Timely harvest can therefore ensure that these pests are not carried into the store along with the beans or grain. Thus, timely harvesting (avoiding late harvesting) significantly reduced infestation by the bean bruchid and cowpea bruchids in Kenya (Olubayo and Port, 1997). As a rule, do not leave crops in the field when they are ready for harvest, this increases the chances of infestation by some storage pests

Drying

Drying is an important procedure in storage protection. It prevents seed form germinating and prevents attack by fungi. Some fungi can cause cracking of seed thereby making the seeds more susceptible to pest attack. All seed must be dried to 12-13 % moisture in order to be stored safely. To make sure the seed is properly dried put one seed or kernel in the mouth and chew. If it cannot easily be cracked it is dry enough - if it crushes between the teeth it is not dry enough. This is known as the tooth test.

Heat used for drying the produce will also kill larvae and chase away adults of insect storage pests. Care should be taken to avoid overheating since excessive heat can damage seed or grains. Care should be taken not to exceed the following temperatures: beans: 35 °C - seeds: 43 °C - cereals: 60 °C.

The following methods of drying are possible:

- Seed can be spread out in the sun on a hard clean surface to dry for several days in dry weather, until a seed cannot be bitten into when putting it in the mouth. The thickness of the layers of cobs, panicles, pods or grains must not exceed 5 cm, and the seed must be turned regularly in order to ensure good and even aeration. In the evening, the produce must be put in a pile and covered.
- Simple driers. Several designs of solar driers are available.

Sorting and cleaning the produce

Check whether the produce is infested by taking samples. Pay particular attention to cracks and gaps where insects may hide. If the produce is infested, ensure it is stored separately (quarantine) and treated in order to prevent the pests infesting clean produce. In case of heavy infestation discard the produce. In case the produce is slightly attacked, heating to no more than 50°C can kill moths and weevils; use a thermometer, as heating to any higher temperature will destroy the germination capacity the seeds

Removal of infested grains or cobs and pests can also be done by hand, sieving, winnowing or moving the grain (shaking, restacking). When using methods that merely separate the pests from the stored product, ensure that the pests removed from the produce are killed to avoid re-infestation.

Store location

Site stores away from any potential source of infestation. The grain and tuber moths are good flyers and adults from infested stores often infest growing crops in the field. Separations of stores from fields may help to reduce attack.

Characteristic of store

A good seed store must be airy, shady, cool and dry. Temperature variations should be as small as possible, because it encourages condensation of water, which promotes fungal development.

Crops in the store should be protected against dampness rising from the ground, and the site should be safe from flooding in the rainy season. The roof should have no leaks. Keep the temperature and humidity as low as possible (perform controlled ventilation). There are indications that storing grain in a dry place may help reduce infestation of grain moths.

Hermetic, airtight storage at low humidity gives good protection against storage pests. However, to avoid mould growth care should be taken to ensure that the produce is dry. This is particularly applicable for long-term storage in warm dry areas. It is advisable however, not to store seed grain for more than a few months. In conditions where the relative humidity is high, airtight storage is not recommended due to the risk of mould growth.

Hermetic storage is useful for storing small amount of seeds or grains (e.g. to be used for replanting); they can be stored in a strong airtight container with a close fitting lid (glass, ceramic, strong plastic can be useful). Ceramic pots that do not have lids must be covered very carefully or topped up with dry soot, ashes or fine dry soil.

Storage hygiene

Always keep the store and its surroundings clean. It has been said: "the most important, economic and effective tool for storage hygiene is the broom". Before newly harvested crops are stored, the store should be carefully prepared well ahead of time. Old stored products should be removed and the room completely cleaned up. The whole building should be well aired and if possible fumigated or disinfected (see store fumigation and disinfection below). The walls roof and floor should be both watertight and rat proof, and small holes and cracks, which are potential breeding places for storage insects, should be sealed.

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Inspecting the store

Periodic inspection (weekly to fortnightly) and removal of any infested produce is essential. Check for droppings and footprints of birds and rodents. Look for flying moths at dusk. Brush stacks of bags with a stick or broom to disturb and discover resting moths. Lift bags in order to detect moth cocoons along the line where bags touch each other.

When looking for beetles, pay particular attention to cracks, bag seams and ears where they often hide. Empty individual bags in a thin layer onto a sheet and examine the contents for beetles and larvae. This should be done in the shade so that the insects do not flee immediately.

Insects can be also be sieved out using a box sieve with a mesh of 1 to 2 mm. Identify the insect found in order to perform the correct treatment. These measures should prevent the breeding of carry-over insects from former crops. The surroundings should also be cleared to discourage easy re-infestation by insects and rodents.

Infection with fungi can be detected by the mouldy smell, which is noticeable even before any visual changes to the product can be seen. Pay attention to water marks on bags, which can be still noticed after the bags have dried.

Store fumigation
Farmers in the Philippines as well as in Benin lit fires in which powdered chilli pepper is burnt underneath grain stores once a month to keep away storage pests. One disadvantage is that the smoke is very sharp and uncomfortable for human eyes and respiratory system.

Store disinfection

After the store has been cleaned completely and all old deposits of dust (possibly containing insect eggs) has been removed, it is good practice to dust the whole store with diatomite earth, lime or ashes as a further prevention of problems. Where larger grain borer has attacked the wood in the construction, the wood should be treated with any of the approved wood preservatives or thoroughly sprayed with kerosene, oil mixture to get rid of any surviving grain borers.

Modernised granary	**Traditional granary**
	 Raised traditional granary with several layers of thick grass and old oil smeared on the lower part of

Raised modernised granary with a high iron sheet roof with old oil smeared on the lower side of the support poles to prevent termite attack.	support poles to prevent termite attack.

Additives are useful to protect stored produce from pest attack:
The use of mineral substances such as fine sand, clay dust, lime and wood ash cause invisible injuries to the stored food pest leading to dehydration. They also fill the spaces between the grains, making difficult for the pest movement and respiration. When using mineral substances the amounts required are around 50 to 100 g per kg of stored product, except for sand, of which larger amounts are required.

The addition of ashes, fine sand, lime, diatomite earth, and mineral or vegetable oils is particularly useful for protecting small farm seed storage, or for storing small amounts for replanting. However, this is not always practical for large quantities of seed in terms of labour required. For larger amounts of grains and seeds it is often more practical to simply mix the seed with any strong smelling plant material available to repel insects. Some plants such as pyrethrum and derris can actually kill storage insects.

Wood ash
Wood ash either alone or mixed with powdered chilli pepper is an efficient method of pest control. However, ashes may have an effect on the taste of the treated product. The success of this method depends on the amount of ashes being added. Ashes at 2 to 4 % by weight of grain is said to give 4 to 6 months protection if the moisture content of the grain is below 11%. Ashes from casuarinas, derris, mango and tamarind are particularly suitable. Any other ash mixed with powdered pyrethrum, Mexican marigold or syringe seeds will increase the protection against insects. Ashes do not control the larger grain borer.

Lime
Mixing seeds with 0.3% lime have given good results in weevil control.

Sand
In districts where fine sand is easily available it can be used for protection of stored products. It is best used with bigger seeds, the intention being that all the spaces between the larger seeds should be filled by sand, which can easily be removed again by sieving. The more sand used the better, but at least equal amounts of sand and seed should be used.

Bt. (Bacillus thuringiensis)
Bt in powder form mixed with fine sand is effective against potato tuber moth. It may also be effective against grain moths as well. For more information see on potato datasheet T

Vegetables oils
Oils of coconut, castor bean, cottonseed, groundnut, maize, mustard, safflower, neem and soybean affect egg laying, and egg and larval development of stored pests. The addition of vegetable oil is particularly useful in protecting legumes against pulse

beetles (bruchids). Losses in pulses can be prevented with the addition of 5 ml oil per kg of grain/seed. To be effective the seed must be coated properly with oil. Sunflower oil is not very effective. The effect of oil treatment decreases with time, so seeds stored this way should be treated again at any new sign of infestation. Small seeds may loose some of their germination capacity after oil treatment. If neem seed oil or any other non-food oil is used the bitter taste can be removed by immersing the seed in hot water for a few minutes before food preparation.

Admixture of plant parts

Traditionally many different types of plant parts are used against store products pests. Examples of plant materials that help protecting the stored grain/seed:

Plant names	Plant parts	Treatment
Aloe	Whole plant	Parts dried, ground and dust mixed with the grain
Chilli peppers	Ripe, driedpods with ashes, dung or fine clay	Whole pods mixed with grain or dusted as powder on beans
Pyrethrum	Flower heads	Pick on hot days. Dry in the shade. Crush to powder and mix with grain/seed.
Sunnhemp (Crotolaria)	Seeds	Mix seed between gaps in stored larger size grains.
Datura (thornapple)	Leaves and stems (careful - seed are very poisonous)	Dry and mix with produce
Derris	All parts	Stored produce dusted or sprayed
Eucalyptus	Leaves	Layered or mixed with stored produce
Lantana sp.	Leaves	Crushed and placed among seeds
Syringa (Melia Azedarach)	Leaves, ripe seeds	Dried, powdered, mixed with stored grain using 2% if powder from seed, 4% if powder from leaves
Mexican Marigold	Whole plants	Add dried plants in layers, or mix in powdered plant or place 3-5 cm layer of crushed plants in base of grain bins
Spearmint	Whole plant	4% leaf powder will give good protection for more than 4 months
Neem	Leaves, crushed seeds and their extracts and oils	-

The dosages of plant substances required are generally around 50 g per kg of stored product (Gwinner et al., 1990).

Module 5- Weed Control

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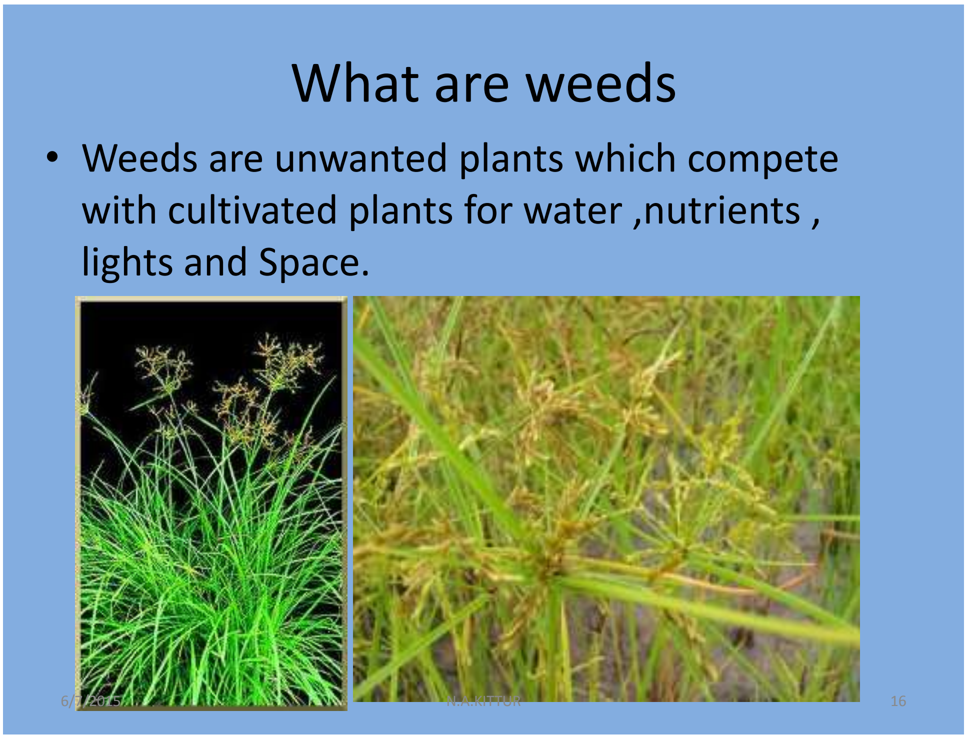
Session-1: **Weed control and vertebrate pests**

Duration- **30 mts**



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Definitions of weeds

- Anything that grows where they are not supposed to grow in a crop
- They compete with main crop for moisture, nutrients, light etc.
- Thus they reduce the crop yield
- They also act as alternate host for insects, pests, diseases
- They release harmful substance also in the soil
- Crop loss can be 15-30 % in farmers field
- Render harvesting difficult

Control measures

- Mechanical - by equipment, hand and other mechanical equipment
- Cultural – by manipulation crop canopy
- Chemical- by herbicides

	
A weed infested field	**Mechanical hand weeder**

Characteristics of weeds

- Produce enormous quantity of seed- e.g.parthenium, wild oats 250/plant, wild amaranthus- 11 million
- On an average annual weeds produce 16500/plant
- They can survive drought stress
- Can germinate under stress conditions
- Grow at a faster rate than crops
- They are viable for very long time-up to 50 years
- How parthenium came to INDIA ?

