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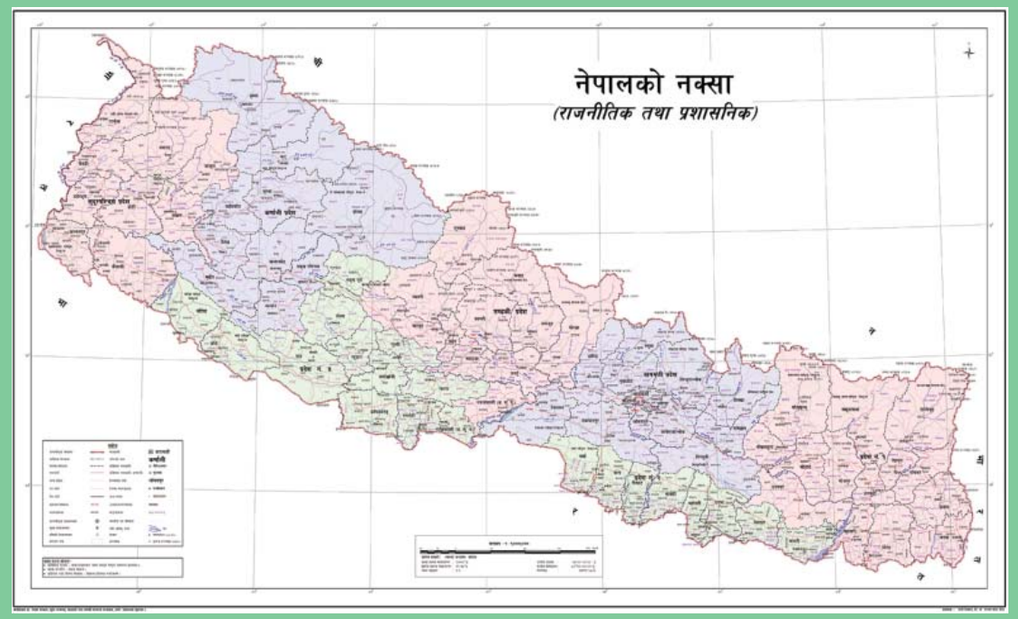

Sustainable Integrated Nutrient and Pest Management

Government of Nepal
Ministry of Education, Science and Technology
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Technical and Vocational Stream

Learning Resource Material

Sustainable Integrated Nutrient and Pest Management

(Grade 12)

Secondary Level
Plant Science

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

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Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline and self-reliance, creativity and thoughtfulness. It is essential to develop in them the linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills. it is also necessary to bring in them the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values so as to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This Learning Resource Material for Plant Science has been developed in line with the Secondary Level Plant Science Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops and seminars, interaction programs attended by teachers, students and parents.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Dr. Lekhnath Poudel, Prof. Khemraj Dahal, Lal Prasad Amagain, Arjun Prakash Poudel, Nabin Rawal, Buddhalal Budha, Mahesh Paudel is highly acknowledged. The book is written by Dinesh Timilsina and the subject matter of the book was edited by Badrinath Timsina and Khilanath Dhamala. CDC extends sincere thanks to all those who have contributed in developing this book in this form.

This book is a supplimentary learning resource material for students and teachrs. In addition they have to make use of other relevnt materials to ensure all the learning outcomes set in the curriculum. The teachers, students and all other stakeholders are expected to make constructive comments and suggestions to make it a more useful learning resource material.

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Ministry of Education, Science and Technology
Curriculum Development Centre

Contents

UNIT 1

Introduction

A. Objectives

- To import the knowledge of importance and scope of IPNM
- To import the knowledge of effect and impact of chemical fertilizer and pesticide on soil, health and environment

B. Content elaboration

1.1 Definition, importance and scope of integrated plant nutrient management

Definition: Integrated plant nutrient management system (IPNMS) is a holistic approach, which integrates crop management with soil and plant nutrient management so as to improve soil fertility and achieve higher crop yields.

Integrated nutrient management is the maintenance or adjustment of soil fertility and plant nutrient supply at an optimum level to sustain the desired crop productivity.

Concept: IPNM is a concept to integrate all available means of soil, nutrient and crop management options so as to achieve optimum land productivity. (Subedi and Weber, 2011)

It emphasizes the principle that fertilizer and manure should be applied on the basis of soil fertility status, crop demand and available resources. It is therefore, an approach that seeks to both increase agricultural production and safeguard the environment for the future.

IPNM aims to optimize the condition of the soil, with regard to its physical, chemical, biological and hydrological properties, for the purpose of enhancing farm productivity, whilst minimize land degradation.

IPNM would include the use of farmyard manures, natural and mineral fertilizers, soil amendments, crop residues and farm wastes, agro forestry and tillage practices, green manures, cover crops, legumes, intercropping, crop rotations,

fallows, irrigation, drainage, plus a variety of other agronomic, vegetative and structural measures designated to conserve both water and soil.

Why is IPNM needed?

The increasing use of chemical fertilizers to increase the production of food and fiber is causing concern for the following reasons:

- Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients.
- The decline in productivity can be attributed to the appearance of deficiency in secondary and micronutrients.
- The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers, especially the nitrogenous ones.

Importance of IPNM

Socio-Economic Benefits

- Reduces the external inputs for crop production,
- Increases crop production (results from the 54 farmer field experiments have shown a 25 to 30 % increase in crop yield),
- Efficient use of locally available farm resources
- IPNM empowers farmers by increasing their technical expertise and decision-making capacity.

Environmental Benefit

- Reduce use of chemical fertilizers
- Enables sustainable crop production,
- More efficient use of plant nutrients which reduces losses through leaching or emissions into the atmosphere.
- It helps to take advantage of the combined and harmonious use of organic and inorganic nutrient resources to serve the concurrent needs of food production.

Scope of IPNM

The increasing use of chemical fertilizers to increase the production of food and fibre is causing concern for the following reasons:

- Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients.
- The decline in productivity can be due to deficiency in Secondary and micronutrients.
- The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers, especially the nitrogenous ones.
- The recent energy crisis, high fertilizer cost and low purchasing power of the farming community have made it necessary to rethink alternatives.
- The available quantity of animal excreta and crop residues cannot meet the country's requirements for crop production. Therefore, maximizing the usage of organic waste and combining it with chemical fertilizers and bio-fertilizers in the form of integrated manure appears to be the best alternative.

1.2. Definitions and approaches of *sustainable agriculture* and organic agriculture

Sustainable Agriculture (SA)

Definition: Sustainable agriculture is a type of agriculture that focuses on producing long-term crops and livestock while having minimal effects on the environment. This type of agriculture tries to find a good balance between the need for food production and the preservation of the ecological system within the environment. In addition to producing food, there are several overall goals associated with sustainable agriculture, including conserving water, reducing the use of fertilizers and pesticides, and promoting biodiversity in crops grown and the ecosystem.

"Sustainable agriculture is the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of environment and conserving natural resources" – FAO

A sustainable agriculture is ecologically sound, economically viable, socially just and humane.

Four Scientific Principles of Sustainability:

1. Reliance on Renewable resources (Solar Radiation)
2. Biodiversity
3. Population Control
4. Nutrient Recycling

Approaches of sustainable agriculture

1. **Efficacy :** Many of the approaches in conventional agriculture (minimum tillage, chemical banding) would fall into the "efficiency" category. They demonstrate a reduction in resource use and associated negative environmental impact, and in many cases a reduction in input expenses for the farmer. They represent, however, only an initial step towards a truly sustainable system.
2. **Substitution :** Efforts to substitute safe products and practices (botanical pesticides, bio- control agents, imported manures, rock powders and mechanical weed control) are also gaining popularity. These substituted practices focus to conserve our ecology and environment.
3. **Redesign :** The systems that focus on redesign of the farm are the most sophisticated, generally the most environmentally and economically sustainable, over the long term. These farm systems recycle resources to the greatest extent possible, meaning that little is wasted, few pollutants are generated, and input costs are reduced substantially. For example, chicken and orchard operations have been successfully integrated. The manure is used as a fertilizer, the chickens eat pests that attack the fruit, the feed bill for the chickens is greatly reduced, and the eggs and/or meat can be consumed or sold. Three to seven year crop rotations can be designed that minimize tillage, use legumes and green manures to maintain soil fertility, prevent pest and disease outbreaks, and provide a diverse diet for livestock.

Organic Agriculture

Organic Agriculture is a production system that sustains the health of soils, ecosystems 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." Organic agriculture is nothing more than a modernization in agriculture. It is a combination of science, technology and nature (IFOAM).

According to USDA (1980), Organic farming as a production system, which avoids or largely excludes the use of synthetic organic fertilizers, pesticides, growth regulators and livestock feed additives.

Principles of Organic Agriculture (IFOAM)

1. **Principle of health**: OA should sustain and enhances the health of soil, plant, animals, human and planets as one and indivisible.
2. **Principle of ecology:** OA should be based on living ecological systems, work with them, emulate them and help sustain them.
3. **Principle of fairness:** OA should build on relationships that ensure fairness with regard to the common environment and life opportunities.
4. **Principle of care:** OA should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Approaches of organic agriculture

- Conversion of land from conventional management to organic management.
- Management of the entire surrounding system to ensure biodiversity and sustainability of the system.
- Crop production with the use of alternative sources of nutrients such as crop rotation, residue management, organic manures and biological inputs.
- Management of weeds and pests by better management practices,

physical and cultural means and by biological control system.

- Maintenance of livestock with organic concept and make them an integral part of the entire system.

1.3. Effect and impact of chemical fertilizers on soil structure, soil fertility and environment

Soil health is the foundation of productive farming practices. Fertile soil provides essential nutrients to plants. The current industrial agriculture system promotes the reliance on agrochemicals, both synthetic fertilizers and pesticides, while neglecting to consider their negative effects on the economy of local communities, human, health and environment. In high productivity irrigated regions, excessive and imbalanced use of agrochemicals like fertilizers and pesticides often leads to decline in soil fertility.

Effect and impact of chemical fertilizers on soil

- Excessive use of urea and other nitrogenous fertilizer decrease soil pH level by making soil acidic.
- Excess potassium, magnesium in the soil can lead to a calcium deficiency in plants, since plants absorb calcium, magnesium and potassium largely in the ratio in which they are present in the soil.
- In the soil excess potassium causes a loss of structure. Reduced soil air levels result in reduced root respiration and the production of toxic compounds in plants
- Ammonium sulphate is a very strong biocide, hindering nitrogen fixation and killing nematodes and earthworms.
- Deficiency of trace nutrient may occur due to heavy application of NPK.
- Soil becomes compact because of use of nitrogenous fertilizers.
- Alkaline fertilizers like sodium-nitrate develop alkalinity in soil reducing its fertility and making it barren.
- Phosphatic fertilizers (Phosphorous) does not dissolve in water and its overuse may cause hardening of soil.
- Alkaline fertilizers like sodium-nitrate develop alkalinity in soil reducing its

fertility and making it barren.

- Superphosphate has a negative effect on free-living nitrogen fixing bacteria.
- Heavy doses of fertilizers can result in soils becoming more acidic that has serious implications in terms of long term productivity of soils.
- Inappropriate/imbalanced or excessive, use of fertilizers is a major cause of pollution of ground waters or surface water bodies resulting from inefficient use of applied nutrients.
- The excessive use of chemical fertilizers reduces the biodiversity of the soil microbes as a result there is negative impact on the available nitrogen, phosphorus and potassium (NPK) from soil.