Classification of weeds

- Most weeds are Antophyta (angiosperms)
- Dicots and monocots
- Out of 250,000 sp of plants around 250 are regarded as weeds
- They are annual, biennial, perennial
- Most important are annuals as they compete with crops (PICS)
- Perennials – ***Cynodon dactylon, S. spontaneum, Cyprus rotunda(mutha)***

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Crop-weed competition

- Germinate same time as the crop and compete from day 1.
- Initially both grow without competition
- As both grow competition become fierce
- Critical period is 15-60 DAS
- Once the crop canopy covers the soil surface there is very little damage – sorghum, cowpea, millets
- Weeds must be at low level during this critical period

Managing weeds

- **Un**derstand weed biology
- Prevention - cultural practices, clean seed, weed free seed (post harvest), clean manure, control weed along irrigation canals as water spreads to fields

Eradication

- Complete removal by physical means
- May be costly as labour requirement can be very high
- Required with high value crops such as vegetables

Control Mesures:

(a) Physical

- Chemical, cultural, biological
- Physical – hand pulling, hoeing, tillage, mowing, burning, flooding, smothering
- Implements require energy, back-breaking, labour intensive, time consuming, costly
- Tillage equipment behind a tractor – hoes, cultivators etc

(b) Cultural

- Use quality seed with good germination so that crop growth is vigorous, faster
- Plant population in a row is higher
- Quick canopy coverage
- Some crops are ideal – Sudan grass, Sorghum, cowpea competes well
- Close row crops are better competitor
- Crop rotation to break the cycle

(c) Chemical

- Large scale use of chemicals
- They are called herbicides as they kill weeds
- They are selective – do not kill the crop but kill the weeds
- Using biotechnology – e.g. roundup ready herbicide of Monsanto

(d) Biological control

- **U**sing natural enemies
- May be highly host specific
- Controlling Lantana by ***Teleonemia scruplosa***
- Parthenium - Mexican beetle
- Aquatic vegetation – by Chinese carp
- Prickly pear – by Cochneal insects in Maharashtra and Tamil Nadu

(e) Integrated weed management (IWD)

- **Is** an integrated approach just like IPM
- Combination of cultural, biological and chemical
- Again very crop specific
- Weeds also can add biomass into soil provided they are well integrated and decomposed before the next sowing

Crop-weed competition

- Germinate same time as the crop and compete from day 1
- Initially both grow without competition
- As both grow competition become fierce
- Critical period is 15-60 DAS
- Once the crop canopy covers the soil surface there is very little damage – sorghum, cowpea, millets
- Weeds must be at low level during this critical period

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Vertebrate pests:

Crops are also damaged by vertebrates:

Rabbuts
Rodents
Nilgai
Wild boar and pig

Nilgai

From base of Himalaya
To Karnataka
Population in India around 1 lakh
Large scale damage in gangetic plan
Can be legally hunted in U.P

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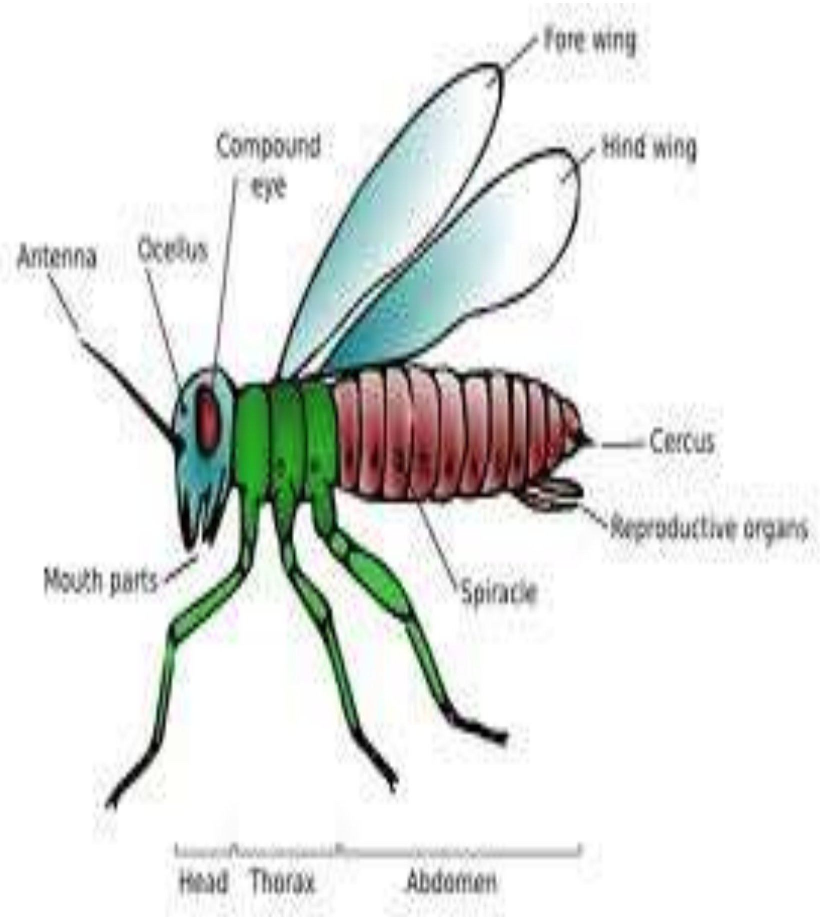
Module 6- Insect pests of field crops



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Session-1: Understanding insect pests

Duration-60 mts

Learning outcome:

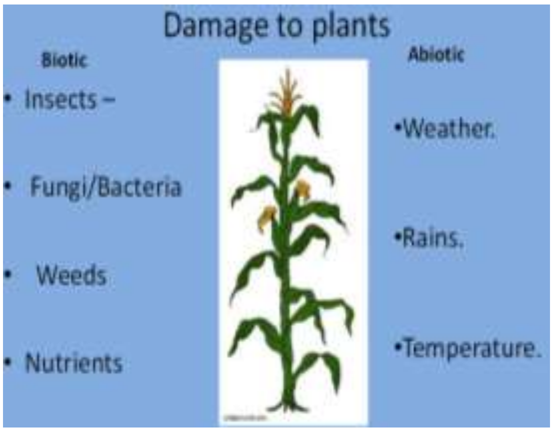
At the end of the session participants will be able to :

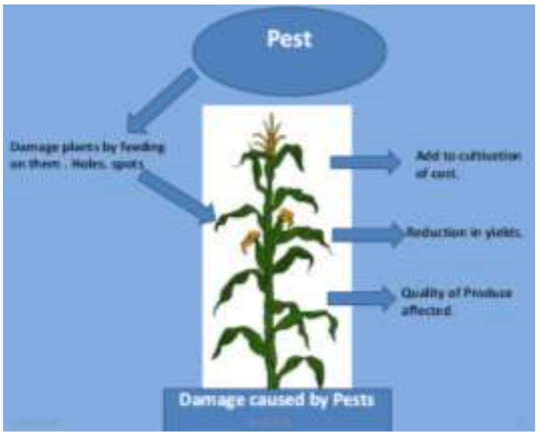
- Define pests
- Define insect pests
- List the damage they cause
- Demonstrate the life cycle of major pests
- List some of the major insects of crops

Introduction:

What are pests?

Pests can be defined as any living plant or animal which affects the normal growth of the cultivated crop for its survival and multiplication. Such as insects, Mites, Fungi, Bacteria, Virus , Weeds ,Nematodes, Rodents, Birds and Mammals. It is any living plant or animal which affects the normal growth of the cultivated crop for its survival and multiplication.



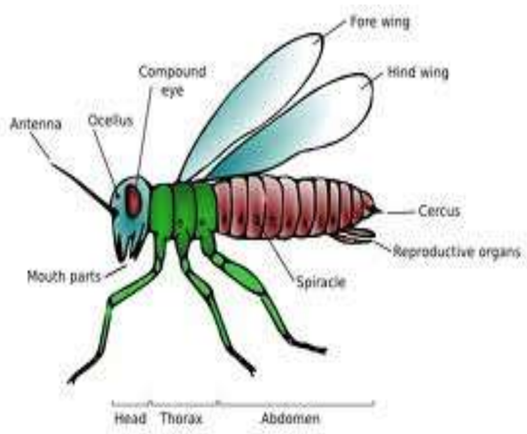


Out of 9,10,000 species of animals 6,40,000 are insects (73%)

They are the largest group of animals in the Animal Kingdom

They have definite characteristics, like

- Body is divided into three parts **Head, Thorax, and Abdomen.**
- They have **3 pairs of Legs** and 2 **pairs of wings.**
- They undergo Metamorphosis **Egg, Larvae Pupa and Adult.**



Definition of insect pest:

Any insect that can directly or indirectly injure, cause damage to any plant

Classification of Pests:

Pests are broadly classified into two categories based on their feeding habits:

A. Sucking pests
B. Fruit and Shoot borers

Sucking Pests:

Sucking pests suck sap from the plant. Following are the important sucking pests:

- Thrips (Thysanoptera)
- Plant/Leaf bugs, Lace Bugs
- Bug-like Insects
- Plant hoppers - Psyllids, Aphids,
- Whiteflies
- Mealybugs
- Scales
- Mites (Acarina)
- Spider mites, Eriophyid mites

Damage due to sucking pests:

Following are major damages due to sucking pests:

- **Plant distortion** when they feed on juvenile tissues. Cells are damaged and as the leaves and stems continue to expand they become distorted
- **Honeydew** is a clear, watery excrement that is produced mainly by insects that feed in plant phloem bundles. Honeydew often promotes the growth of sooty molds. Cell feeding often produces tiny spots or speckles of yellow
- **Dead Spots** - some sucking pests dissolve tissues within leaves or stems and this results in dead spots, even on expanded plant parts.
- **Salivary secretions** can clog vascular bundles, thereby stunting, discolouring or killing plant parts outward from the clogged area
- **Tar spots** - Sucking pests remove lots of liquids and little nutrients, they produce two types of diagnostic excrement –Tar spots are dark, shiny spots of resinous-like material

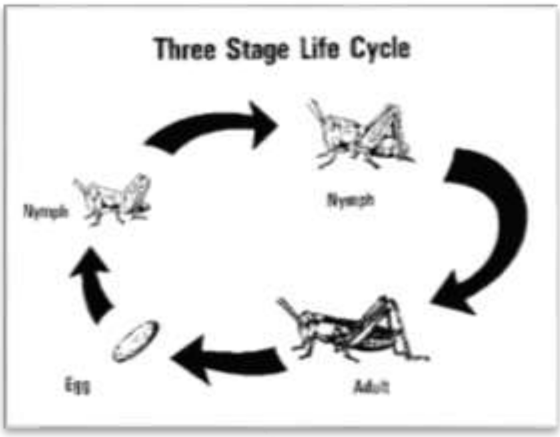
Sucking Pest life cycle:

Sucking pests complete their life cycles in four stages:

Adult: Winged fly. Duration is three to five days. Very active but can't cause damage to plants.

Egg: Lays small eggs. Egg stage completes in 3-5 stages. Non movable. No damage

Nymph: Most active. Nymph stage completes in 7 – 10 days. Cause damage to plants.