Effect and impact of chemical fertilizers on the environment

- The biggest issue facing the use of chemical fertilizers is groundwater contamination. Nitrogen fertilizers break down into nitrates and travel easily through the soil. Because it is water-soluble and can remain in groundwater for decades.
- Chemical fertilizers will ultimately end up leaking into our water bodies; ponds, streams, ground water etc. and contaminate water supply as a result of which humans as well as animals may suffer numerous short term and long term hazardous chemical effects on their health and body.
- Chemical fertilizer is poisonous to microorganism. They decrease their population on soil.
- With long-term and large-scale use of chemical fertilizer, some environment issues will appear, such as soil acidification and crust.
- Long-term use of chemical fertilizer can change the soil pH, upset beneficial microbial ecosystems, increase pests, and even contribute to the release of greenhouse gases.
- Many types of inorganic fertilizers are highly acidic, which in turn often increases the acidity of the soil, thereby reducing beneficial organisms and stunting plant growth.
- The major risk to surface water is increased ***eutrophication*** (when water bodies such as lake, pond etc. become enriched with fertilizers which

accelerate the growth of algae and cyanobacteria which depletes the oxygen supply and creates a life threat to the living organism inhibiting the pond, lake etc.)

- Chemical fertilizers can cause root burn of fertilizer burn, as chemical fertilizers do not allow enough water intake for the plants.
- Repeated applications may result in a toxic buildup of chemicals such as arsenic, cadmium, and uranium in the soil. These toxic chemicals can eventually make their way into your fruits and vegetables.

1.4. Definition, importance and scope of integrated pest management

Integrated pest management (IPM)

It is comprehensive approach to pest manipulation that uses a combined means to reduce the status of pests to tolerable level while maintaining a quality environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. It is environmentally friendly, economically viable and socially justice approach for pest management.

Definition: According to Smith and Reynolds (1966) " Integrated pest management is a pest population management system that utilizes all suitable techniques in a compatible manner to reduce pest populations and maintaining them at levels below those causing economic injury."

Advantages of IPM

- Decreased use of chemical application will reduce risks to the health of staff members.
- Decreased use of chemical application will reduce the risk of deterioration & disfigurement of holdings.
- Decreased use of chemical application may result in a financial savings.
- The environment improvements made to the facility to implement an IPM program will enhance the long-term stability of the holdings over & above protection against pests.
- IPM may be the only solution to some long-term pest problems where

chemical application has not worked.

- IPM ultimately allows the institution to have greater control over and knowledge of pest activity in their facility.
- IPM is the pest management technique of choice for major institutions.
- Low risk of environmental pollution and health hazards.
- Conservation and effective use of natural enemies of the pests.
- Eco-friendly and as a sustainable long term solution to pest management.
- No phyto-toxicity, young seedlings and premature abortion of flowers and fruits.
- Planning in advance and timely management of pests of economic importance.
- Creation of environment of selective pesticides and method to reduce pesticide application.

Disadvantages of IPM

- IPM will require more staff, time than traditional pest management, even if implementation is contracted to a pest management company.
- IPM will require the coordinated effort of all staff members to properly implement.
- IPM may initially be more expensive than traditional pest management.
- Many farmers lack basic knowledge on the pests, their ecology and biology.
- Problem in the transfer of technology because of farmer's illiteracy.
- IPM efforts are nullified by chemicals control practices.

1.5. Definition and concept of biological methods of pest management

General Concepts of Biological Control Methods

The term biological control clearly implies control of a pest through some biological agency, and the term biological agency, means a living microorganism or macro organism other than the diseased or damaged plant acting as host & the pathogen or pest causing the disease or damage.

Definition: Biological Control

"Any activity of one species that reduces the adverse effect of another." In pest management, biological control usually refers to the action of parasites, predators or pathogens on a pest population which reduces its number below a level causing economic injury. Herbivorous insects and pathogens that attack pest weeds are also considered biological agents.

Agents of Biological Control:

1. Parasites & Parasitoids

Parasite- An organism that lives in or on the body of another organism (the host) during some portion of its life cycle.

Parasitoid- an arthropod (insects, mites, spiders & other closer relatives) that parasitizes and kills another relatives; a parasitoid is parasitic in its immature stages & free living as an adult.

The major types of insects that are parasitoids: wasps, flies, some beetles, mantisflies, and twisted-winged parasites.

Adult female parasitoids lay their eggs inside the host (the host arthropod is usually in its immature stage) by penetrating the body wall with their ovipositor or they attach their eggs to the outside of the host's body.

2. Predators

Predators- "Free-living animal that feeds other animals (prey); it may attack prey in both its immature and adult stages; usually more than one prey individual is required for the predator to complete its life cycle.

Major types of animal that are predators: birds, fish, amphibians, reptiles, mammals, arthropods, and some plants (e.g. Venus fly trap). Major types of insects that are predaceous: dragonflies and damselflies, mantids, true bugs, some thrips, lacewings & relatives, beetles, some wasps and ants, and some flies. Spiders and some mites are also important predators of arthropods.

3. Pathogens

Major pathogens used in biological control of insects:

Bacteria:*Bacillus thuringiensis* = Bt (many caterpillar pests, beetles, mosquitoes, others)

Viruses: *Nucleopolyhedrosis*viruses = NPV (Gypsy moth, European corn borer), *Granulosis* viruses (Codling moth)

Fungi: *Metarhizium* (cockroach motels), *Beauveriabassiana* (Colorado potato beetle, Corn rootworms)

Protozoa: *Nosema locustae* (grasshopper)

Nematodes: *Steinemema* and *Heterorhabditisspp*. (Soil weevils, Stem-boring caterpillars)

4. Herbivorous Insects & Microbial Pathogens of Weed Pests

- Importation of a moth to control prickly pear in Australia; the larvae bore into the stalk of the cactus
- Introduction of a leaf-feeding beetle to control Klamath weed in the western U.S.

1.6. Effect and impact of chemical pesticides on health and environment

Pesticide is a toxic chemical substance or mixture of substances or biological agents that are intentionally released into the environment in order to avert, deter, control and/or kill and destroy populations of insects, weeds, rodents, fungi or other harmful pests.

Overall negative impact of chemical pesticide

a. Development of resistance in insect
b. Outbreak of pest
c. Hazard of pesticide residue
d. Environmental pollution
e. Phytotoxicity
f. Adverse effect on non-target organism
g. Resurgence of pest

1. Impact of pesticides on Human Health

Chronic Impacts (Long-term)

- Increased risk of cancer (Brain, breast, prostate, ovaries, testes)
- Neurological impairment (confusion, nervousness)
- Development effects
- Reproductive effects (stillbirth, birth defects, spontaneous abortion, infertility)
- Organ damage (Liver, Lungs, Kidney)
- Intrusion with the human hormone system (reproductive hormones)

Acute Impacts (Short-term)

- Eyes: tearing, irritation, conductivities
- Skin: rash, blistering, burns, sweating, contact dermatitis, jaundice
- Nervous system: headache, dizziness, mood disturbances, depression, muscle twitching, paralysis, unconsciousness, coma
- Respiratory system: throat pain, cough, difficulty in breathing, respiratory failure
- Cardiovascular system: Cardiac arrhythmias
- Gastrointestinal tract: Nausea, vomiting, diarrhea, abdominal pain

Impact on environment

Pesticides can contaminate soil, water, turf and other vegetation. In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects and non-target plants. Insecticides are generally the most acutely toxic class of pesticides, but herbicides can also pose risks to non-target organisms.

- Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, because they are sprayed or spread across entire agricultural fields.
- Runoff can carry pesticides into aquatic environments while wind can carry

them to other fields, grazing areas, human settlements and undeveloped areas, potentially affecting other species.

- Pesticides that are applied to crops can volatilize and may be blown by winds into nearby areas, potentially posing a threat to wildlife.
- The use of pesticides decreases the general biodiversity in the soil.
- Animals including humans may be poisoned by pesticide residues that remain on food, for example when wild animals enter sprayed fields or nearby areas shortly after spraying.

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. Define IPNM.
2. Define integrated pest management.
3. What do you mean by sustainable agriculture.

2. Short (Answer question)

1. Write down the principle of organic agriculture.
2. Discuss the effect and impact of chemical fertilizers on soil.
3. Discuss the importance of IPM.

3. Long (Answer question)

1. Write down objectives, importance and scope of IPNM in Nepal.

UNIT 2

Integrated Plant Nutrient Management

A. Objective

- To import the knowledge of integrated plant nutrient management approach.

B. Content elaboration

2.1. Definitions, concepts and approaches of Ecosystem, Agro-ecosystem, Agroecology

Concepts of Ecosystem

The concept of ecosystem was first put forth by A.G. Tansley (1935). According to E.P. Odum, the ecosystem is the basic unit of organisms and their environment interacting with each other and with their own components. An ecosystem may be conceived and studied in the habitat of various sizes, e.g. one square meter of grassland, a pool, a large lake, a large tract of forest, balanced aquarium, a certain area of river, a part of sea and ocean. All the ecosystems of the earth are connected to one another, e.g. river ecosystem is connected with the ecosystems of oceans, and a small ecosystem of dead logs in a part of large ecosystem of a forest. . According to Odum, ecosystems generally include four categories of basic structural components.

1. Abiotic components
2. Producers, mainly green plants
3. Consumers, almost exclusively animals
4. Decomposers, mainly bacteria and fungi

Abiotic components: Abiotic component of ecosystem includes basic inorganic elements and compounds, such as soil, water, organic matter, nutrients etc.

Biotic components

1. **Producers (autotrophic elements):** They are chiefly green plants which produce carbohydrates. They convert the radiant energy into chemical form.
2. **Consumers:** They are the living members of ecosystem which consume the

food synthesized by producers. There are different categories of consumers, such as;

Primary consumers: These are purely herbivorous animals that are dependent for their food on producers or green plants. For e.g. Insects, rodents, rabbit, deer, cow, goat etc. are common herbivores in the terrestrial ecosystem and small crustaceans, mollusks etc. in the aquatic habitat.

Secondary consumers: These are carnivores (flesh-eating animals) and omnivores (plant & flesh eating). Examples, sparrow, fox, dog, cat, wolves, snakes etc.

Tertiary consumers: These are the top carnivores, which prey upon other carnivores, omnivores and herbivores. Eg lions, tiger, hawk, vulture etc.

Parasites, scavengers and saprobes: The parasitic plants and animals utilize the living tissues of different plants and animals. They utilize dead remains of animals and plants as their food.

3. **Decomposers and transformers:** They are the living components of the ecosystem and they are fungi and bacteria. They degrade the complex organic substances into simpler compounds. They play a very important role in maintaining the dynamic nature of ecosystems.

Types of ecosystem

1. Aquatic ecosystem {Natural; Fresh water, Pond & lake, River & spring, Marine, Ocean} {Artificial; Rice field, Fish pond reservoirs, Aquaria, Canals}
2. Terrestrial ecosystem {Natural; Forest, Grassland, Desert} {Artificial; Crop fields, Gardens, Lawns, Parks}

Concepts of Agro-ecosystem

The agricultural system or agro-ecosystem is man-engineered ecological system or unit. It contains both abiotic and biotic components that are interdependent and interacting and through which nutrients are cycled and energy flow.

Agroecology

Agroecology is defined as "the study of the relation of agricultural crops and environment." Agroecology is the scientific discipline that uses ecological theory to study, design, manage and evaluate agricultural systems that are productive but also resource conserving.

2.2. Revitalization of soil

Revitalization of soil is the process of reviving of the soil and revegetation in the soil. Its texture, structure and chemical properties are revived by various methods.

Land Revitalization in the Field

- **Liming:**Application of chalk or limestone ($CaCO_3$), quicklime (CaO) or hydrated lime ($Ca(OH)_2$) to increase soil pH has been commonly used.
- **Bio-solids and Liming:** The use of bio-solids and similar organic wastes such as paper mill sludge, alone and in combination with other materials also is a long-standing practice
- **Application of gypsum for treatment of alkaline soil.**

2.3. Land Degradation

The change in the characteristic and quality of soil which adversely affects its fertility is called as Degradation. Land degradation is the major consequences of direct interference of human activities in the natural phenomenon.

Land degradation means

- Loss of natural fertility of soil because of loss of nutrients.
- Less vegetation cover
- Changes in the characteristic of soil.
- Pollution of water resources from the contamination of soil through which water sweeps into ground or runoff to the water bodies.
- Changes in climatic conditions because of unbalanced created in the environment.

Causes of Land Degradation

a. Deforestation

Deforestation is taking place at a faster rate due to increasing demands of timber, fuel and forest products which results into degradation of land resources.

b. Overgrazing

Overgrazing refers to excessive eating of grasses and other green plants by cattle. It results into reduced growth of vegetation, reduced diversity of plant species, excessive growth of unwanted plant species, soil erosion, and degradation of land due to cattle movement.

c. Agricultural practices

The modern agricultural practices, excessive use of fertilizers and pesticides has adversely degraded the natural quality and fertility of the cultivation land.

d. Industrialization

Development of industries for the economic growth of the country leads to excessive deforestation and utilization of land in such a way that it has lost its natural up gradation quality.

e. Urbanization

Increasing growth of population and demand for more residential areas and commercial sectors is also one of the reasons for land degradation.

Prevention and Control Measures for Land Degradation

a. Strip farming:

It is a practice in which cultivated crops are sown in alternative strips to prevent water movement.

b. Crop Rotation

It is one of the agricultural practices in which different crops are grown in same area following a rotation system which helps in replenishment of the soil.

c. Ridge and Furrow Formation

Soil erosion is one of the factors responsible for lad degradation. It can be prevented by formation of ridge and furrow during irrigation which lessens run off.

d. Construction of Dams

This usually checks or reduces the velocity of run off so that soil supports vegetation.

e. Contour Farming

This type of farming is usually practiced across the hill side and is useful in collecting and diverting the run off to avoid erosion.

2.4. Organic Recycling

Recycling is the process of converting waste materials into new materials and objects. Organic recycling is basically done by composting. Composting is nature's process of recycling decomposed organic materials into a rich soil known as compost. Anything that was once living will decompose.

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. Define ecosystem
2. What do you mean by agro-ecosystem?
3. Define organic recycling.
4. List out two biotic and abiotic components of ecosystem.

2. Short (Answer question)

1. Describe about the revitalization of soil.

3. Long (Answer question)

1. What are the causes of land degradation and also describe about its preventive measures.

UNIT 3

Types and Methods of Preparation of Manures and Fertilizers

A. Objective

- To import the knowledge of manures and fertilizers preparation methods.

B. Content elaboration

3.1. Types of bio-fertilizers, Rhizobium culture, Mycorrhiza culture

Bio-fertilizers are microbial inoculants that are carrier-based preparations containing beneficial microorganisms in a viable state.

'Bio-fertilizer' is a substance which contains living microorganism which, when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Bio-fertilizers add nutrients through the natural processes of fixing atmospheric nitrogen, solubilizing Phosphorus, and stimulating plant growth through the synthesis of growth promoting substances.

Types of bio-fertilizers

A. Nitrogen fixing bio-fertilizers

- Rhizobium: Fixes 50-100 kg/ha/year of nitrogen
- Cyanobacteria: Fixes 20-30 kg/ha/year of nitrogen
- Azospirillium: Fixes 20-40 kg/ha/year of nitrogen
- Azolla: Fix atmospheric nitrogen in association with nitrogen fixing blue green algae Anabaena azollae
- Azotobacter: Fixes the atmospheric nitrogen by converting into ammonia.

B. Phosphate solubilizing bio-fertilizers

- Group of beneficial bacteria capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds.
- Pseudomonas, Bacillus and Rhizobium are among the most powerful

- Seed inoculation of PSB: 30 kg P2O5 /ha

C. Phosphate mobilizing bio-fertilizers (Mycorrhiza)

- A symbiotic generally mutualistic association between a fungus and the roots of a vascular plant.
- The mycelium of the mycorrhizal fungus can make them available to the plants they colonize.

D. Silicate and Zinc solubilizing bio-fertilizers

- Microogranisms are capable of degrading silicates and aluminium silicates
- Bacillus spp can be used as bio-fertilizer for zinc or alumunium silicates because these organisms solubilize the zinc present in the soil and make it available to the plants.

E. Plant Growth Promoting Rhizobacteria (PGPR)

- Species of Pesudomonas and Bacillus can produce phytohormones or growth promoters.
- They produce include indole-acetic acid, cytokinins, gibberellins and inhibitors of ethylene production.

Rhizobium

It is a bacteria that grows in root nodules of legumes (soyabean, pea, clover, alfalfaetc)

Rhizobium Inoculants: Use of Rhizobium culture in legumes is most promising. On average, its use can supply 15-20 kg N/ha to legumes; increase yield up to 20%. The association of nitrogen fixing bacteria (Rhizobium) with legumes is one of the most important bacteria plant interactions. Rhizobium bacteria in roots of legume plants fix atmospheric N_2 in nodules formed on the roots of plants.

Rhizobium culture

Rhizobium culture strains are antigenically very selective and require particular host or nodulation. The surface antigen on the Rhizobial cells recognizes the binding sites (specific root exudates) on the roots of the leguminous plants. This

characteristic makes them host-specific. Specific Rhizobial cell can penetrate the roots of the specific leguminous plants only and form nodules. They multiply within the nodule using the carbon source from the plant and in turn fix part of the atmospheric nitrogen to the plant.Rhizobium is a soil habitat bacterium, which can able to colonize the legume roots and fixes the atmospheric nitrogen symbiotically. The morphology and physiology of Rhizobium will vary from free-living condition to the bacteroid of nodules. They are the most efficient biofertilizer as per the quantity of nitrogen fixed concerned. They have seven genera and highly specific to form nodule in legumes, referred as cross inoculation group.

Mychorrhiza Culture

Mycorrhiza is a symbiotic mutualistic relationship between special soil fungi and fine plant roots. Since the association is mutualistic both organism benefit from the associations.

Mycorrhizal fungi are difficult to culture. At present, they can only be grown with plants. The fungi grow quite slowly compared with many other microorganisms and propagule number, in many products, is often not very concentrated. This means that large volumes/weights of inoculum have to be applied to crops. The large volumes of inoculum required, the costs associated with slow growth of a fungus that has to be grown with plants, and a product that carries other undefined microorganisms means that it is not necessarily a convincing alternative to inorganic fertilizers.

3.2. Types of organic manures

Organic manures are natural products used by farmers to enhanced sustainable crop production.

a. Bulky Organic Manure : (FYM, Green manures, Crop residue, Compost)

Compost: Rural compost

Green manure: About 15-20 tonnes of leguminous green manures (Dhaincha, Sunhemp, Cowpea, Cluster bean etc.) are incorporated in the field during the rainy season

b. Concentrated Organic Manure : Oil Cakes (Edible oil-cakes, Non-edible oil-cakes)

Nutrient content of commonly used concentrated manures:

Oil Cake	N	P_2O_5	K_2O
Linseed cake	7.8	1.5 – 1.9	1.4
Mustard cake	5.5	1.4	1.2
Neem cake	5.2	1.0	1.4
Sesamum	6.2	2.0	1.2

3.3. Methods of preparing and using bio-fertilizers 22

Method of preparation: In laboratory, bio-inoculum is prepared in suitable carrier like lignite powder (mesh size 50-100) as a semisolid preparation. Before inoculums preparation, the carrier is autoclaved at 15lbs pressure and 121 °C for 1 hour and cooled. Its pH is adjusted by 10% $CaCo_3$ to 7.3 before addition of inoculums. Bio-inoculum is added to trays containing sterile lignite powder under aseptic conditions. It is kept for half an hour at room temperature. Rate of inoculums is determined by counting viable count of culture and maintained throughout the preparation. Bio-inoculum so prepared is filled in sterile plastic bags and incubated for 24 hrs. The culture growth in inoculumis monitored at the interval of 30, 60, 90, 120, 150, 180 and 210 days of storage by spread plate method. The shelf life and viability of culture in the inoculum is finally estimated. Bio-inoculum so prepared is ready for packaging and sell provided its bio-fertilization effect on crops is predetermined.

Methods of application or use: There are four ways for application of solid bio-fertilizers.

Method 1 (Seed Treatment): The most extensively used method is the seed treatment. The bio-fertilizer is applied at the rate is determined from the amount of seed to be sown in a field. Before the application, bio-fertilizer is mixed in water (1:2) to form slurry. The slurry is poured in container with seeds to be sown. The combination is mixed properly such that each seed is coated by bio-

fertilizer. The seeds are dried under the shade and the sown. This method is recommended for pulses, oilseeds and fodder crops.

Method 2 (Seedling treatment): Dose wise diluted formulation is required for seedling treatment. About 1 part of bio-fertilizer in 10 parts of water is prepared. The roots of seedlings to be transplanted in field are dipped in bio-fertilizer solution for 30 minutes. After the treatment, the seedlings are immediately planted in field without drying. This method is recommended for crops like tomato, brinjal, potato, cabbage, onion, paddy and chilly which are replanted at seedling stage. It is also used for the treatment of ornamental bushes like roses, jasmine, dahlia, marigold and chrysanthemum.

Method 3 (Set treatment): For this treatment the ratio of bio-fertilizer to water is 1:50. The explants or cut pieces of planting material are immersed in bio-fertilizer mixture for 30 minutes. The treated pieces are dried in shade and then planted in field. The crops like sugarcane, banana, grapes and strawberries are recommended to be treated by Set treatment. Bio-fertilizers can also be used for intermittent application for the standing crop or soil treatment before plantation or sowing. For such direct soil applications, bio-fertilizer is mixed, rice husks or lignite (1kg per 25 kg of carrier) and then directly put in the soil. The applied area needs to be irrigated immediately. The liquid bio-fertilizers are applied by spraying or by fertigation.Spraying is recommended for standing citrus plants, vines, mango,guava,custard apple, apple and peach orchards. In fertigation, bio-fertilizer is mixed in water and other micronutrients in a tank. It is reached to individual plant via irrigation sprinklers or sprinklers or sprayers or piping. This method is usually employed in shade nets and green houses.

3.4. Organic manure and farm yard manure

Manures

Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition. Manures are the organic materials derived from animal, human and plant residues which contain plant nutrients in complex organic forms. Naturally occurring or synthetic chemicals

containing plant nutrients are called fertilizers. Manures can also be grouped, into bulky organic manures and concentrated organic manures based on concentration of the nutrients.