Fruit and shoot borers:

Fruit and Shoot borers bores into young shoots and fruits. Following are the major fruit and shoot borers:

- Brinjal fruit and shoot borer
- Bhendi fruit and shoot borer
- Cotton boll worms

Damage of Fruit and Shoot borers:

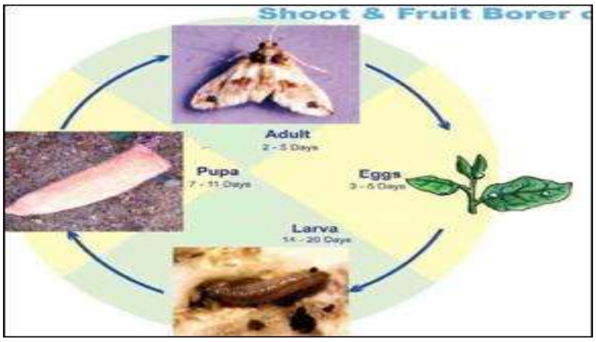
- Larval feeding inside shoots result in wilting of the young shoot
- The damaged shoots ultimately wither and drop off.
- Reduce the fruit number and size
- Destruction of fruit tissue – Unfit for marketing

Life cycle:

Fruit and shoot borers complete their life cycle in **four stages**:

Egg: Spherical in shape and creamy white in colour, present singly. This stage completes in 2-3 days.

Larva: Shows colour variation from greenish to brown. This stage completes in 40 - 50 days. Very active and damage plants



Pupa: Brown in colour, occurs in soil, leaf, pod crop debris. Inactive, no damage to plants. This stage completes in 10 – 12 months.

Adult: Light pale brownish yellow stout moth. Forewings are olive green to pale brown in colour with a dark brown circular spot in the Centre. Hind wings are pale smoky white with a broad blackish outer margin. This stage completes in 5 – 10 days. Very active, no damage to plants.

Type of damage caused by Insects

- **Direct damage**
- **Sucking** – Suck the sap of leaves and stem and cause Curling ,Yellowing ,Reddening and growth is affected. Aphids ,Jassids ,Thrips ,White Flies.

Chewing

Chew leaf stem or root portion causing holes , Skeletonize or destroy leaves. Ex. Grass Hopper,Beetles

Boring and Mining

Cause damage by boring or mining into the plants. Ex Stem **Borer, leaf Miners.**

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Indirect Damage – Some Insects transmits Virus diseases from infected plant to healthy plants.

Some insects Secrets Honey dew like substance on which sooty mould develops interfering with Photosynthesis.

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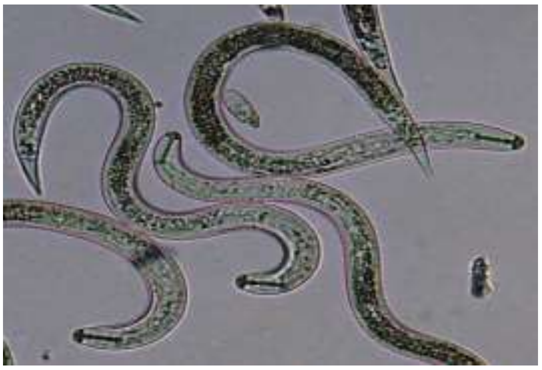
Mites

Mites are also insects and cause similar damage as sucking insects but have four pairs legs and generally suck sap causing symptoms like reddening, bronzing and curling of leaves.



Nematodes

Nematodes are minute threadlike worms ,plant nematodes generally live in the soil in large numbers infesting roots .Galls and Curling of plant part.

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Beneficial insects:

What is a beneficial insect?

Insects that performs valued services like pest control and pollination

Major beneficial insects:

Lace wings: Little green or brown insects with large lacy wings. It is the larvae (which look like little alligators) that destroy most of the pests. They are sometimes called aphid lions for their habit of dining on aphids. They also feed on mites, other small insects and insect eggs

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Lady bird beetle:

Young larvae, black with orange markings, eat more pests than the adults, and they can't fly. Yellowish eggs are laid in clusters usually on the undersides of leaves

Hover flies: Also known as syrphid fly, hover fly or flower fly. Adults look like little bees that hover over and dart quickly away. They lay eggs (white, oval, laid singly or in groups on leaves) which hatch into green, yellow, brown, orange, or white half-inch maggots that look like caterpillars. They raise up on their hind legs to catch and feed on aphids, mealybugs and others.

Wasps: The eggs then hatch, and the young feed on the pests from the inside, killing them. **Braconid wasps** feed on moth, beetle and fly larvae, moth eggs, various insect pupae and adults. If you see lots of white capsules on the backs of a caterpillar, these are the braconid cocoons--leave the dying caterpillar alone

Ichneumonid wasps control moth, butterfly, and beetle and fly larvae and pupae.

Trichogramma wasps lay their eggs in the eggs of moths, killing them and turning them black.

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Tachinid flies: Parasites of caterpillars. Adults are 1/3 to 1/2 inch long. White eggs are deposited on foliage or on the body of the host. Larvae are internal parasites, feeding within the body of the host, sucking its body fluids to the point the pest dies.

Damsel bugs: Predators as adults and larvae, feeding on caterpillar and other pests

Ground beetles: Adults consume gross hopper eggs, eggs, aphids, caterpillars, and other soft bodied insects. Adults also may feed on pollen and nectar.

Plants that attract beneficial insects: There are certain plant species which attracts beneficial insects. Following table shows beneficial insects and plants attracts them:

Beneficial insect	**Plants attract**
Lace wings	Coriander, Sun flower,
Lady bug	Coriander, Marigold
Hover flies	Coriander, Marigold

Wasp	Coriander, Marigold
Tachinid flies	Buck wheat

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Session– 2: Pest surveillance and Economic Thresh hold level(ETL)

Duration: 30mts

Learning outcomes:
At the of the session participants will able to:

(1) Employ the need for pest surveillance
(2) Describe the concept of Economic Thresh(hold level
(3) Decide time of spray

Introduction:

One of the basic requirements in managing pests is constant vigil and surveillance, monitoring of biotic and abiotic components of the crop ecosystem to assess or predict pest outbreaks. Implicit in this concept is the principle of economic threshold level, the point at which pest control is initiated.

The use of precise monitoring techniques coupled with accurate **economic threshold levels (ETL)** allows the most effective and efficient use of pesticides. The approach is essential to minimize costs, to maintain stability of the agro ecosystem, and to reduce the amount of pesticides released into the environment. However, pest surveillance should not be concerned with pest incidence only. It should be used as a tool to determine the factors which actually cause pest occurrence.

Uses of pest surveillance

1. Surveillance is important for predicting pest outbreaks.

2. The degree of success of the plant protection measures will largely depend upon an effective pest surveillance and monitoring programs.

3. By sampling immature stages of insect/pests, it is possible to forecast the numbers of pests expected in the later stages and spray dates are determined so that the first larvae are destroyed.

Surveillance methods

Systematic sampling

Taking samples in the alternate rows and beds, depending upon the size of the plot and the number of rows, it can easily be decided about the rows and beds in which the sampling can be done.

Diagonal Fashion:

The person should start taking samples from one corner and walk diagonally taking samples from alternate beds. Once the samples are taken in one diagonal line, samples should be taken from the nearest other corner. The percentage of pest incidence and the number of pests per plant are to be calculated.

Figure 7. Surveillance crew in a groundnut field.

Figure 8. A pheromone trap in groundnut.

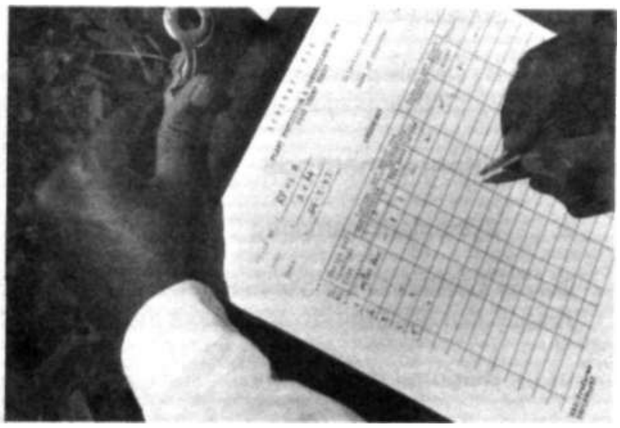


Figure 9. Observation for thrips on groundnut.

Figure 10. Surveillance data sheet.

Protection Levels

- **Economic protection**
  Followed for trials protected to avoid moderate or bulk damage. These trials are sprayed only when severe infestation cause economic damage affecting the progress of further research.
- **No protection**
  Related to trials which are not sprayed at all.

Timing of spray application

Pesticides are frequently applied as a prophylactic or on a fixed calendar schedule irrespective of the occurrence or level of the pest population. However, fewer applications are needed if they are timed more accurately and this will reduce selection pressure for resistance. A routine pest assessment is required, preferably aided by a pest forecast of the probable level of infestation, to avoid fixed schedules.

i) **Economic injury level.** It is the lowest population density that will cause economic damage. ii)

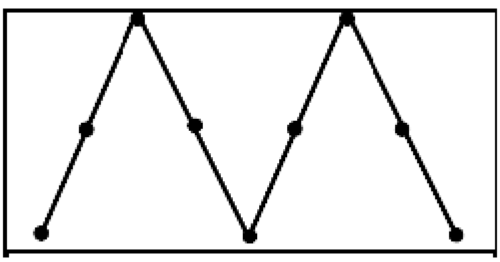
ii) **Economic threshold.** The population density at which control measures should be applied to prevent the increasing pest population from reaching the economic injury level.

Apart from counting the number of insects in a crop, various trapping techniques can be used to sample populations, e.g., pheromone traps, light traps, and attractant (such as fishmeal) traps.

Time of sampling and the stage of the life cycle sampled are most important. Detection of eggs is most important to avoid delay in taking the appropriate control measure.

Some larvae are very difficult to find until they reach the third or fourth instar while others feed inside plant parts. A pesticide application should be done early, at the start of an infestation of first instar larvae, otherwise less control is achieved.

Crop Monitoring Techniques



Pattern 1 – Used for insects that often are uniformly distributed: including aphids, bertha armyworm, diamondback moth and lygus bugs.

Every field should be monitored on a regular basis to detect specific insect pests and to determine densities within the crop (e.g. Pattern 1). With an adequate monitoring program to establish presence of pest species and to monitor changes in population densities, producers are more likely to be aware of potential problems.

The first step is to determine the potential insect pests. Producers unfamiliar with th possible insect pests of a crop should acquire a production guide for the crop. Th second step is to identify the insects, their life stages and to detect their presence by th effect they have on the crop.

Know the signs of a potential problem.

The most obvious sign of a problem is physical damage to the crop. Stands that show patches of thinning, stunting, or dying off may be the first indication of an infestation as they are usually visible from a distance. If the problem is due to insect damage examine individual plants to determine chewing or sucking damage to leaves, stems flowers and buds, and possibly, the insects themselves.

Being able to recognize the symptoms of damage within the crop and on individua plants can help to indicate the presence of an insect pest and its identification.

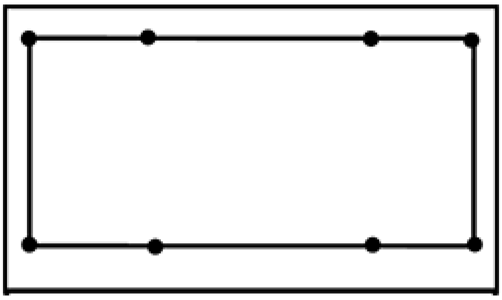
Symptoms of insect damage will vary, depending on the type of mouthparts of the insec pest. Damage caused by insects with chewing mouthparts is often easy to identify, eve when the insects are not readily visible. These insects may remove material from leaves stems, or other plant parts giving it a ragged or chewed look. Injured roots will ofte show sign of bored holes or lesions, while above ground the plant may appear wilted c stunted. Examples of insects with chewing mouthparts are grasshoppers, larval and adul beetles, larvae of moths and butterflies (caterpillars) and larvae of flies (maggots).

It is more difficult to discern damage caused by insects with sucking mouthparts as th symptoms are often not readily visible. Insects with sucking mouthparts pierce the plar and feed on sap and juices. Damage may appear as tiny dots where the mouthparts hav pierced the plant tissues. Eventually symptoms may include dead plant tissue in lea tips, heads, etc. Since these insects inject a chemical to prevent the sap from coagulatin while feeding, plant juices will continue to flow after the insect has moved or Therefore, evidence of sucking insects may be seen as glistening sap extruded on pod and stems.