Organic Manure

Organic fertilizers have proved to be the safest and long lasting soil improvisers. They do not exert harmful and polluting effects on the soil and plants. These fertilizers consist of natural and bio-degradable components and elements which can easily be worked upon by little microorganisms and thus reach the crops and plants in a safe manner.

Types of organic manure

Cover Crop Manure

Green manure can be made in a couple of different ways. You can plant a cover crop which you will let grow for a season, then cut and till under. Cover crops can also be grown and cut and added to a compost pile to be used later on the garden. Some of the best cover crops are oat, rye, cow pea, millet, fava beans, mustard, clover, vetch, buckwheat, lupin, fenugreek, sunn hemp, alfalfa, and velvet bean. All of these crops are excellent sources of nitrogen and will also provide other nutrients to your soil.

Animal Manure

The next type of organic manure is animal. This type of fertilizer can be found from friends with horses, cows, chickens, rabbits, goats etc.

Mineral Manure

Minerals gradually release into the soil over long periods of time. They can take years to finally break down into nutrients.

Bulky organic manures

Bulky organic manures contain small percentage of nutrients and they are applied in large quantities. Farmyard manure (FYM), compost and green-manure are the most important and widely used bulky organic manures. Use of bulky organic manures has several advantages :

- They supply plant nutrients including micronutrients
- They improve soil physical properties like structure, water holding capacity etc.,
- They increase the availability of nutrients
- Carbon dioxide released during decomposition acts as a CO_2 fertilizer and
- Plant parasitic nematodes and fungi are controlled to some extent by altering the balance of microorganisms in the soil.

Farmyard manure

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 percent P_2O_5 and 0.5 per cent K_2O.

Sheep and Goat Manure

The droppings of sheep and goats contain higher nutrients than farmyard manure and compost. On an average, the manure contains 3 per cent N, 1 per cent P_2O_5 and 2 per cent K_2O.

Poultry Manure

The excreta of birds ferment very quickly. If left exposed, 50 percent of its nitrogen is lost within 30 days. Poultry manure contains higher nitrogen and phosphorus compared to other bulky organic manures. The average nutrient content is 3.03 per cent N; 2.63 per cent P_2O_5 and 1.4 per cent K_2O.

Concentrated organic manures

Concentrated organic manures have higher nutrient content than bulky organic manure. The important concentrated organic manures are oilcakes, blood meal, fish manure etc. These are also known as organic nitrogen fertilizer. Before their organic nitrogen is used by the crops, it is converted through bacterial action into readily usable ammoniacal nitrogen and nitrate nitrogen. These organic fertilizers are, therefore, relatively slow acting, but they supply available nitrogen for a longer period.

3.5. Green manuring and mulching

Green Manure

Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest. Green manuring is growing in the field plants usually belonging to leguminous family and incorporating into the soil after sufficient growth. The plants that are grown for green manure are known as green manure crops. The most important green manure crops are sunnhemp, dhaincha,clusterbeans and *Sesbaniarostrata.*

Advantage of green manure

- Increase and recycle plant nutrients and organic matter
- Improve soil fertility (Leguminous crops fix atm. N_2)
- Improve soil structure
- Improve the ability of the soil to hold water
- Control soil erosion
- Prevent weed growth
- Stop nutrients being washed out of the soil, for example, when the ground is not used between main crops.

Nutrient content of green manure crops

Plant	Scientific name	Nutrient content (%) on air dry basis		
		N	P_2O_5	K
Sunhemp	*Crotalaria juncea*	2.30	0.50	1.80
Dhaincha	*Sesbania aculeate*	3.50	0.60	1.20

Mulching

Mulching means covering the ground with a layer of loose material such as compost, manure, straw, dry grass, leaves or crop residues. Green vegetation is not normally used as it can take a long time to decompose and can attract pests and fungal diseases.

Alternative mulching materials include black plastic sheeting or cardboard.

However these materials do not add nutrients to the soil or improve its structure.

Effects of mulching on the soil

- Decreasing water loss due to evaporation
- Reducing weed growth by reducing the amount of light reaching the soil
- Preventing soil erosion
- Increasing the number of micro-organisms in the top soil.
- Adding nutrients to the soil and improving soil structure
- Adding organic matter to the soil

How to use mulches

- Always apply mulches to a warm, wet soil. Mulch applied to a dry soil will keep the soil dry.
- Care should be taken as to the thickness of the mulch applied. Too much mulch will prevent air flow and encourages pests.
- To allow the germination of planted seeds through the mulch, a layer of less than 10 cm should be used.
- To clear an area of land of persistent weeds a layer of 10 cm or more can be used.

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. Define bio-fertilizer with examples.
2. Write any two green manuring crops.

2. Short (Answer question)

1. Discuss green manuring crops with examples.
2. What do you mean by bio-fertilizer ? Enlist its type along with examples ?
3. Describe the method of using bio-fertilizer.

4. Describe about the Rhizobium culture.

3. Long (Answer question)

1. What are the effects of mulching on the soil? Also describe the advantages of green manure ?
2. Briefly describe about the types of manure and fertilizer.

UNIT 4

Cropping system

A. Objective

- To impart the knowledge of cropping system.

B. Content elaboration

Cropping system : The term cropping system refers to the crops, crop sequences and management techniques used on a particular agricultural field over a period of years.

Crop Rotation: Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons. It is done so that the soil of farms is not used for only one set of nutrients. E.g. cotton- gram, sugarcane- wheat.

Principles of Crop's Rotation

1. The crops having deep root system should be grown after crops with shallow root system. E.g. Arhar-Maize
2. The crops requiring more fertilizers should be followed by the crops, which require less fertilizer. E.g. Wheat-Cotton
3. The crops requiring high water requirement should be followed by less water requirement crops. E.g. Rice - Gram
4. The leguminous (pulse) crops should be grown after non-leguminous (non pulse) crops. E.g. Moong- Wheat or Maize - Pea
5. The crops require less inter-culturing should be grown after the crops, which require high interculturing. E.g. Potato- Wheat
6. Meeting the domestic needs of the farmers and his livestocks. E.g. moong - Rice - Potato- wheat
7. More expensive crops should be followed by less expensive crops. E.g. Maize-moong
8. The crops of the same family should not be grown in succession so that insect pests diseases and weeds may not perpetuate. E.g. moong-wheat

9. An ideal crop rotation should provide proper utilization of labour, animal and implement throughout the year.
10. The crops that increase soil erosion should be followed by the crops that decrease soil erosion. E.g. maize- moong
11. The selection of crops should be done on the availability of land, climate and financial conditions.

Rotational intensity

Rotational intensity or intensity of crop rotation = $\frac{\text{No.of crop grown in ratation}}{\text{Duration of crop rotation}} \times 100$

Cropping Pattern

Cropping pattern means the proportion of area under various crops at a point of time. The cropping patterns of a region are closely influenced by the geo-climatic, socio-cultural, economic, historical and political factors.

Cropping intensity is the ratio of total cropped area to net area available for cultivation in year expressed in percentages.

Cropping intensity = $\frac{\textbf{Total cropped area}}{\textbf{Net area available for cultivation}} \times 100$

Intercropping

Growing of two or more crops simultaneously on the same piece of land (field) is called intercropping. There is a crop intensification in both time and space dimensions. There is intercrop competition during all or part of crop growth.

Type of intercropping:

- **Mixed Intercropping:** Growing two or more crops simultaneously with no district row arrangement. e.g. cowpea + maize.
- **Row Intercropping:** Growing two or more crops simultaneously where one or more crops are planted in rows.

  Maize + soybean = 1:1

  Potato + mustard = 3:1

  Wheat + rayo = 8:1

- **Strip Intercropping:** Growing soil conserving and soil depleting crops in alternate strips running perpendicular to the slope of the land or to the direction of prevailing winds for the purpose of reducing erosion.E.g. growing 6 rows of maize and 10 rows of cowpea for soil conservation.
- **Relay Intercropping:** Seeding planting two or more succeeding crops after flowering and before the harvest of the standing crop. For Example: rice/lentil

4.1. Bio-intensive farming system

Bio-intensive farming is a self-help food raising method based on building and maintaining soil fertility and using no chemicals. Bio-intensive agriculture is an organic agricultural system that focuses on achieving maximum yields from a minimum area of land, while simultaneously increasing biodiversity and sustaining the fertility of the soil.

Principle and Features of Bio-intensive Farming System:

The concept of bio-intensive farming system is based on the agro-ecological principles of sustainable organic agriculture system and participatory rural development. These principles include the scientific crop rotation, mixed farming with specialized crop and/or livestock/agroforestry enterprise, optimization of organic recycling, plant/animal biodiversity, participatory research and extension, and higher degree of economic self-reliance of farm households against external techno-economic shocks.

1. Empowerment of People's Organizations
2. Conservation and Utilization of PGRs
3. Eco- and Health-friendly Rural System
4. Equitable Access to Natural Resources and Public Service
5. Sustainable Technology

4.2. Permaculture system

Permaculture or permanent agriculture is a system of agricultural and social design principles centered on simulating or directly utilizing the patterns and features observed in natural ecosystems. The term permaculture (as a systematic

method) was first coined by David Holmgen, then a graduate student, and his professor, Bill Mollison, in 1978.

The three core tenets/ethics of permaculture are:

a. **Care for the earth:** Without a healthy earth, humans cannot flourish

b. **Care for the people:** Access to those natural resources necessary for their existence

c. **Return of surplus**: Fair share that each of us should take no more than what we need before we reinvest the surplus.

Design Principles of Permaculture

1. Observe and interact.
2. Catch and store energy.
3. Obtain a yield.
4. Apply self-regulation and accept feedback.
5. Use and value renewable resources and services.
6. Produce no waste.
7. Design from patterns to details.
8. Integrate rather than segregate.
9. Use small and slow solutions.
10. Use and value diversity.
11. Use edges and value the marginal.
12. Creatively use and respond to change.

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. Define crop rotation.
2. Define intercropping.
3. What do you mean by permaculture?

4. Define cropping intensity.

2. Short (Answer question)

1. Explain the types of intercropping.
2. Define permaculture. Write down three ethics of permaculture.

3. Long (Answer question)

1. State the principles of crop rotation with examples.

UNIT 5

Farmer's Field School

A. Objective

- To impart the knowledge of farmers field school approach

B. Content elaboration

1.1. Concept, and approach of Farmer Field School

Concept of Farmers Field School

Farmer Field School is a school without walls. Farmers and extension workers are students. The Farmers Field is the class room and the plant is the teacher. As the plant grows the students gain knowledge in the light of their observations. They get together at a fixed time every week once and make their own decisions based on observations and data analysis for the health of the plants.

Farmers Field School (FFS) - Tool of IPM generation and dissemination

A Farmers Field School (FFS) is a "school without walls" bringing 25-30 Farmers from a village to undergo an intensive training on IPM over the entire life cycle of a crop. Thus, in FFS farmer participants meet for 14-16 weeks, from land preparation to crop harvest, and they are being facilitated by a trainer. Selection and initiation of a FFS depends upon interest of the farmers, baseline survey, supports from local leaders, gender matrix and cropping calendars. Each FFS has at least 1000m^2 "Learning Field". Each week, farmers practice agro-ecosystem analysis (AESA) in the "Learning Field", which includes plant health, water management, nutrient management, weed density, disease surveillances, weather, insect pest and their predators/parasite observation. Farmers interpret their observation in the AESA to make filed management decisions. A FFS, thus, trains farmers to make them experts in their own fields.

Basic Principles of FFS

- Doing is better than hearing or seeing
- Experiences are the start of learning

- The field is the classroom
- The topic in the farmers field school is linked to the actual field condition and relevant to need of that locality
- Farmers are the good decision makers

General curriculum of a field school

- A field school group formation
- Pre-test of the trainees based on their field problems
- Field observation- IPM and non-IPM demonstration
- Agro-ecosystem analysis of IPM and non-IPM plots
- Special topic each week relevant to crop growth stages and pest problems
- Field trails to study different components of IPM
- Presentation and discussion each week based on their observation and decision makings
- Post-test with the same pre-test questionnaire to evaluate their learning and skills

Approach of farmer field school (Steps)

1. Conduct Groundworking activities

- Identify focus enterprises
- Identify priority problems
- Identify solutions to identified problems
- Establish farmers' practices
- Identify field school participants
- Identify field school sites

2. Training of Facilitators on

- Crop/livestock production and protection technologies
- Field guides on how to effectively deliver crop/livestock production and protection topics using non-formal education methods (NFE)
- Participatory technology development (PTD) with emphasis on the approaches and developing guidelines on conducting PTD

- Non-formal education methods with emphasis on what, when and how to use NFE in FFS
- Group dynamics
- Special topics to be addressed at every stage of training.

3. Establishment and Running FFS

With the guidance of facilitators, the group meets regularly throughout the season, and Carries out experiments and field trials related to the selected enterprise.

- Implement PTDs (Test and Validate)
- Conduct AESA and Morphology and collect data
- Process and present the data
- Group dynamics
- Special topics

4. Evaluating PTDs

- Analyse collected data
- Interpret
- Economic analysis
- Presentation

5. Field days

- During the period of running the FFS, field days are organized where the rest of the farming community is invited to share what the group has learned in the FFS.
- Farmers themselves facilitate during this day

6. Graduations

- This activity marks the end of the season long FFS. The farmers, facilitators and the coordinating office usually organize it.
- Farmers are awarded certificates

7. Farmer run FFS

- FFS farmer graduates now have the knowledge and confidence to run their own FFS.

8. Follow up by facilitators

Occasionally the core facilitators will follow-up on schools that have graduated preferably on monthly basis. The core facilitators also backstop on-going farmer run FFS.

Processes of IPM FFS

1. Agro-ecosystem Analysis (AESA)

A. Field visit / Field Observations
- Go to the field in subgroups (5 farmers per subgroup)
- Choose 10 plants randomly
- Observe plant, pests, natural enemies, diseases, weeds, weather etc

B. Drawing
- Each subgroup presents their observations and analysis in drawing
  - Plant, Weather, Disease symptom, Pests, Natural enemies, Water level

C. Presentation and Discussion
- Each subgroup presents their analysis
- Group Discussion
- Decision about pest control measure is made
- Facilitator will facilitate the discussion

2. Supporting IPM Field Studies

A. IPM validation trials
- IPM Practices Vs Farmer Practices
- Conducted on 100 m2 plot, each 500 m2

B. Crop Compensation
- To demonstrate that crop plants can compensate for some damage by producing new leaves or shoots

C. Field cages

- To demonstrate how natural enemies keep pest population under control

D. Plastic bagging

- To demonstrate how enclosing cacao pod with the plastic bag can prevent attack from pod borer

E. Side-grafting

- Farmers learn how to make a side-grafting on cacao

F. Use of insect traps

- Farmers learn how to monitor insect population using traps

G. Insect zoo

- To study life cycle of insects
- To study feeding behavior of insects
- To study predator and parasitoids

3. Group Dynamics

- A variety of team building games and exercise employed during the training
- To foster togetherness within the group
- To sharpen farmer communication and organizing skills

4. Ballot Box

a. FFS starts with a ballot-box pretest of knowledge and ends with a posttest

b. A simple tool to measure the level of a farmer's knowledge on an agro-ecosystem

c. Question focus on:

- Recognition of pests, natural enemies, diseases
- Recognition of damage from pests and diseases
- Management of pests and diseases etc.

5. Field Day

a. At the end of FFS season

b. To show the results of FFS to other farmers, agricultural staff, local

government officials

- IPM plot vs. Farmer Practice plot
- Other field experiments
- Insect zoo (pests and natural enemies)

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. Define IPM FFS.

2. Short (Answer question)

1. State the basic principle of farmer field school.
2. State the general curriculum of a farmer field school.

3. Long (Answer question)

1. Write down Step and processes of conducting IPM FFS.

UNIT 6

Integrated Pest Management and FFS

A. Objective

- To impart the knowledge of integrated pest management approach and FFS

B. Content elaboration

6.1. Useful insect pests prevalent in various ecological conditions

Useful or Beneficial insects: Useful insects include pollinators which is important in the pollination process of all plants, and natural enemies of pests such as parasitoids and predators which are important in the suppression of pest damage to crops. Therefore, proper understanding and identification of natural enemies, as well as pollinators in agricultural fields.

Useful or Beneficial or Predator Insects	Prefer Crops / Ecology / Habitat	Prey or Feed on
Assassin Bug	Legumes, Rice, Mango, Hibiscus	Leafhoppers, Plant bugs, Caterpillars & their eggs & larvae
Hoverflies	Flowers (Sunflower, Marigold), Buckwheat	Aphids, Thrips, Mites & other small insects
Ground Beetles	Amaranth, White clover, Mulch	Cutworms, Ants, Maggots, Earthworm, Slugs & other beetles
Lady Beetles	Mustard, Sunflower, Buckwheat, Cowpea, Knotweed, Native grasses	Aphid, Mites, Thrips, Scale insects, Mealy bugs & insect eggs
Brown/Green Lacewing	Carrot, Sunflower, Buckwheat, Corn,	Leafhoppers, Mites, Red-banded thrips, Mites, Immature mealy bugs, Moth eggs & small caterpillar
Long-Legged Flies	Tree Cervices , Dead O.M.	Aphids, Thrips, Young caterpillars, Mites
Tachinid Flies	Various Crops	Green clover worm, Bean leaf beetle, Grasshopper, Caterpillars
Robber Flies	Native vegetation, Permanent hedge row	Flies, Wasps, Grasshopper, Leafhoppers, Beetles, Butterflies
Spiders	Low vegetation or Woody	Red-banded thrips, Plant

	Plants	Hoppers, Caterpillar, Moths
Trichogramma Wasps	Legumes & other various crops	Armyworms, Corn earworms, Cutworms, Corn Borers

6.2. Mechanical, cultural, biological and chemical methods of pest management in Nepal

There are two ways by which pest population are brought under control: i.e. natural forces or human intervention. The natural control is permanent and is not dependent upon human beings. Natural factors keeping pest at lower level or killing them are: climatic factors, natural barriers, and diseases. The measures adopted by human beings are mechanical, physical, cultural, biological, chemical, legal, and integrated.

I. Mechanical Control/Method of Pest Management:Mechanical methods involve the use of mechanical devices or manual operations for the control of pests.

Advantages of Mechanical Methods	Disadvantages
1. It utilizes home labor & low cost equipment	1. It is more laborious & time consuming
2. It is most feasible method in certain places, e.g. kitchen garden	2. It is impracticable in commercial scale.
3. It does not pose danger & residue problem and other adverse side effects.	3. It is quite old & out of fashion.
4. It gives immediate results	4. It requires repeated uses, small pests cannot be seen & pests inside the plants cannot be controlled.

Mechanical method includes following different practices:

a. Destruction

- **Hand picking:** Usually large size insects (caterpillar, bugs) and their egg masses are hand-picked and destroyed. This method is applicable for the destruction of egg masses & gregarious larvae of the cabbage caterpillar, the hairy caterpillars, and the tobacco caterpillars.

- **Shaking or heating**: Infested plants & their branches are shaken or beaten with a stick to drive among the pests. Houseflies are killed by swatting them with a fly flapper or a rolled magazine; locusts are driven among or killed by beating plants with brooms or twig of plants. Mustard sawfly can be shaken off the plants into a flat vessel containing kerosene & water.
- **Sieving and winnowing:** Insects of stored grains are removed by sieving and / or winnowing.

b. Exclusion

- **Banding:** The use of 5 cm wide sticky/greasy band around the trunk of a mango tree, before hatching eggs of the mango mealybug in the soil prevents the upward movements of the nymphs.
- **Wrapping of fruits:** Bunches of grapes are wrapped in muslin bags to protect from wasps & bees. Pomegranate fruits are covered in bags to protect from butterfly laying eggs on them.
- **Wire gauge screening:** Doors & ventilators of buildings are screened to prevent the entry of houseflies & mosquitoes.
- **Trench digging:** The digging of 30-60 cm wide & 60 cm deep trench around the field gives protection to the crops from the attack of migrating insects such as hairy caterpillars, grasshopper & locust nymphs.
- **Covering materials:** Damages to pubes from the pulse beetle can be avoided by covering them with 3-5 cm thick layer of sand, saw dust or ash. Beetles are unable to enter up to the grain.
- **Pest smashing/collecting devices**: These devices include hopper-dozens, aphid dozens, which smash & collect pests by running over them.
- **Use of water barrier:** The legs of food or plant cabinets, cages are kept dipped in pots containing water. This prevents the entry of ants to food & plant materials.
- **Sticky/ Water pan trapping:** Different traps can be devised such as sticky or mater-pan, sound trap suction traps etc. Aphids & whiteflies are attached by yellow pan trap. Sound traps are used to scare the insects away.

II. Physical Method/Control of Pest Management

Physical methods involve the manipulation of temperature, humidity and use of radiant energies. These methods are particularly useful for destroying stored grain pests.

a. Manipulation of Temperature

- **High temperature:** Most of the insects are killed in a short time when they are exposed to high temperature of 60-66°C. This principle has been employed for killed stored grain pests by superheating the empty go-downs. Drying infested stored products in sun for 3-4 hours in summer also kills & prevents store grain pests. Go-downs can be heated by hot water pipes or by electricity.
- **Burning:** Flame thrower with kerosene fuel have been used for burning the adults & nymphs of desert locusts on desert, barren lands & shrubs in the uncultivated areas.
- **Low temperature:** Nearly all insects become inactive at 60-40 F. Practically no damage occurs from insects at temperature below or near freezing point will prevent all insect damage.

b. Manipulation of Moisture: Draining of marshy land & standing water is the most effective method of destroying mosquitoes and houseflies. Drying of grains (<10% moisture) before storage is a sound practice to prevent insect damage by stored grain pests.

c. Manipulation of Light

- Light Trap: Several species of insect pests are attracted to light. In general insects appear to be strongly attracted at about 3650A, hence ultraviolet lamps have been used to such insects.
- Unattractive Lamps: The use of yellow or red lamps reduces the nuisance of insects that are attracted to ordinary or ultraviolet lamps. Sodium vapor lamps involve higher initial costs but produce higher lumen output with less input wattage and do not attract many insects.

d. Use of Radiant Energy: The atomic energy consists of X-rays, B-rays, G-

rays. All these rays are effective in causing the death of tissues & sterility in insects. Gamma-rays are being used for the disinfection of stored products. Cobalt-60 source of G-radiation was used to sterilize the pupae of screw-worm fly, which developed into adult and mated normally, and eradication of screw-worm flied was achieved in Florida.

e. Use of Sound Wave: Male mosquitoes are attracted by special sound waves & made sterile by electronic flash gun in Canada.