More advanced symptoms of severe injury include shrivelled stems and seeds and reduction in number of seeds set. Extreme cases in canary seed have been observe where aphid feeding has resulted in empty, whitened tips of heads. Examples of insect with sucking mouthparts are leafhoppers, plant bugs (e.g. Lygus) and aphids.

There are many other signs of insect infestations: lodged plants; silken webs discolouration of plant tissue; cocoons or pupae found on leaves; insect frass (faeces on and around plants; and of course direct observation of insect adults and/or larvae These signs should arouse suspicion of a potential problem and help determine wha insect(s) could be causing the damage.

Scouting



Pattern 2 – Used when pests are at the edges of fields. Including flea beetles Colorado potato beetle and grasshoppers..

Insects are rarely uniformly distributed throughout a field. They are simply too dependent on local environmental conditions and, often, terrain is variable even withi a single field. Hills and depressions within a field dictate the local pattern of so moisture, and insects sensitive to soil moisture conditions will distribute themselve accordingly.

Cutworms, for example, can be found first on the tops of hills, because of the warmer drier soil, and may not be noticed in low-lying areas until the insects become larger an more numerous. Conversely, wireworms will be less abundant on hilltops, preferrin the more moist soils found in low-lying areas.

Many insects tend to be edge feeders because of migration from ditches and adjacen fields with damage more prevalent around the margins. Therefore, field scouting can b most effective using Pattern 2. Concentrating control in affected areas can reduce inpu costs while keeping insect populations below the economic threshold. Scouting for sign of infestation where they are most likely to occur will lead to early detection.

The life stage of an insect is an important factor to determine the best timing for contro measures. For example, egg and pupal stages are usually difficult to control. These ar non-feeding life stages and are not considered a threat to the crop. Because they ar immobile in these stages they are often in locations that are more difficult to access b predators and control measures (e.g. Bertha Army worm pupae or Wheat Midge cocoon in the soil).

Even larvae, which are more susceptible to insecticides, can be difficult, or no economically feasible to manage when they are below the soil surface. In a few cases insects (e.g. blister beetles) may exhibit both destructive and beneficial behaviou depending on life stage. As adults, blister beetles can cause serious damage to portion of canola fields. However, the larval blister beetle is predatory on grasshopper eggs.

Once the presence of a pest has been confirmed, its identification must be verified Correct identification may require consulting a reference guide or an agronomist. T facilitate this process, collect samples of the damage and a few specimens of the pest including as many life stages as possible. The insect and associated damage should b compared with good reference material. If uncertainties remain, contact the Agricultur

Knowledge Centre at 1-866-457-2377, or contact the Crop Protection Laborator (address below). These resources will help to ensure a proper identification.

Sampling

Once the pest has been identified, the level of infestation in the crop must be establishec There are several important points to consider while sampling.

First - It is important to utilize a sampling technique that is appropriate for the type c insect being monitored. The monitoring method is largely related to specific insec behaviour. Highly mobile insects like flea beetles and grasshoppers provide tw different examples of monitoring techniques.

Rather than attempt to count flea beetles, a per cent plant damage threshold is used. Fc grasshoppers, the economic threshold is measured in insects per square metre. Howevei sampling such mobile insects by counting the number within a measured area i difficult.

An example for estimating grasshopper densities .

1) Before counting grasshoppers in a field or roadside, measure a distance of 50 metre on a reasonably level surface. Usually, this will be adjacent to the actual area to b sampled, such as a road. Flag both ends using markers or specific fence posts on th field margin. These points should be easily visible for the observer because they will b used as starting and end points.

2) To begin the count, start in the area to be sampled, aligned with one of the markers Walking parallel to the measured distance, move through the crop toward the othe marker making some disturbance with your feet to encourage any grasshoppers to jump Any grasshoppers that jump through a one metre field of view in front of the observe are counted. A metre stick can be carried as a visual guide to give perspective for a on metre width. After doing this a few times, one can often visualize the required widt and a metre stick may not be required.

3) At the end of the 50 metres, the total number of grasshoppers counted is divided b 50 to give an average per square metre. A hand-held counter can be useful to count th number of insects while the observer measures off the required distance. This tool ma not be practical under high insect populations.

It is important to sample randomly and gather numerous samples. The samples mus represent, as much as possible, the entire field being monitored. Random samplin reduces the risk of biased estimates that could result from uneven distribution of insec populations. Collecting numerous samples will also increase the accuracy of an overal field estimate?

Areas of a field may have insect numbers that are in excess of economic thresholds However, other areas may be very low in pest densities. In these situations, a decisio could be made to either not spray, due to the overall average density being belov economic threshold, or to concentrate control measures on the more highly infeste areas. Either choice would actually benefit the producer financially while reducin environmental impacts.

Third - Keep in mind the edge-effect. In situations where insects migrate into a fiel from an adjacent field or ditch, the population density is likely to be highest at fiel margins. Some pest species prefer the edges of a field because of light, temperature o moisture factors.

Edge effects can also be important for other reasons. Although they may distort tru population estimates, they may indicate a potential problem before it becomes serious Be sure to sample throughout the field, not only the field margin, to avoi overestimating population densities.

Sampling methods can vary according to the particular pest.

1) % damage to leaves, plants, foliage, or
2) # of plants showing damage; or
3) # adults or larvae/stem / plant.

Walk through the crop to obtain or observe the required sample units (i.e. leaves, stems, whole plants or insect counts) every few steps. To get an accurate population estimate, sample randomly at reasonably spaced intervals.

As previously discussed, the best estimate of a population or damage will be achieve with adequate, representative samples taken over a well-distributed pattern. A zigza route through the field sampling approximately every 10 metres is a commonly use pattern.

If the chart says:

1) # adult insects or larvae / m^2

Use a metre-stick or pre-measured piece of string to mark off a square metre of the crop Examine this area, counting the numbers of pests seen. Do this at several randoml chosen and widely-spaced sites. Average your results.

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Session 3 Ill effects of pesticides

Duration – 60 mts

Effects can be classified as follows:

- Acute effects (direct, short-term)
- Chronic effects (indirect, long-term)

Acute effects (direct, short-term):

5 million agriculture workers suffer poisoning every year, and about 20.000 are killed by pesticides (accidental).Very often caused by Organophosphates (*Parathion*). Poisoning can occur by farm application and by eating contaminated food.

Chronic effects (indirect, long-term):

Even very low levels of pesticide can cause health problems, as they can accumulate within the organism. Pesticides exposure have been linked to:

A. Neurological problems (OP)
B. Cancer
C. Reproductive problems (endocrine disruptors, OP)

A. Neurological problems:

Many Organo Phosphates (OP) interfere with the neurological system. OP have been linked with depression, cognitive problems especially in children, poor learning capacity.

B. Cancer:

Many pesticide are clearly recognized as carcinogenic, substances that can greatly increase the chances of suffering cancer (Vinson et al 2011). The risk of lymphoma and leukaemia increased significantly in exposed children when their mother was exposed during pregnancy. The risk of brain cancer was correlated with paternal exposure either before or after birth. The incidence of brain cancer was influenced by the father's exposure to pesticides.

C. Reproductive problems:

Certain pesticides mimic hormones, these are endocrine disruptors. Data suggests that endocrine disrupting chemicals could be implicated in the rise of human reproductive abnormalities. *Reduced male fertility, testicular cancer, low sperm numbers and quality have all been linked to long-term exposure of some pesticides.*

The indirect toxicity related to two principles:

- **Bioaccumulation** – the tendency for a compound to accumulate in an organism's tissues (especially in fatty tissues for fat soluble organochlorines such as DDT) and
- **Bio magnification** – an increase in concentration up the food chain.

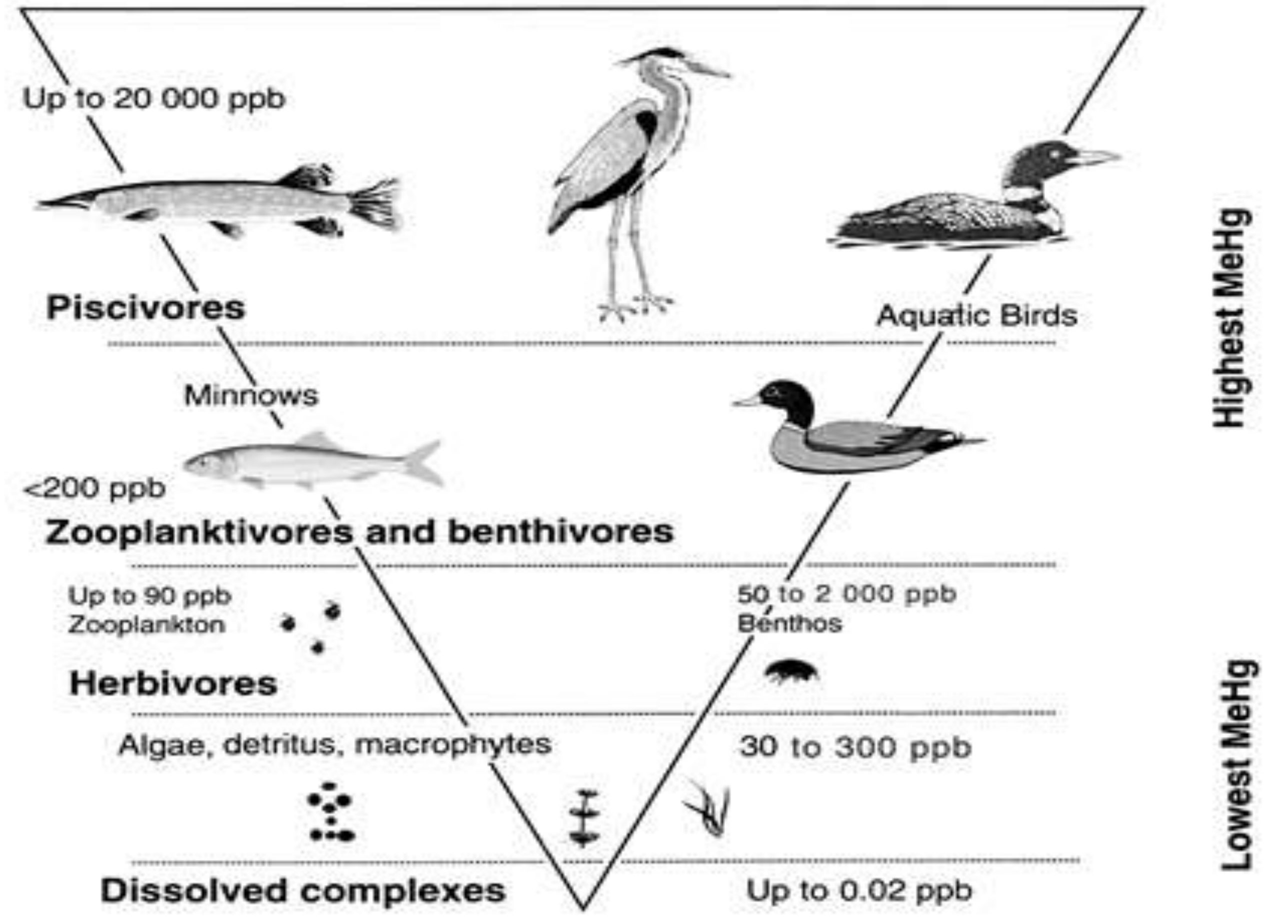


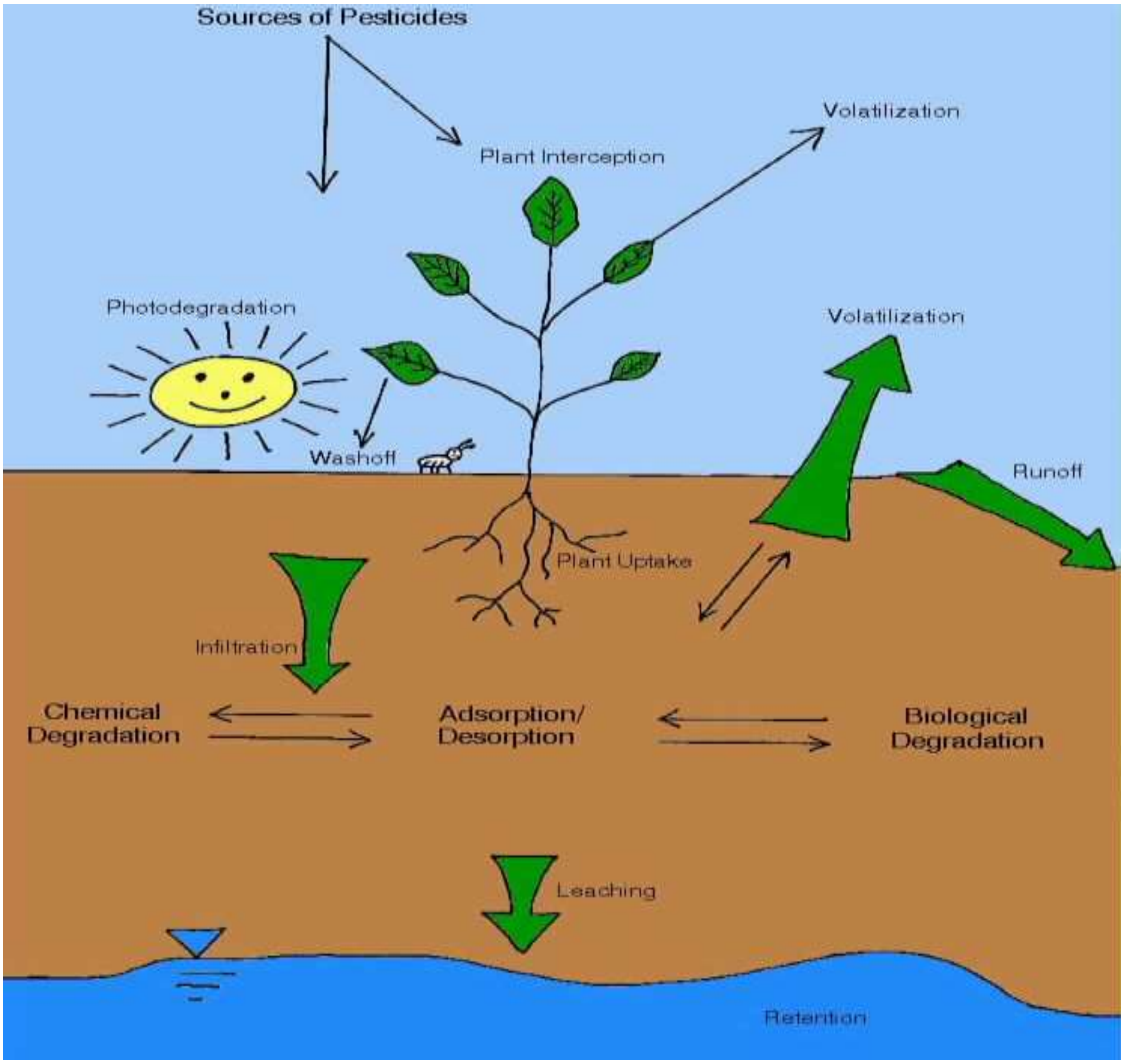
Figure 4: Bioaccumulation and biomagnification of mercury

Movement of Pesticides in the environment:

Pesticide residues can move very far distances in air, in water (rivers, lakes, sea), in groundwater (aquifers, wells), in trophic web (zooplancton, etc)

Pesticide atmospheric transport:

Same as natural reserves can be polluted, so organic products grown without chemicals.



Environmental Impacts:

A. **Loss of biodiversity**:
   - Global amphibian decline
   - Declined in bee populations

B. **Fisheries losses:**
   - Endangered Pacific salmon

C. **Groundwater pollution**

D. **Loss of biological control of pests:**

Pesticides might harm pest's natural enemies. Chinese scientists have recently shown that the majority of 14 commonly used insecticides had a drastic lethal effect on a beneficial wasp that helps pest control in rice (Wang et al., 2008). Even after 7 days after insecticide application, residues were killing this beneficial wasp.

E. **Resistance to pesticides:**

In the beginning, most pests were sensitive to DDT but a few were resistant. The resistant forms survived and reproduced. In the end, most pests were resistant to DDT

Session-1: Understanding disease

Duration-45 mts

Learning Outcomes

At the end of the session participants will be able to :

- Define disease
- What causes disease in plants
- Various symptoms of disease
- Major diseases of crop plants

DEFINITIONS OF PLANT DISEASE

In general, a plant becomes diseased when it is continuously disturbed by some causal agent that results in an abnormal physiological process that disrupts the plant's normal structure, growth, function, or other activities. This interference with one or more of a plant's essential physiological or biochemical systems elicits characteristic pathological conditions or symptoms.

Plant diseases can be broadly classified according to the nature of their primary causal agent, either infectious or non-infectious. Infectious plant diseases are caused by a pathogenic organism such as a fungus, bacterium, mycoplasma, virus, viroid, nematode, or parasitic flowering plant. An infectious agent is capable of reproducing within or on its host and spreading from one susceptible host to another. Non-infectious plant diseases are caused by unfavourable growing conditions, including extremes of temperature, disadvantageous relationships between moisture and oxygen, toxic substances in the soil or atmosphere, and an excess or deficiency of an essential mineral. Because non-infectious causal agents are not organisms capable of reproducing within a host, they are not transmissible.

In nature, plants may be affected by more than one disease-causing agent at a time. A plant that must contend with a nutrient deficiency or an imbalance between soil moisture and oxygen is often more susceptible to infection by a pathogen; a plant infected by one pathogen is often prone to invasion by secondary pathogens. The combination of all disease-causing agents that affect a plant make up the disease complex. Knowledge of normal growth habits, varietal characteristics, and normal variability of plants within a species—as these relate to the conditions under which the plants are growing—is required for a disease to be recognized.

The study of plant diseases is called plant pathology. Pathology is derived from the two Greek words *pathos* (suffering, disease) and *logos* (discourse, study). Plant pathology thus means a study of plant diseases

Plant disease symptoms

	description and causes	**examples**
prenecrotic	symptom expression that precedes the death of cells or the disintegration of tissues	
water-soaking	a water-soaked, translucent condition of tissues caused by water moving from host cells into intercellular spaces	late blight lesions on potato and tomato leaves; bacterial soft rot of fleshy vegetables
wilting	temporary or permanent drooping of leaves, shoots, or entire plants from lack of water	bacterial wilt of cucumber; *Fusarium*wilt of tomato
abnormal coloration	yellowing, reddening, bronzing, or purpling in localized areas of leaves where chlorophyll has been destroyed; may be due to a variety of causes	cabbage and aster yellows; halo blight of beans; potassium or phosphorus deficiency
necrotic	localized or general death of cells or disintegration of tissues	
blast	sudden blighting or death of young buds, flowers, or young fruit; failure to produce fruit or seeds	*Botrytis* blight of peony buds; oat blast
blight	sudden or total discoloration and killing of large numbers of blossoms, leaves, shoots, or limbs or the entire plant; usually young tissues are attacked; the disease name is often coupled with the name of the host and the part attacked—blossom blight, twig blight, tip blight	fire blight of pome fruits; *Diplodia* or *Sphaeropsis* tip blight of conifers
canker	a definite, dead, often sunken or swollen and cracked area on a stem, limb, trunk, tuber, or root surrounded by living tissues	anthracnose of sycamore and brambles; *Nectria*canker of hardwoods; fire blight of pome fruits
damping-off	decay of seed in soil, rapid death of germinating seedlings before emergence, or emerged seedlings suddenly wilting, toppling over, and dying from rot at or near the soil line	preemergence damping-off and postemergence damping-off; both are common in seedbeds
dieback	progressive browning and death of shoots, branches, and roots starting at the tips	winter injury; wet soil; excess soil nutrients; girdling cankers; stem or root rots; nematodes
firing	drying and dying of leaves	nitrogen or potassium deficiency in corn;*Verticillium* wilt of eggplant
fleck	a small, white to translucent spot or lesion visible through a leaf	ozone injury to many plants; necrotic fleck of lily

net necrosis	an irregular crisscrossing of dark brown to black lines giving a netted appearance	in potato tubers of plants with virus leaf roll
pitting	small dead areas within fleshy or woody tissue that appears healthy externally; definite sunken grooves or pits are formed	virus stem-pitting in apple and peach trunks; stony pit of pear fruit
rot	decomposition and putrefaction of cells, later of tissues and organs; the rot may be dry, firm, watery, or mushy and is characterized by such names as hard rot, soft rot, dry rot, black rot, and white rot	bacterial soft rot; berry rot; bud rot; bulb rot
scald	blanching of young fruit, foliage, and shoot tissue; generally superficial	sunscald; apple and pear scald
scorch	sudden death and "burning" of large, indefinite areas in leaves and fruit	toxicity from pesticides and air pollutants; ; wind; lack or excess of some nutrient
shot hole	dead spotting of leaves with diseased tissue dropping out, leaving small holes	bacterial spot;*Coryneum* blight of peach
spot	a definite, localized, round to regular lesion, often with a border of a different colour, characterized as to location (leaf spot, fruit spot) and colour (brown spot, black spot); if numerous or if spots enlarge and merge, a large irregular blotch or blight may develop	gray leaf spot of tomato; black spot of rose; tar spot of maple
streak	narrow, elongated, somewhat superficial necrotic lesions, with irregular margins, on stems or leaf veins	virus streak of pea, raspberry, and tomato; Stewart's wilt of sweet corn
stripe	narrow, elongated, parallel, necrotic lesions especially in leaf diseases of cereals and grasses	*Helminthosporium*stripe of barley;*Scolecotrichum* brown stripe of forage grasses
hypoplastic	the underdevelopment of plant cells, tissues, or organs	
abortion	halting development of an organ after partial differentiation	ergot of rye and other grasses
chlorosis	yellowing or whitening of normal green tissue due to partial or complete failure of chlorophyll to develop	strawberry and aster yellows; genetic variegation in corn; iron deficiency of azalea
stunting or dwarfing	the underdevelopment of the plant or some of its organs	dahlia stunt or mosaic; curly top of beans; little-leaf disease of pines

rosetting	shortening of internodes of shoots and branches, producing a bunchy growth habit	peach and lily rosette
hyperplastic or hypertrophic	an overdevelopment or overgrowth of plant cells, tissues, or organs; hyperplastic has come to mean an increase in number of cells, hypertrophic an increase in cell size	
abscission or cast	early dropping of leaves, flowers, or small fruits; usually associated with premature formation of an abscission (separation) cell layer	black spot of rose; early blight of tomato; apple scab
callus	overgrowth of tissues, often at margins of a canker or wound	*Nectria* canker of hardwoods; stem pitting of peach
curl	distortion and crinkling of leaves or shoots resulting from unequal cell growth of opposite sides or in certain tissues	tobacco and tomato mosaic; leaf roll of potato; peach leaf curl
epinasty	downward or outward curling and bending of a leaf or petiole	2,4-D injury to broadleaf plants; *Fusarium* wilt of tomato
fasciation, or witches'-broom	a distortion that results in a dense, bushy overgrowth of thin, flattened, and sometimes curved shoots, flowers, fruit, and roots at a common point; usually due to adventitious (abnormally located) development of organs	witches'-broom of hackberry; hairy root of apple; leaf gall or fasciation of geranium (see also *Rosetting*under *Hypoplastic* in this table)
metamorphosis or transformation	development of more or less normal tissues or organs in an abnormal location	crazy-top of corn and sorghum; formation of aerial potato tubers
russeting	usually a brownish, superficial roughening or corking of the epidermis of leaves, fruit, tubers, or other organs; often due to suberization (cork development) of cells following injury	spray or weather injury to apples; sweet potato scurf
scab	roughened to crustlike, more or less circular, slightly raised or sunken lesions on the surface of leaves, stems, fruit, or tubers	apple, peach, and cucumber scab; common scab of potato
gall, knot, or tumefaction	formation of local, fleshy to woody outgrowths or swellings; the outgrowth is often composed of unorganized cells	crown gall; black knot of plum; *Fusiform* gall rust of pine; nematode

Disease triangle:

In order for a disease to develop, there must be a suitable host plant, an infectious pathogen (microorganism that causes the disease), and a suitable environment.