III. Cultural Method/Control

The control of pests through adoption in farming practices in such a way that the pests are either eliminated or reduced & their damage is negligible. This is one of the oldest traditional practices learnt by experience in farming.

Advantages of Cultural Method	Disadvantage
1. Readily available & adopted by the farmers.	1. The effective application of the cultural practices requires a thorough knowledge of life-histories & habit of pest & their host plants.
2. Do not entail any extra investment.	2. Should be applied well in adavance.
3. No need of experience of supervisors/farmers.	3. Always does not result economic return.
4. Safe to man, animal & natural enemies.	4. Specific to particular pest only.
5. More attractive in context of sustainable agriculture. And No problem of resistance.	5. Sometimes needs the cooperation of farmers in large area in order to be effective.

a. Sanitation and good husbandry

- Collection & destruction of crop residues
- Eradication of affected plants & plant parts
- Destruction of weeds, alternative, collateral host
- Wild grasses are alternate host for sugarcane borers
- Removal & destruction of infested fruits-fruit flies, coffee fruit, borer

- Removal & destruction of early pods- cocoa pod borer to break

b. Tillage

Tillage operation is a good method of controlling many pests. Reported e.g. are:

- 10 cm deep ploughing& destruction of refuses reduced 98% pink bollworm population
- Birds such as crew & mynah pick up many insects exposed to soil surface.
- Minimized the white grubs, wireworms, cutworms etc populations
- Careful hand weeding of rice increases average yield by 45%
- Tillage also significantly reduces nematodes (*Meloidogyne sp.*) Of tobacco
- However, tillage operation favor wheat disease by 50% whereas only 17% in control or no tillage.

Thus, tillage reduces the pest by:

- Mechanically damaging the pest
- By burying or exposing a developmental stage of the pest
- By changing physical condition (pH, moisture, O_2 content) of soil
- By eliminating the alternate or main host plants
- By hastening the grown vigor of crops

c. Improved cropping system/pattern

Crop rotation: Change in the sequence of cropping patterns of different nature or alternating botanically unrelated crops

- Much lower incidence of pests
- Pressure on pests which have a narrow host range & limited mobility
- Break the life cycle of insect pests & nematodes
- Alternation of cereals & legume crops is a common practice. Legumes in rotation with grass crops greatly reduce white grub injuries.
- Rotation of groundnut with non-leguminous crop helps to minimize the leaf minors in groundnut

Intercropping: Serve as predator, repellent etc.

- Maize & groundnut intercropping markedly decreased corn borer-spider

activity increased due to groundnut

- Intercropping of tomato with cabbage; maximum reduction of DBM & Leaf Webber in cabbage. (1 row cabbage & 1 row tomato where cabbage is transplanted 30 days later tomato). Tomato secretes volatile compounds & it acts a repellant for insects.
- Carrot fly on carrots control by inter-planting with onion
- Groundnut with pearlmillet reduced thrips, jassids& leaf minor & also increase parasitic activities of *Goniozus sp.*

Stripe cropping: Use to prevent wind erosion & insect migration

- Mustard saw fly migrated from fallow to nearby plants only

Trap cropping: Use as barrier or hazard or camouflage; as alternate host diverting the pest away from the main crop; & benefiting natural enemies of the pest

- Okra attracts bollworm & red cotton bug. So, planting few rows of okra on cotton field helps to attract those pests.

d. Use of manure & fertilizer

- Balanced nutrients are less infested than excess or less fertilization
- Phosphorous deficit soil in wheat; damage by wireworm, stem fly
- Excess nitrogenous fertilizer; increase incidence of borers, plant hoppers &gallmidge in rice but excess potash & phosphorus reduces the incidence of aphids, gallmidge etc.

e. Time of sowing & harvesting

Most pests cause damage to a particular stage of the crop or appear only during certain period of the year. So, sowing or harvesting time manipulation helps to escape crops from pest damage.

- Okra planted during March-April; serve damage by fruit & shoot borer than planting during the rainy season
- Early sowing is practiced in case of mustard against mustard aphid, Bengal gram against noxious pest, cucurbit vine against red pumpkin beetle.

f. Procuring pest free seeds: Healthy & good seed should be selected.

g. Use of resistant varieties

- IR-8, IR-20 varieties- Resistance to borer & leafhoppers
- PusaSawani of okra- Resistance to borer
- Winter Majestin of apple- Wolly aphid

IV. Biological Method/Control

Eradication or suppression of undesirable pests by encouragement, artificial introduction or increase & their natural enemies such as predators, parasite & disease causing organisms is called biological control. The term biological control was first used by Smith in 1919 to signify the use of natural enemies.

Advantages of Biological Control	**Disadvantages**
1. Selective with no side effects i.e. safe	1. Lack of such technology at hand (at present)
2. No need of costly application equipments& safety garments	2. Cannot achieve total pest control, some degree of pest damage always occurs
3. Easy to handle	3. Sometimes limits the use of chemicals against other pests
4. Does not harm other natural enemies (NEs)	4. Short shelf life (compared to chemical pesticides)
5. Development of pest resistance is less likely	5. Act slowly results may be unpredictable etc
6. Use of local resources, regenerative multiplication, self propagatingetc	

Bio-Control Techniques or Methods includes

1. Conservation & Encouragement
2. Introduction/Inoculation
3. Augmentation (rearing or release)

Agents of Biological Control

B.C. Agents	**Control /Action**
Insect Predators: Coccinellidae (Lady bird bettle) Mantidae(Praying mantid) Syrphidae (Syrphid flies)	Feed on aphids, scale insects & mealy bugs Feeds on moths & other weaker insects Feeds on maggots & aphids.

Insect Parasites: Braconidae *(Apanteles falvipes*) Trichogrammatidae (*Trichogram maminutum)* Ichneumonidae (*Xanthopimpla predator*)	Larval parasites of *Chilo partellus* Egg parasite of *Chilopartellu s*& other insects Pupal parasites of *Chilo partellus*
Predatory Vertebrates: Birds: House sparrow, Mayna,Crowetc Mammals: Bats, Shrew, Mongoose Amphibian & reptiles: Frogs & Lizards Fishes	Feed on eggs, larvae & adults of insects Feed on eggs, larvae & adults of insects Feed on eggs, larvae & adults of insects Feed on mosquito larvae &chironmid larvae
Arachinds: Spiders, Predatory & Parasitic mites	Feed on Paddy leaf hoppers
Nematodes: *Neoaplectanac arpocapsae*	Used for controlling codling moth
Protozoa: *Nosema bombycis* *Malpiaghamoeba melliferae* *Xanthomous grandis*	Causes disease in silkworm Causes disease on grasshopper Attacks on grasshopper, butterflies
Parasitic Fungi: *Aspergillus* *Beauveria* *Coccusviridis*	Attacks on Skippers Attacks on Diptera Attacks on scale insects
Bacterial Diseases: *Bacillus thuringiensis* (Bt)	Control insects like Gram pod borer, Cabbage butterfly, Cabbage moth, Cabbage looper, Rhinoceros beetle by causing disease
Virus Diseases: Nuclear Polyhydrosis Virus (NPV) Gramulosis Viruses	Attacks on Tobacco caterpillar, Gram pod borer, Soybean looper, Blackdiamond Moth Attacks on Potato Tuber Moth, Coodling moth

6.3 Concept, principles and methods of IPM

Integrated Pest Management (IPM) is an economically justified & sustainable system of crop protection that utilizes all suitable techniques in a compatible manner & aims at maximizing & sustaining productivity leaving the least possible adverse consequences on the environment. IPM utilizes a wide range of pest control strategies and tactics. The goal of this strategy is to prevent pests from reaching economically damaging levels with the least risk to the environment.

This system of pest management includes the use of mechanical, physical,

biological, legal & chemical measures along with the application of pheromones, hormones, antifeedants & chemosterilants.

Why Practice IPM ?

- **IPM helps to keep a balanced ecosystem:**

  Introducing chemicals into the ecosystem can change ecosystem balance. Pesticides can kill beneficial insects that consume pests, leaving few natural mechanisms of pest control.

- **Pesticide can be ineffective:**

  Chemical pesticides are not always effective. Pests can become resistant to pesticides. Pests may survive in situations where the chemical does not reach pests, is washed off, is applied at an improper rate, or is appled to an improper life stage of the pest.

- **IPM can save money**

  IPM can avoid crop loss caused by pests and prevent unnecessary pesticide expense. Applicators can save on pesticide costs.

- **IPM promotes a healthy environment**

  Using IPM strategies helps keep adverse effects of pest management on environmental components to minimum level.

- **IPM maintains a good public image.**

  IPM is now demanded by many sectors of our society. IPM has been implemented to grow our food, to manage turf and to protect humans, pests, and livestock health.

Principle of IPM

- To grow healthy crops
- To protect beneficial organism
- To regularly evaluate crops
- To make farmer perfect

Components of IPM

1. Identify and monitor pest

We have to know what's happening in ours fields before we can make good management decisions. Never classify an organism as a pest or treat it as a pest until it is clearly an organism as a pest. We should visit our crops often and on a regular basis to identify and monitor pest populations and/or the resulting loss or damage, track crop growth and field conditions, and find other problems.

2. Select best management tactics

Pest management tactics should be effective, practical,economical, and environmentally sound. To select the best control tactics, we have to:

- **Understand** the life cycle and habits of the pest. Some control methods will work only if they are used at the right time.
- **Decide** whether the infestation is serious in terms of economic loss.
- **Compare** the costs and benefits of various control methods
- **Make** plans for the future. Not every part of an IPM program can be put into effect immediately. Some tactics, such as planting resistant varieties or rotating crops, require long-range planning.

A number of economic concepts are helpful in determining the point at which the pesticides or other management practices should be applied:

- **Economic damage** occurs when the cost of preventable crop damage exceeds the cost of control.
- **Economic injury level** is the lowest pest population that will cause economic damage. For many pests it is important to use control measures before this level is reached.
- **Economic threshold** is the pest population level at which a control tactic should be started to keep the pest population from reaching the **Economic injury level.**

3. Record and evaluate results

It is very important to record and evaluate the results of our control efforts. To

evaluate an IPM we should:

- **Monitor** our fields and keep records. Each time we visit our fields, make a note of crop and pest conditions – record crop yields and quality, and record any counts on pest populations.
- **Record** control measures
- **Compare** effectiveness that are chosen

Pest management Methods

a. Biological control

Most pests have natural enemies that control or suppress them effecitively in some situations. Natural enemies, including pathogens and insects, are being used successfully as biological control agents to manage certain insect, mite, fungus and weed pests.

b. Mechanical control

Mechanical control involves the use of devices, machines, and other physical methods to control pests or alter their environment. Traps, screens, barriers, fences, and nets are examples of devices used to control pest activities or remove pests from area.

c. Cultural control

The goal of the cultural control is to alter the environment, the condition of the host, or the behavior of the pest to prevent or suppress an infestation. In agricultural crops, selection of crop plant varieties, timing of planting and harvesting, irrigation management, crop rotation, and use of trap crops helps reduce populations of weeds, micro-organisms, insects and other pests.