Symptoms of Diseases:

Most names for plant diseases are descriptive of the physical appearance of the affected plant.

Fungal diseases:

Most plant diseases – around 85 percent – are caused by fungal or fungal-like organisms. Following are symptoms of a fungal disease:

- Birds-eye spot on berries (anthracnose)
- Damping off of seedlings (phytophthora)
- Leaf spot (septoria brown spot)
- Chlorosis (yellowing of leaves)

Bacterial diseases:

Following are the major symptoms of bacterial diseases**:**

- Leaf spot with yellow halo
- Fruit spot
- Canker
- Crown gall
- Sheperd's crook stem ends on woody plants

Viral diseases:

Following are the symptoms of Viral diseases:

- Mosaic leaf pattern
- Crinkled leaves
- Yellowed leaves
- Plant stunting

Symptoms of Major diseases:

Blight: Blights are the general and rapid destruction of the growing succulent tissues like leaves, shoots, twigs and blossoms. The blighted tissue often gives the appearance of tissue being burnt with fire.	
Leaf spot:These are the localized lesions produced on the leaves of the host plants as a result of pathogen infection	
Cankers: The localized necrotic lesions are sunken and surrounded by successive layers of cork cells.	
Scab: These are the localized lesions which are due to the slightly raised and cracked outer layer of the fruits, leaves or tubers etc. the cracked tissue becomes dry and corky	
Anthracnose: It is a type of disease in which dark necrotic, sunken lesions are produced on mainly leaves, fruits and stem. The fungal pathogens produce their spores in the asexual fruiting body called acervulus.	

Blotch: These are usually large, irregular shaped spots on the surface of the plant leaves, stem or flowers. At initial stages, when new leaf arises these may appear as small red or purple colour, circular spots on upper surface and later on lower. On maturity the spots on the upper surface are usually glossy dark purple and those on the lower are chestnut brown color	
Dieback: It is the progressive and extensive death of the shoots and roots that starts from the tip of the shoots	
Damping off: The young or seedlings collapse at the back due to pathogen attack before or after the germination. Older plants are seldom killed by damping off but there is definite reduction in size and growth pattern and hence yield is reduced.	
Root rot: The disintegration and decay of the tissues of roots by various fungal pathogens	
Galls: Abnormal growths (swollen/raised tissues) formed by the interaction of the certain fungi on the host leaves, stems, roots or flowers	

Warts: Hard, benign protuberances (called **warty excrescences**) produced on the stems or tubers and caused by fungal or viral pathogen	
Leaf curling: Easily distinguishable symptoms like distortion, discoloration and curling of the leaves due to fungal pathogen (*Taphrina deformans*). In the early stages the leaf show red colouration, thicker and softer than normal mature leaves	
Wilt: In case of fungal attack the vascular bundle is blocked out by the pathogen and results in the loss in turgidity and drooping of the leaves and shoots of the plant. Wilting due to pathogen attack is permanent. Most common vascular wilts are caused by *Fusarium* and *Verticillium*	
Rusts: This is a disease characterized by rusty appearance on the leaves and stems of the host plant	
Smuts: It is a disease characterized by masses of dark, powdery spores	

Mildew: Presence of whitish mycelium and fructification covering the areas on leaves, stems or fruits. If the whitish mycelium is present on the upper surface it is called **Powdery Mildew** and if it present on the lower surface of the leaf it will be **Downy Mildew**

 **Downy Mildew**	 **Powdery Mildew**

Ergot: The grains in the heads of the cereals are replaced by black or purple coloured sclerotia (ergot fruiting body) of ergot fungus *Claviceps purpurea*, just before the harvest

Session-1:Non Negotiable for Paddy and other rainfed crops:

Duration-45 mts

Learning outcome:

At the end of this session participants will be able to :

1. Relate to Non-negotiable protocols for paddy and rain fed crops
2. Employ various botanicals for pest and disease control

Paddy:

Deep summer ploughing: Summer ploughing exposes the pupae surviving inside the soil. Depth of ploughing should be more than 6 inches.

Exposed pupae will die due to excess heat (or) eaten away by birds

When: May – June Immediately after the first showers

Why: To expose Pupae or larva to scorching sun and birds

How: Deep plough up to six inch depth

Community bonfires: Immediately after the first shower (one inch rain fall) mass bonfires in the fields attract adults of Red hairy caterpillars particularly

When: Immediately after the first rains – evening between 6 -7 PM

Why: Adult insects will attract to the fire and will die

How: All farmers in area should go for fires in their fields on the same day

Seed treatment:

A. Take 2 l. of Cow urine, 1 kg of cow dung and 1kg of live soil (putta matti) mix thoroughly with seeds and dry in shade for 1 hour, later these seeds can be sown in nursery bed

B. Dip the paddy seedlings in solution consists of 2 lts of cow urine, 1 kg. of cow dung, 1 kg of soil, 105 gm of Asafoetida and10 l. Water

When: Before Sowings

Why: Prevent seed borne pests and diseases

How: Bheejamruth or any other botanical extract recommended for seed treatment

Clipping of the tips: Cut seedling tips while transplanting into the main field. This will prevent Stem borer attack as Stem borer lays eggs on the tips of the leaves.

When: Just before transplanting

Why: To prevent stem borer attack

How: Cut the tips of the plants

Alleys: Leaving 1 feet path at every 2 m interval in East –West direction will avoid attack of Hoppers

When: During transplanting

Why: Prevent white fly infestation

How: 1 feet path at every 2 m interval in East –West direction

White and Yellow sticky traps: Arrange 15-20 Yellow and White sticky traps per acre. Green leaf hoppers and thrips stick to these traps. Clean these traps once in two days and add sticky material to traps for effective trapping. Height of these traps should be the same with the plant height

When: After transplantation
Why: Reduce sucking pests
How: Paste glue or castor oil on white and yellow plates keep them at plant height

Bird perches: Arrange 10-15 bird perches per acre immediately after transplanting and remove these at grain filling stage (60 days after transplanting). Bird perches will attract birds and birds will eat pests. Broad costing of yellow rice will attract more birds. Height of bird perches should be more than the height of plants

When: 10 -15 days after transplantation
Why: Birds will sits on the perches and will eat larvae
How: Place 10 -15 perches per acre above the plant height

Pheromone traps: Keeping 5-10 Pheromone traps in zigzag way to mass trapping of Stem borers. Lure has to be changed once in a month or after the expiry date

When: One month after transplantation
Why: To prevent stem borer
How: Place 10 -15 pheromone traps per acre above the plant height

Application of Botanical extracts: If all the above mentioned principles are followed religiously, there will not be any need to apply botanical extracts. However list of pests and botanical extracts

NPM for Rain fed Crops:

Deep summer ploughing: Summer ploughing exposes the pupae surviving inside the soil. Depth of ploughing should be more than 6 inches. Exposed pupae will die due to excess heat (or) eaten away by birds

When: May – June Immediately after the first showers
Why: To expose Pupae or larva to scorching sun and birds
How: Deep plough up to six inch depth

Community bonfires: Immediately after the first shower (one inch rain fall) mass bonfires in the fields attract adults of Red hairy caterpillars particularly

When: Immediately after the first rains – evening between 6 -7 PM
Why: Adult insects will attract to the fire and will die
How: All farmers in area should go for fires in their fields on the same day

Growing of trap crops: Grow yellow flower Marigold (tall growing plants are preferred) and Castor around field, ensure flowering before main crop completes vegetative stage

When: Along with main crop sowings

Why: To attract pests – these plants will provide space for laying eggs

How: Crisscross – cover entire field

Border crop: Sow 3 rows of tall growing Jowar or Bajra or Maize (without any gap in the row). This will provide enabling environment for friendly insects and it also prevents

When: Along with main crop sowings
Why: To attract friendly insects, prevent pesticide drift from neighbouring fields
How: Two rows around the field

Seed treatment: Take ½ lt. of Cow urine, 250 g of cow dung and 250 g. of living Soil (putta matti) mix thoroughly and mix to 5-6 kg seeds, after thorough mixing dry in shade

When: Before Sowings
Why: Prevent seed borne pests and diseases
How: Bheejamruth or any other botanical extract recommended for seed treatment

White and Yellow sticky traps: Arrange 15-20 Yellow and White sticky traps per acre. Green leaf hoppers and thrips stick to these traps. Clean these traps once in two days and add sticky material to traps for effective trapping. Height of these traps should be the same with the plant height

When: After transplantation
Why: Reduce sucking pests
How: Paste glue or castor oil on white and yellow plates keep them at plant height

Bird perches: Arrange 10-15 bird perches per acre immediately after transplanting and remove these at grain filling stage (60 days after transplanting). Bird perches will attract birds and birds will eat pests. Broad costing of yellow rice will attract more birds. Height of bird perches should be more than the height of plants

When: 10 -15 days after transplantation
Why: Birds will sits on the perches and will eat larvae
How: Place 10 -15 perches per acre above the plant height

Pheromone traps: Keeping 5-10 Pheromone traps in zigzag way to mass trapping of Stem borers. Lure has to be changed once in a month or after the expiry date

When: One month after sowing
Why: To prevent pests like fruit and shoot borer in Brinjal and diamond back moth in cabbage
How: Place 10 -15 pheromone traps per acre above the plant height

Application of botanical extracts: If all the above mentioned principles are followed religiously, there will not be any need to apply botanical extracts. However list of pests and botanical extracts

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Session-2:Non chemical Disease Management

Duration – 60 mts

Introduction:

The problems caused by synthetic pesticides and their residues have increased the need for effective biodegradable pesticides with greater selectivity. Alternative strategies have included the search for new types of pesticides which are often effective against a limited number of specific target species, are biodegradable into nontoxic products and are suitable for use in integrated pest management programs. The natural plant products derived from plants effectively meet this criterion and have enormous potential to influence modern agrochemical research. When extracted from plants, these chemicals are referred to as botanicals. The use of botanical pesticides is now emerging as one of the prime means to protect crops and their products and the environment from pesticide pollution. Botanicals degrade more rapidly than most chemical pesticides, and are, therefore, considered relatively environment friendly and less likely to kill beneficial pests than synthetic pesticides with longer environmental retention. Most of the botanical pesticides generally degrade with in few days and some times with in a few hours, these pesticides needs to be applied more frequently. More frequent application coupled with higher costs of production makes botanicals more expensive to use than conventional pesticides. Moreover, in spite of wide recognition that many plants possess pesticidal properties, only a handful of pest control products obtained from plants (pyrethrum, neem, rotenone) are in use because commercialization of botanicals is hindered by several issues discussed in this chapter.

Management practices for non-chemical disease and pest management

Selection of Seed:

Seed should be free from diseases and should select resistant varieties

Incorporating weeds:

Weeds and other voluntary plants should incorporate into soil

Reduce/no chemical fertilizer usage:

Reduce (or) avoid chemical fertilizers to prevent diseases. Avoid application of Nitrogenous fertilizer during cloudy days

Crop rotation:

Rotate crops particularly with pulses to prevent disease spread

Sanitation of Field:

For all crops and numerous diseases of these crops, straw is the primary source of future inoculums. Incorporating this residue into the soil by tillage hastens the destruction of the pathogen by beneficial fungi and bacteria. In addition, diseased plant material which is buried under the soil surface prevents future movement of the spores by wind.

Planting Dates and Rates:

Susceptible cultivars of some crops may escape significant damage from disease by planting at a time which avoids exposure to inoculums and thus severe infection. Certain diseases can be controlled by early seeding. The aphids that transmit this disease do not arrive in significant numbers until early summer. Younger plants, which would have been seeded later, are more attractive as food to aphids.