Sanitation involves eliminating food, water, shelter, or other necessities important to the pest's survival. Sanitation includes practices as removing weeds, destroying diseased plant material or crop residues, etc.

d. Genetic control method

Genetic modification of plant has been a new way of controlling insects and other pest population. Genetic control; refers to employment of an insect to

destroy its own kind or self-destruction of the species. The great advantage of using genetic control is that genetic trait existing in a population can be fully utilized for self-control.

e. Host resistance method:

Sometimes plants can be selected to resist specific pest problems. Many plants actually repel various pests, and some contain toxic substance.

f. Chemical Control

Chemical controls are pesticides that are either naturally derived or synthesized. Pesticides often play key role in pest management program. Major benefit associated with the use of pesticides are their effectiveness, the speed and ease of controlling pests, and in many cases, their low cost compare with other methods.

6.4 Host plant resistance and botanical methods of pest management

Host Plant Resistance

Host Plant Resistance (HPR) is a heritable characters possessed by the plant to avoid, tolerate and/or withstand pest infestation without subsequent loss in yield compared to a susceptible host at the same initial level of infestation under similar environment condition.

History

- "Underhill'' variety of wheat reported resistant to Hessian fly in USA, 1782.
- "Wintermajetin" variety of apple reported resistant to woolly apple in USA, 1831.
- During the last 20 years alone, more than 500 insect resistant cultivars of rice, maize, cotton, sorghum, alfalfa & wheat have been developed & released worldwide.

Advantages of HPR

- Easy to adopt- genetically incorporated seed alone to insect control.
- Economic return is high in the long run.

- The effects of the resistance are cumulative overtime both within & growing season. Thus, HPR is confounded every year.
- Harmony with environment & other pest control measures.
- Improve the search efficiency of predators & parasites &reduce the rate of insecticide application.
- Prevent the spread of plant diseases vectored by insects.
- Sale to man, animals and the environment.
- HPR is specific to the pest & non-target species are not disturbed.

Disadvantages

- Takes longer time to develop plants resistant to insects i.e. 3-5 years for a pest or 10-15 years for a complex of several insects.
- Different resistant cultivars may be required for different geographic regions. This may be an expensive & time consuming process.
- Development of biotype is a serious threat which breaks the resistance of crop genotypes.
- Conflicting traits- development of resistant plant for one species may favor another species.

Botanicals methods of pest management

Neem, *Azadirachta indica*	Marigold, *Tagetes spp* (Sayepatri)
China berry, *Melia azedarach* (Bakaino)	Century plant, *Agave Americana* (Ketuki)
Sweet flag, *Acorus calamus* (Bojo)	Prickly ash, *Zanthoxy lumarmatum* (Timur)
Malabar nut tree *Justicia adhatoda* (Asuro)	Black pepper, *Piper nigrum* (Marich)
	Spearmint, *Menthaspicata* (Barbari)
Mug-wort, *Artimesia vul garis* (Titepati)	Holy basil, *Ocimum sanctum* (Tulsi)
Stinging nettle, *Urtica dioica* (Sisno)	Turmeric, *Curcuma longa* (Haledo/Besar)
Tobacco, *Nicotiana tabacum* (Surti)	Lemongrass, *Cymbopogon citrates* (Kagatighass)
Pyrethrum, *Chrysanthemum cinerariaefolium* (Godawari)	Ash (Kharani)

Botanicals product : Neem based pesticides: Margosom or Neemarin or Biomultineem (Azadirachtin 0.03%)

Pests	Botanicals
Aphids	Spray Neem fruits extract of 50g fruit dust over night soaked in 1 litre water or Chinaberry fruits extract of 1 kc of chinaberry fruits dust 24 hours soaked in 10 litre water.(Joshi, 1994)
Paddy leaf & plant hopper	Spray neem oil emulsion 3% (@3ml/litre water + 0.5 ml Beepol)
Grain weevils (rice, wheat, maize)	Amix sweet flag stolen powder @10 g powder per kg grains or Turmeric powder @20 g/kg of grains or Timur grains @ 10 g/kg
Pulse beetles	Admix basil leaf powder @5g/kg of grains or rice husk ash @5 g/kg of grains
Fruit flies (mango, citrus, melons,guava, jackfruits)	Use extracts of neem fruits to repel female. And tobacco extracts & ginger extract to kill fruit flies. Use a cotton pad treated with 0.25 ml of Tulsi leaves extract in ethyl acetate for luring & trapping the fruit flies.

6.5 Organic pest management method or practice

Pest and disease management consists of a range of activities that support each other. Most management practices or methods are long-term activities that aim at preventing pests and diseases from affecting crop. Management focuses on keeping existing pest populations and diseases low. The general approach in organic agriculture to deal with the causes of a problem rather than treating the symptoms also applies for pest and diseases. Therefore, management is of a much higher priority than control.

The basic organic pest and disease management are :

- Maintain a healthy soil
- Use suitable varieties
- Maintain a healthy crop
- Use of natural pesticides
- Promote natural predators
- Monitor the crop regularly

I. Prevention practices & monitoring

a. Selection of adapted and resistant varieties
b. Selection of clean seed and planting materials
c. Use of suitable cropping system
d. Use of balanced nutrient management
e. Input of organic matter
f. Application of suitable soil cultivation methods
g. Use of good water management
h. Conservation and promotion of natural enemies
i. Selection of optimum planting time and spacing
j. Use of proper sanitation measures (Hand weeding, Plastic mulching, Mowing)

Monitoring

- Typical signs of pest attacks on crop plants
- Typical signs of disease attacks on crop plants

Inducing plant resistance:

- Use of plant extract (Hedera helix, Rheum rhabarbarum, Reynoutria-sachalinensis)
- Use of compost extract (Compost: Water:: 1:5 to 1:8 i.e one liter of compost for every 5 to 8 liter of water)

II. Curative Methods

a. Promoting and managing natural enemies: For host plants providing food or shelter for NE's (Hedges, Beetle banks, Flower strips, Companion plants)

b. Mechanical control: Light traps, Colour & water trap, Yellow sticky trap, Fruit bagging,)

c. Biological control: Releasing NE's (Bacteria, Viruses, Fungi, Entomopathogenic nematodes)

d. Natural pesticides: Plant extracts (Rotenone, Nicotine, Pyrethrinsetc)

Other Natural Pesticides	Against
Soft soap solutions	Aphids / Sucking Insects
Light Mineral oil	Various insect pests
Sulphur	Spider mites,, Powdery mildew, Downy mildew (prevents spore germination);S + Lime
Plant ashes	Ants, Leaf miner, Stem borer, termites, potato moths, Storage weevils, soil borne diseases
Bordeaux Mixture (Fungicidal+Bactericidal)	Leaf spots, Powdery mildew, Downy mildew, anthracnose pathogens
Acidic clays (Fungicidal effect due to aluminium oxide or sulphate)	Powdery Mildew, Downy Mildew
Milk (1 litre of milk to 10-15 litres of water)	Blights, Mildew, Mosaic viruses and fungal, viral diseases
Baking Soda (100gm baking soda + 50 gm soft soap + 2 litre of water)	Mildew and Rust diseases

e. Others: Sulphur, Bordeaux mixture, Acidic clays, Milk, Baking soda etc.

6.6 Biotechnological method of pest management

In context of IPM, molecular technology/biotechnology aims at developing new control methods. **Biotechnology** is defined as the application of scientific & engineering principles to the processing of materials by biological agents to provide goods & services. A recent off-shoot of biotechnology is **genetic engineering** which involves Gene splicing, recombinant DNA cloning & tissue culture technology.

Transgenics plants are genetically modified (GM). The following are some of the practical methods or applications of biotechnology in pest management:

1. Monoclonal antibodies are used in testing seeds, planting materials, cuttings and grafting for the presence of viruses & bacteria.
2. Development of new varieties of field crops is an important component of biotechnology supplementing conventional breeding for desired traits

including resistance to insects pests & diseases, drastically reducing the time for breeding a new variety

3. Tissue Culture has been used for developing insect resistance in two ways i.e. screening insect resistance at cellular level & creation of somaclonal variability for insect resistance.
4. In vitro regeneration makes use of the fact that each plant cell contains all the genetic information needed to regenerate a complete plant. Meristemictissue that has no virus used in tissue or in vitro cultures to produce virus-free plants. The technique is also used for producing transgenic plants.
5. Herbicides- resistant plants are those in which resistance has been incorporateted through gene transfer using a bacterium that is resistant to herbicide. Usually, the bacterium ***Agrobacterium tumefaciens is used for transferring the resistance gene.***
6. Transgenic plants resistant to virus infection are obtained by incorporating into plants the "coat protein-gene" of six economically important viruses, such as tobacco mosaic virus & potato X potexvirus. Several transgenic plants (tobacco, potato & tomato) with built-in protection against virus infection have been developed.
7. Transgenic plants possessing insect resistance can be obtained by transferring a natural "*insecticide-gene",* originating from Bacillus thuringiensis, into plants. Transgenic plants produce a protein (toxin) that, when ingested by a feeding caterpillar, will kill it.
8. Insect-pathogenic symbionts of plants. If a gene governing the production of insect toxins is introduced into the soilborne bacterium Pseudomonas, which lives in close association with plant roots (rhizosphere), the plant itself is influenced by the transgenic bacterium & becomes repulsive to soil-living insects that normally feed on its roots.
9. Investigating the molecular biology of key genes controlling insect development & reproduction
10. Studying *gene-to-gene relationships by host-pathogen interactions.*

6.7 Hormones, Pheromones, Sterile insect technique methods

Hormones : Insect hormones are internal secretions that regulate a wide range of physiological processes including growth, development & maturation. Insect are known to produce different hormones by hair endocrine organs such as neurosecretory cells, corpora cardiac, corporaallata&protheracis glands.

Pheromones: A pheromones is a chemical or a mixture of chemicals released by an organism in the environment that causes specific reaction in a receiving organism of the same species.

The main pheromones are

- **Sex Pheromones:** They are pheromones released by an organism to attract an individual of the opposite sex, encourage them to mate with them. It is specifically focus on indicating females for breeding, attracting the opposite sex, & conveying information on their species.
- **Alarm Pheromones:** It is a pheromone which warns member of same species about the presence of enemies (predators) & elicit changes in behavior in different insect species. In aphid, pair of cornicles secretes alarm pheromones called as *Tarpenes.*
- **Trail Pheromones:** The trail pheromones functions through the medium of air, followers perceive by their antennae to reach the destination for mating or to utilize food source. *Hexanoic, heptanoic, decanoic, nonanic acids* in some ants.
- **Aggregation Pheromones:** These pheromones include aggregation of insects for their protection, reproducing & feeding. After mating or continued feeding for some time pheromone production stops to prevent over crowing. *Frontalin* in barl beetle.

Sterile insect technique method:

The sterile insect technique is a method of biological control, where numbers of sterile insects are released. The released insects are normally male as it is the female that causes the damage, usually by laying eggs in the crop or in case of mosquito. The sterile males compete with the wild males for female insects. If a

female mates with a sterile male then it will have no offspring, thus reducing the next generation population. Repeated release of insects can diminish small populations, though it could be impossible to eradicate it and is not efficient against dense insect populations. Insects are mostly sterilized with radiation.