Botanical extracts for Pest and Disease Management

A: 5% Neem Seed Kernal Extract:

- "Azadiractin" present in the Neem will effect on different stages of the pest life cycle. It will act through stomach and contact

Required materials:

- Neem seeds – 5Kgs
- Surf – 100grs

Preparation:

- 5Kg of Neem seeds dried under shade with good quality can be powdered
- This powder can be packed in cloth and keep in 10lts of water for 10-12 hrs
- Extract the decoction by pressing the cloth pack for 10-15mints
- Filter this solution through a thin cloth
- Add 100grs of surf to the filtered solution
- Add 100lts of water to the solution and spray it in 1acre during evening time

Note:

- 10-15Kg of Neem powder is required (depending on the crop stage and pest intensity)
- Shouldn't store the solution
- Depending on the crop stage and intensity increase the dosage
- This solution can be used in all crops and nurseries
- This solution can be used in orchards to get better yields
- Instead of surf we can use soap nut of 500grs

Uses of Neem Seed Kernel Extract:

- It affects egg and larva stages. Larvae can feed on the leaves, as the leaves tastes bitter
- "Azadiractin", which is present in the Neem, affects the lifecycle of the pests. The pest will die as larvae or pupae
- This solution will not affect human health, friendly insects and environment
- "Lemonades" present in Neem will help in keeping the crop healthy

B: Chilli Garlic Extract:

Alkaloids viz Capsaicin and Allesis present in chillies and garlic will act through contact. These will create tingling to the insect and insect will fall from the tree and die

Materials required:

1. Green Chillies - 3 Kg

2. Garlic - 1/2Kg

3. Kerosene - 250ml

4. Surf - 100gr

Methodology:

1. Grind the chillies after removing the petioles and add 10lts of water to it. Keep this solution throughout the night.

2. Grind the 1/2 kg garlic and add 250 ml kerosene keep it for a night

3. Next day morning filter the chilli solution through a thin cloth

4. Do the same for garlic solution

5. Mix chilli solution, garlic solution and surf powder thoroughly and make a mixture

6. Add 100 l of water to the above solution. This can be applied for one acre

Precaution:

- Apply oil to your body while preparing this decoction
- Cover your body while spraying
- Apply this solution only one or two times in a cropping season
- Don't store the solution

C: 10% Vitex extracts:

Take 10Kg of Vitex leaves and boil it for 30mints and make it cool. Add some soap nut solution to it. Add 1000 – 150 L of water to it and is can be used for one acre. This will prevent many diseases in Paddy and other crops.

D: Agniasthram:

Can be Use against stem and fruit borers Take 10 L cow urine in a big container. Add 1 Kg ground Tobacco leaves, 5 Kg ground Neem leaves, 1 or 2 Kg of ground green

chillies, ½ Kg ground Garlic and boil till it simmers. Let the contents cool for 48 hours. Filter through a cloth and mix 2- 3 L of the decoction with 100 L of water before spraying in the field.

E: Neemasthram:

Can be Use against small and sap sucking pests Mix 5 Kg of ground Neem leaves or 5 Kg of dry leaves or fruits into 100 L water. Add 5 L cow urine and 1 kg cow dung to this mixture and mix well. Let it ferment for 24 hrs and filter through a cloth. Spray in the fields.

F: Brahmaasthrm:

Required Material:

- Cow urine 10 to 15 L
    - Neem leaves 3 kg
    - Custard apple leaves 2kg
    - Castor leaves2kg
    - Pongamia leaves 2kg
    - Lantana leaves 2kg
    - Papaya leaves 2kg
    - Dattura leaves 2kg
    - Guava leaves 2kg
    - Bitter gourd leaves 2kg

Preparation:

- Take any of the five varieties leaves of mentioned above
- Take 10 -15 L of cow in a vessel
- Grind any of the 5 leaves separate leaves
- Add these in to the vessel and boil them for 5 times.
- Allow it to cool for 48 hours
- Then add 2 to 2.5 L of brahmasthram to 100 l of water to spray on once acre.

Botanical extracts for Disease Management:

Dried Ginger – Milk Extract:

Can be Use against all kinds of diseases

- Dried Ginger Powder : 200 gm
- Water : 2 L
- Cow or Buffalo Milk : 5 L
- Buttermilk can be substituted for milk

Mix dried ginger powder with 2 L water and boil till the contents become to a liter. Boil milk in another container. Cool both the contents and mix. This makes a decoction

Note:

- This decoction should be used on the same day and cannot be stored
- Mix the decoction in 200 L of water and spray per acre of crop

Sour Butter milk solution:

Fermented butter milk is mixed in water and sprayed. Good results can be obtained when sprayed in early stages of cotton.

Cow Dung Urine Asafoetida solution:

- Mixing of 200grs of Asafoetida in cow dung and urine make it strong fungicide. This solution is effective against Blast in Paddy.
- It is also effective against Bacterial diseases in Paddy
- Presence of Sulphur in Asafoetida make this solution as fungicide

Panchagavya:

Panchagavya is a growth regulator produced from a combination of five products obtained from the cow along with a few other bio products. Collect fresh cow dung (5 kg), mix it with ghee (1 litre) and keep it in a plastic barrel separately for three days. On the same day, mix the other ingredients, namely cow urine (three litres), cow's milk (two litres), curd (two litres), yellow banana (400 gm, without skin), coconut water (three litres), jaggery (one kilo dissolved in three litres water) in a plastic barrel separately. Filter the jaggery solution before adding it to the other ingredients. On the third day, mix the contents of both the barrels and leave them aside for seven days. Stir the contents with a wooden stick twice aday. After seven days, filter the product with a khada or terracot (TC) cloth and store it in closed containers. (Pierce small holes in the cap of the containers to prevent bursting.) This is diluted @ 300 ml/10 litres water and sprayed.

Seed treatment

Seed borne infestation of insects and diseases pose devastating consequences to crop production. The concept of seed treatment is the use and application of biological and chemical agents that basically can control or contain primary soil and seed borne infestation. This helps to improve crop safety which in turn leads to good establishment of healthy and vigorous plants which results in better yields. The benefit of seed treatment leads to increased germination and ensures uniform seedling emergence. As already seen it protects seeds and seedlings from early season diseases and insect pests thereby improving crop emergence and growth. Treating seeds with *Rhizobium*also enhances the nitrogen fixing capability of legume crops and their productivity. Overall seed treatment leads to improved plant population and thus higher productivity. It is estimated that 80% of the seeds sown in our country is untreated as against 100% seed treatment practice in developed countries. Seed treatment also gives protection to the emerged seedlings from sucking insect pests.

General Seed Treatment Techniques:

• Smear all types of seeds with a paste of ash and water and dry it under the sun before sowing.

This will control the seed borne diseases and enhance seed vigour and germination percentage

• Treat the seeds with butter milk (125 ml / kg of seeds) to prevent fungal diseases in crops

• Mix the seeds of cereals, legumes and cotton in cactus *(Euphorbia neriifolia)* milk solution (100 ml in 1 litre of water) and dry in darkness for 8 hours before sowing. This will enhance the protection from stem borer larvae, termites and other pests

- Mix Vi*tex, Tulsi* and *Pongam* leaves extract (pound 3 kgs of each leaves and extract) with fresh cow dung solution and soak 25 kg of paddy seeds tied in a gunny bag in this solution for 12 hours. Seeds should be shade dried for half an hour before sowing. This will produce healthy and disease resistant Seedlings.

Note: 3 kgs of each of the leaves should be collected and pound. This should be added to 1 litre of water and the extract is filtered. This should be added to fresh cow dung extract (5 kg cow dung in 15 litres of water)

Seed Treatment for Improved Germination:

- Dry seeds in bright sun light (between 12.00 p.m. to 1.00 p.m.) for half an hour before sowing to improve the germination and seedling vigour

- Soaking the seeds in cow dung extract enhances the germination capacity. Take ½ kg of fresh cow dung and 2 litres of cow's urine and dilute with 5 litres of water. Soak 10 - 15 kg of seeds that are previously soaked in water for 10 - 12 hours, in this cow dung extract for 5 - 6 hours. Dry the seeds in shade before sowing in the nursery

Botanical extracts for Seed treatment:

Beejamruth:

Ingredients:

- Cow dung 5 kg
- Cow urine 5 lit
- Cow milk 1 lit
- Lime 250 gm
- Water 100 lit

Mix all the ingredients and keep overnight. Sprinkle the formulation on seeds to be sown, then dry in the shade before sowing.

Seed treatment with Cow Urine:

Required materials:

- Cow urine – 2 l (preferably buffalo's urine which can effectively control fungal diseases)
- Cow dung: 1 Kg
- Mond or live soil: 1 Kg

Mix all the above mentioned materials with seeds and allow them for drying up to one hour.

Note: This method is suitable for the crops with seed rate of 30-60Kgs, e.g., Ground nut

Seed treatment with raw milk for viral diseases:

For any variety of seed spraying of cow milk and water mix with 1:9 ratio and drying under shade will be beneficial

Cow dung urine solution for fungal diseases:

- Large number of microbes present in the cow dung and urine which are useful for controlling many fungal diseases
- Nutrients present in the solution are useful for effective plant growth
- This can be applied for two to three in a crop period

Required material:

- Cow dung – 5Kg
- Cow urine – 5l
- Lime – 150g

Preparation:

- Store 5Kg cow dung, 5lts of cow urine and 5lts of water in a tub
- Cover the tub and allow the solution for fermentation for 4days
- Stir the solution with a stick every day
- After 4days filter the solution and add 150grs of lime to it
- Add 100lts of water to the solution to spray it in 1 acre

Precautions:

- As this solution is thick use a mesh or gunny bag to filter the solution(first time)
- After that add water and filter through a thin cloth
- We can store the solution for 1 or 2 days (farmers experience)

Note:

- This solution will improve the resistance power of the crops
- Spraying of this solution will improve the drought resistant capacity

Trap crops

Trap crop is a crop which attracts pests more than the main crop. Pests prefer trap crops for feed or oviposition. Pests are either prevented from reaching the main crop or concentrated in certain parts of the field away from the main crop. The principle of trap crop relies on pest preference for certain crops or stages of crop growth. Two preliminary techniques used in trap crops are:

A. Selection of more preferred species
B. Planting of the same crop before the main crop so that preferred stage of the development will arrive earlier than the main crop

Advantage of trap crops:

Lessens the usage of pesticides

1. Preserves natural enemies
2. Enhance biodiversity
3. Increase productivity

Types of trap crops:

Trap crops can be classified based on spatial distribution and characteristics of trap crop.

Based on characteristics of trap crop:

A. **Conventional trap crop:** It is most common practice. These plants are preferred fro oviposition Growing of trap crops next to the main crops. Ex: Castor and marigold in Ground nut crop

B. **Dead end Trap cropping:** Trap crops which are highly attractive to insects but they or their offspring's can't survive. EgIndian mustered for Cabbage diamond back moth. Sun hemp for bean pod borer

Based on spatial distribution:

A. **Perimeter trap cropping:** Growing trap crops around the main crop.

B. **Sequential trap cropping:** Growing trap crops earlier or simultaneously than the main crop to attract the pest. Ex. Indian mustard as a trap crop for diamond back month in Cabbage

C. **Multiple trap cropping:** Planting of several species simultaneously as trap crops for attracting pests

D. **Push – Pull trap cropping:** Growing combination of trap crop and repellent crops ex. Marigold and Onion in Chillies

Examples of trap crops:

	Name of the main crop	**Trap crop**	**Pest**
1	Cotton	Marigold	Heliothis
		Bhendi	Pod borers
2	Ground nut	Cow pea	Leaf folder
		Castor	Tobacco caterpillar
3	Red gram	Soya bean/ Green gram	Thrips
4	Sun flower	Mari gold	Heliothis
		Castor	Tobacco caterpillar
5	Bengal gram	Mari gold	Heliothis
6	Cabbage	Indian Mustard	Diamond back moth
7	Cotton	Alfa alfa	Laygus bug
8	Garlic	Basil and Mari gold	Thrips
9	Carrot	Onion and garlic	Carrot root fly
10	Cabbage	Radish	Flee beetle

Tips for successful trap cropping:

A. Select a trap crop that is more attractive to pest than the main crop
B. Monitor trap crops regularly
C. Immediately destroy the eggs that are found on the trap crop

Agro Ecosystem Analysis:

Purposes of AESA are: Promote learning by discovery and learners towards their own analysis. Guide farmers to critically analyze and make better decisions on their own fields.

Why AESA? It improves decision-making skills, through afield situation analysis by observing, drawing and discussing. Improves decision-making skills by presenting small group decisions for critique in the large group

Data of collection:

Date:

Day:

Name of the farmer where FFS is being organised:

Attendance:

S.No.	Name of the FFS group	No of farmers attended

General information:

Variety:

Date planted:

Age of crop:

Spacing:

Fertilizer:

Weather:

Time of observation:

Plant population:

Germination %:

Measurement:

Length of leaves:

Width of leaves:

No. of leaves:

No. of diseased leaves:

No. of dead leaves:

Length of plant:

No. of pods:

Observations

Soil moisture:

Diseases:

Insect pests:

Plant health:

Deficiency:

Weeds:

Predators:

Crop related information:

Name of the crop:

Stage:

Crop age:

No of tillers / branches:

Weather information:

Cloudy / Sunny / humid / Temperature (high /low)

Friendly insects:

S.No	Name of the friendly insect	No of friendly insects on 20 Plants

Harmful insects:

S.No	Name of the harmful insect	No of friendly insects on 20 Plants

Diseases:

S.No	Name of the disease	No of plants affected in a sq mt

Field days: During the period of running the FFS, 1-2 field days are organized where the rest of the farming community is invited to share what the group has learned in the FSS. Farmers themselves facilitate during this day.

Experiments: There are many field experiments that could be carried out by farmers during an FFS. It will depend on the situation which experiments are the most appropriate. The facilitator will consider the questions asked by farmers during the first meetings and based on this select, together with the farmers, one or more field experiments. Here are some examples of experiments that are often used during field schools:

Crop compensation: Simulate insect damage by cutting parts of the leaves or by removing shoots or tillers. This type of experiment demonstrates that crop plants can compensate for some damage, by producing new leaves or shoots. Farmers who experience this will be more confident to tolerate some damage.

Use of traps: Set up some traps to study insect populations. For example light traps, yellow sticky traps, or pitfall traps. This can be used to monitor pest populations, but it could also be used as an experiment to see if pests can be controlled with the traps (e.g. control flea beetles in Chinese kale with yellow sticky traps).

Field cages: Discover how natural enemies can keep pest populations under control. Set up two or more field cages; one with only pests (e.g. Brown Plant Hoppers on rice), and one with pests and natural enemies (e.g. Brown Plant Hoppers together with some spiders).

se of botanical pesticides and bio-pesticides: Study how botanical pesticides (e.g. Neem) or bio-pesticides (Bt, NPV, Steinernema, Trichoderma) can be used to manage pest populations. For example set up small experiments where Neem is compared with plots that are unsprayed.

Mulching: Compare plots with and without mulching and see how this has an effect on the development of plants, insects, and diseases.

Plant spacing: Compare different levels of plant spacing and see how the crop plants develop under different conditions. The differences in plant density have an effect on the micro-climate and we can learn how this has an effect on development of pests and diseases

Fertilizer experiments: Set up small plots with different levels of fertilizer use. Compare use of synthetic fertilizer (NPK) with organic fertilizers (compost or manure).

Release of natural enemies: Use predators or parasitoids that are available from pest management centres (PMC) and release them in the IPM plots. Use for example: earwigs, assassin bugs or Trichogramma wasps.

Compare crop varieties: Compare different varieties of the same crop and study how they differ. Pay special attention to differences in pest resistance or tolerance

Intercropping: Compare monoculture with multiple cropping systems. Try intercropping with plants that are known to stimulate natural enemies (e.g. beans or other flowering plants) or use plants that repel insects (e.g. citronella).

Discussion points:

1

2.

3.

Decisions taken

1

2.

3

Experiments details:

1. Short term experiments:

2. Long term experiments:

Module10 - Other interventions

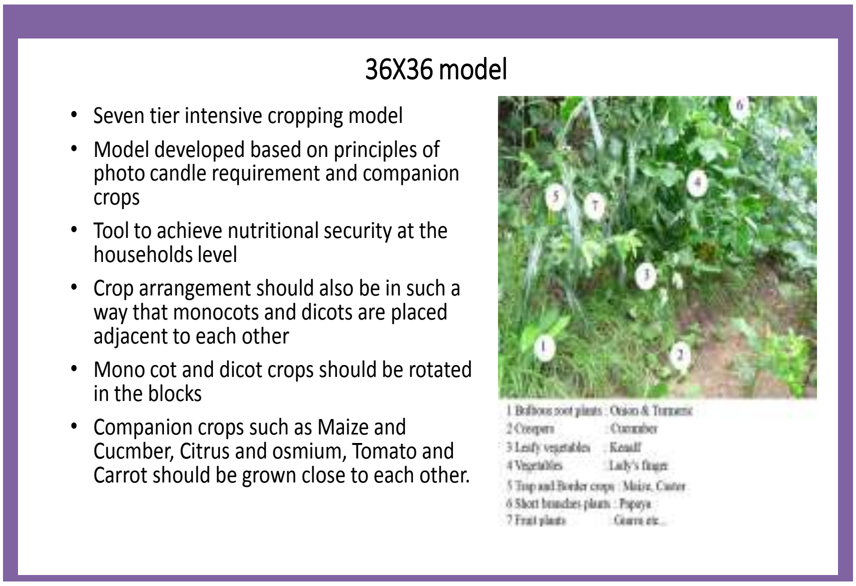
Session-1:36X36 model and CCE
Duration 60 mts

36X36 model

Sufficient space should be given between fruit plants, Redgram, Castor, drumstick etc. In between fruit plants, tuber crops, vegetables etc should be grown in blocks. Care should be taken that all the plants get enough sunlight for photosynthesis. Crop arrangement should also be in such a way that monocots and dicots are placed adjacent to each other. Mono cot and dicot crops should be rotated in the blocks. Companion crops such as Maize and Cucmber, Citrus and osmium, Tomato and Carrot should be grown close to each other. Entire field should be covered either with creepers or with mulch. Creepers can be allowed to grow on the fruit plants.

1. Four corners : Fruit plants such as Mango, Cashew etc
2. For every 9 m from Mango or cashew etc fruit plants such as Seethaphal , drumstick etc can be grown in all directions
3. For every 4.5 ft there should be an irrigation channel across the model
4. For every 90 cm P .Red gram and Castor alternatively can be grown starting from Mango or Cashew etc
5. On Red gram – creepers such as Bitter gourd can be allowed to grow

6. On Castor - Creepers like beans can be grown
7. Between two fruit plants or Red gram/Castor – vegetables such as Tomato, Chillies, Onion etc can be grown
8. Along the irrigation channels Creepers such as cucumber, bitter gourd etc can be grown



9. Along the border green leaf manure crops such as Gliricidea, Subabul, Casiasemia etc can be grown

Module 10 –Other areas

Session-2 Duration-60 mts

System of Rice Intensification

Important features of SRI:

- SRI is not a variety or hybrid – It is a method of cultivation
- Low seed requirement - Only 2 Kg/ Acre
- Low water requirement – Alternate wetting and drying
- Transplantation of tender / young seedlings
- Transplanting at wider space - 25cmX25cm
- Incorporating weeds into the soil while weeding

Raising Nursery:

The nursery bed can be raised in a 48 sq yard plot for transplantation in one acre. A bed width of 4 ft. is ideal and length can be decided by the farmer depending on the situation. As the roots of the 8-12 days seedlings grow up to 3 inches depth it is necessary to prepare raised bed of 5-6 inches height. The nursery bed can be prepared with application of FYM and soil alternately in four layers.

1st Layer: 1 inch thick well decomposed FYM

2nd layer: $1^{1/2}$ Inch soil

3rd layer: 1 inch thick well decomposed FYM

4th Layer: $2^{1/2}$ Inch soil

All these layers should be mixed well, as the FYM helps in easy penetration of roots. To prevent soil erosion, the bed on all sides should be made secure with wooden reapers/ planks or paddy straw rope or anything of that sort. To drain excess water appropriate channels should be provided on all sides.

Seed Preparation and broad casting:

Soak the seeds for 12hrs in Water. Drain the water and transfer wet seed into a gunny bag. Leave it for 24hrs. White root called radicle breaks open the outer coat and start emerging out of the seed at this stage sprouted seed is taken to nursery bed for sowing. To ensure uniform broadcasting, divide the whole seed lot into 4 parts and broadcast four times thinly spread over the bed. Spread well decomposed FYM or Paddy straw over the sown seed thinly. The seeds or not to be directly exposed to sun. Straw can be removed once the seeds germinate. Depending on t requirement,
Water ing should be done twice daily

Preparation of main field:

Field should be evenly levelled and there should not be standing water in the field during transplantation. In SRI method, seedlings are widely spaced (10 x10 inch or 25 x 25cm) and only one seedling is transplanted per hill (3-4 seedlings per hill in conventional system).SRI method can accommodate only 16 hills /sq. metre as against 33-40 hills/ square meter in conventional method.Markers need to be run over the prepared field lengthwise and widthwise. Transplanting at the marked intersection gives the required 25 x 25 cm spacing.

Transplantation:

Young, 8-12 days old seedlings are transplanted in SRI method. Care should be taken to see that the plant does not experience shock during transplanting. In SRI method, a metal sheet is inserted 4-5 inches below the seed bed and the seedlings along with soil are lifted without any disturbance to their roots. Transplanting should be done as quickly as possible, preferably within half an hour to minimise trauma to the roots. Single seedlings with seed and soil are transplanted by using index finger and thumb and gently placing them at the intersection of markings. Light irrigation should be given on the next day of transplantation.

Irrigation and Water Management:

In SRI, irrigation is given to wet the soil, just enough to saturate the soil with moisture. Subsequent irrigation is suggested when the soil develops fine cracks. Irrigation interval depends on soil type and weather conditions. This method helps in better growth and spread of roots. Regular wetting and drying of soil results in increased microbial activity in the soil and easy availability of nutrients to plants.

Weed management:

Absence of standing water provides a congenial environment for weeds to proliferate in SRI. If these weeds are incorporated into the soil, they serve as green manure. First weeding should be done 10-12 days after transplanting. Later, depending on the need, weeding can be done once every 10 days. Different models of manually operated weeders are being developed for effective weed management in SRI. Weeds can be incorporated by moving the weeder between the rows.

Annexure II

Suggested Course Feedback questionnaire:

Course Evaluation

Name of the Participant: ___________________________________

We thank you for your comments and your participation in the course. We hope that it met your expectations

Please mark in the appropriate box.

1. Training Program Value

How relevant is the knowledge and skills imparted during the program related to your job requirements?

☐ 1 ☐ 2 ☐ 3

Very RelevantRelevant Not Relevant

Any

*Comments*____

____

2. Course Value

Remarks	Very Relevant	Relevant	Not relevant
Extent to which the knowledge and skills imparted during the course relate to your job requirements.			
Degree of confidence that the course can help improve your job performance.			

3.Course Contents

Contents	Excellent	Good Standard	Unsatisfactory
Weather and climate, soil of India			
Climate change and how to mitigate			
Cropping systems and crop rotation – principles of rotation, major crops in India, cropping systems in farmers fields			

Physical properties of soil, texture, structure, soil reaction, tillage			
Moisture requirement of crops			
Soil and water conservation			
Water harvesting and its use			
Plant nutrition-Supply and availability of nutrients, Essential nutrients, N,P,K, economy			
Sustainable crop production without chemical fertilizers – principles and application			
Plant protection – major pests types an overview, chemical pesticides and bio-pesticides, concept of ETL, time and method of application, current scenario in farmers field, concept IPM			
Sustainable crop production without chemical pesticides – principles and application- NPM			
Non—negotiable in paddy			
Disease management			
All about seed- definition, seed VS food production, seed chain, seed replacement ratio, SMR,seed quality assurance, farm saved seed, gene bank for protection of crop seed			
PHM- stored grain pests			
Principles of watershed management, soil and water conservation, sustainable crop production			

1. About this program

How effective was the training in achieving the overall goals?

☐ 1 ☐2 ☐ 3

Excellent Good

Poor

2. What did you like most about this training?

____

____

____

6. Where and how do you think improvements can be effected?

7. Is **the duration of this training program sufficient to meet the objectives? If not how many days it should be**

8. Are you confident that you can handle your job

Independently and confidently ☐**s** ☐ **No**

9. Overall rating of the program ☐ 1 ☐ 2 ☐ 3

Excellent Good Poor

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