This technique has successfully been used to eradicate the Screw-worm fly (*Cochliomyia hominivorax*) in areas of North America. There have been many successes in controlling species of fruit flies, most particularly the Medfly (*Ceratitis capitata*) and the Mexican fruit fly (*Anastrephaludens*)

Summary: *This sterile insect technique method comes under the genetic control which involves "mass production sterilization & release of pest population that will mix & male with wild population in the field leading to a reduction in fertility & under certain circumstances to population eradication.*

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. Define IPM.
2. What is host plant resistance?
3. List out two beneficial insect pests.

2. Short (Answer question)

1. Write down the principle of IPM.
2. List out two predators, parasites and pathogens.
3. Make a list of different pest control methods and describe any two of them.
4. Briefly describe about mechanism of resistance for controlling insect pest.
5. List out biological control agent with examples of each.
6. Describe the sterile insect technique method.

3. Long (Answer question)

1. Describe the mechanical pest control method.
2. Describe the cultural pest control method.

UNIT 7

Safety and Pollution Issues

A. Objective

- To impart the knowledge of Safety and pollution issues

B. Content elaboration

7.1. Safe use of pesticides

Pesticides are toxic to both pests and humans. However, they need not be hazardous to humans and non-target animal species if suitable precautions are taken. Most pesticides will cause adverse effects if intentionally or accidentally ingested or if they are in contact with the skin for a long time. Pesticide particles may be inhaled with the air while they are being sprayed. An additional risk is the contamination of drinking-water, food or soil.

Special precautions must be taken during transport, storage and handling. Spray equipment should be regularly cleaned and maintained to prevent leaks. People who work with pesticides should receive proper training in their safe use.

Some safety Measures

1. The label of the pesticide should be in English and in the local language, and should indicate the contents, safety instructions (warnings) and possible measures in the event of swallowing or contamination.
2. Store pesticides in a place that can be locked and is not accessible to unauthorized people or children.
3. Do not carry them in a vehicle that is also used to transport food.
4. Left-over pesticide suspension can be disposed of safely by pouring it into a specially dug hole in the ground or a pit latrine
5. Do not eat, drink or smoke while using pesticide
6. Do not stir liquids or scoop pesticide with bare hands. Use the pressure-release valve of the pump or a soft probe to clear blockages in the nozzle
7. Spray workers should wear protective clothings viz., hand gloves, face

masks, cap, apron, full trouser, etc. to cover whole body.

8. The discharge from the sprayer should be directed away from the body. Leaking equipment should be repaired and the skin should be washed after any accidental contamination.
9. On observing poisoning symptoms give the first aid and show the patient to doctor. Also show the empty container to doctor.

7.2. Pesticide Rules and Regulation in Nepal

Nepal passed the first Pesticide Act in 1991. The purpose of legislation on the formulation, importation and use of pesticides is to enable the society to obtain the benefits from their use with minimal adverse effects to humans and other non-target organisms.

The Pesticide Rules were approved in January 1993. The Act and the rules were gathered to become operative on 16 July 1994. The Act regulates the import, manufacture, sales, distribution and use of pesticides within the country with a view to prevent risks of human beings, animals and foe matters connected herewith. The Act established a Pesticide Registration and Management Division. It also established a Pesticide Committee which composed of members from various ministries, the Pesticide Association of Nepal, scientists and consumer groups for the purpose of discussing pesticide related issues and define its functions, duties and powers.

7.3. Prevention of pollution Caused by Chemical Pesticides 62

- Do not use pesticide without valid need in the field.
- Use only those pesticides which are safer to environment have those having short residual effect in the environment.
- Use of IPM approaches to control pest population.
- Do not use excess dose of pesticide.
- Do not dispose pesticide directly to water source. It should be disposed in specific dug hole away from human settlement.
- The leftover pesticides should not be disposed in soil and water sources. Cleaning of equipment used in spraying should be done carefully.

- Only using pesticides that are labeled or identified for the intended crop and pest
- Considering application site characteristics (soil texture, slope, O.M.)
- Considering the location of wells, ponds and other water bodies. Measuring accurately
- Storing pesticides safely and securely
- Education: Campaigns to train farmers, distributors, and the public (including school children) in the safe handling, use, and storage of pesticides.

7.4. Plant diseases management through cultural and chemical methods

Plant disease management through Cultural Methods

Stevans (1960) had discovered the cultural methods of disease control. According to him, these measures involve agricultural cropping, harvesting and storage, tillage, crop rotation, soil management, growing of resistant varieties, planning of land use, and other related practices.

a. Avoidance of pathogens

- Disease can be prevented by a proper selection of the land or field, choice of time of sowing, selection of varieties, seed and plant stock and by modification of cultural practices.
- The aim of these measures is to enable the host to avoid contact with the pathogen or to ensure that the susceptible stage of the plant and favorable conditions for the pathogen not coincides.

b. Proper selection of geographical area

- Many fungal & bacterial diseases are more severe in wet areas than in dry areas, crop which are susceptible to these diseases, if grown in wet areas are likely to be affected by plant pathogens.
- Eg. Smut disease of bajra caused by *Tolyposporium pencillariae*

c. Selection of field

- The selection of suitable area or field for cultivation is very important from the point of view of better yields, as well as protection of the crop from the ravages in the case of many soil borne pathogens.

Hence it is advisable not to grow in the same field, where there is high incidence of disease appearing, due to build-up of inoculum potential.

- The drainage conditions of the field are also important, low lying, water logged fields favor such diseases as red rot of sugarcane and downy mildews of bajra. In case of fruit orchards the selection of suitable site is very important.

d. Choice of time of sowing

- Pathogens are able to infect susceptible plants only under certain environmental conditions. Eg. *Rhizoctina*root rot of gram is severe if gram is sown immediately after the rains, due to the pathogen develops rapidly under high temperate and moisture conditions.

e. Disease escaping varieties

- Certain varieties escape the onslaught of the pathogen and resist the attack due to their inherent characteristics. Eg. Maturing varieties of wheat or pea escape damage due to *Pucciniagraminis Tritici* & *Esiphepolygoni* respectively.

f. Selection of seed and planting stock

- Since many plants propagate by vegetative parts, the selection of diseases free planting material forms a very important control measures. The planting of disease-free fields is often an important control measures for certain diseases such as red rot of sugarcane & black scruf of potato etc.

Plant disease management through Chemical Methods

Aim of using chemicals in disease control

- Create a toxic barrier between host surface or tissue and the pathogen
- Eradicate the pathogen present at particular site of the host

Chemical used to kill the pathogens or inhibits their growth are known as fungicides, bactericides, nematicides (killing fungus, bacteria, nematode respectively). There are three major classes of chemical treatments:

1. Soil Treatments

2. Seed Treatments
3. Foliar Treatments

Cereal Crops

Wheat

Name of Diseases	Chemical Management
Black Stem Rust, Leaf/Brown/ Orange Rust, Yellow/Stripe Rust	Seed treatment with Plantvax protect till 7 weeks and then 2 spray with carboxin 1%
Kernel Bunt of wheat	Seed treatment with Bentate 3% or Vitavax 3% or Ceresan 2% ml/kg seed
Ear-cookle of wheat	Seed loatation in salt brine (14.5 kg/450 litre) to separate galls
Powdery mildew	Foliar Spray with 1% sodium thiosulphate solution, Spray with 1%Benlate, 1% Karethane

Rice

Name of Diseases	Chemical Management
Blast	Field sanitation and destruction of collateral hosts foliar spray with Blasticidin at 20 ppm
Blight	Seed soaking for 8 hours in Agrimycin (0.025%) and wettable Ceresin (0.05%) followed by hot water treatment for 30 min at 52-54 C
Brown Spot	Seed treatment with Agrosan or Ceresan 2.5 g/kg seed to ward off seedling blight stage
Foot Rot / Bakane Disease	Seed treatment with organomercurials; Agrosan GN, Caresan @ 2 g a.i./kg seed is highly effective

Vegetables

Tomato

Name of Disease	Chemical Management
Leaf Curl (transmitted by whitefly)	Grow nursery under net & apply Carbofuran in the nursery @ 1kg/ha at the time of transplanting
Tomato Mosaic (transmitted by contact & seed)	Treat seed in Trisodium phosphate solution followed by sodium hypochlorite for 95 and 30 minutes respectively.

Cucumber/Cucurbits

Name of Diseases	Chemical Management
Mosaic (transmitted by aphids, Seed)	Spray Dimethoate (0.05%) at weekly interval
Green Mottle Mosaic (transmitted by seeds)	*Soil Fumigation* with methyl bromide helps reduce virus spread through soil.

Cabbage, Cauliflower, Knol-Khol

Name of Diseases	Chemical Management
Damping-off	Drench the nursery beds with a mixture of Mancozeb (0.25%) and Carbendazin (0.05%) on the appearance of damping-off symptoms.
Black rot	Spray of Streptocycline (10g/100 litres of water) at curd-formation stage.
Downy mildew	Spray Mancozeb (0.2 %) at 10-15 days intervals, given after the appearance of symptoms.
Curd rot	Give a protective spray of Mancozeb (0.25%) and Strepto cycline (0.1%) to curds particularly before the likelihood of frost.

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. List two ways to prevent from Pesticide Pollution.

2. Short (Answer question)

1. What are precautions to be taken during and after the use of chemical pesticide?

3. Long (Answer question)

1. Explain the plant disease management through cultural methods.

UNIT 8

Bio-pesticides, organic pesticides and efficiency

A. Objective

- To impart the knowledge of bio-pesticides, organic pesticides and efficiency**.**

B. Content Elaboration

8.1. Preparation and application methods of bio-pesticides, and organic pesticides

Biopesticide is a formulation made from naturally occurring substances that controls pests by non-toxic mechanisms and in ecofriendly manner. They may be derived from animals (e.g. nematodes), plants (Chrysanthemum, Azadirachta, Tobacco) and micro-organisms (e.g. Bacillus thuringiensis, Trichoderma, Nucleopolyhedrosis virus), and include living organisms (natural enemies) etc.

The commercially available plant derived bio-pesticides in Nepalese market are MagroSom, Derusom, Ramban.

Types of Bio-pesticides

- Microbial pesticides
- Plant-incorporated-protectants (PIPs)
- Biochemical pesticides (Pheromone trap)
- Botanical pesticides (Neem oil, Rotenone, Tobacco suspension)
- Biotic agents (parasitoids and predators)

Botanicals Pesticides

a. Preparation of Neem or Margosa Leaf extract

Crush 1-2 kg of neem leaves in a motar-pestle gently. Place this paste in a pot, and add 2-4 litres of water. Cover the mouth of the pot with cotton cloth and leave it for 3 days. Filter to get the clean extract and then dilute with 10 litres of water. Add 10 gm of soap to one liter of this solution and stir well. Spray on to the infested plants. Neem is a well known insecticide, and also acts as a repellent,

anti-feedent and anti-viral and has anti-nematicidal properties.

b. Neem Seed Powder Extract

The neem powder obtained by crushing 400 gm of seeds is dissolved in 2 litres of water and stirred well. Then allow the solution to soak for about 12 hrs. The resulting solution is filtered through a thin cotton cloth, and diluted with water to bring the solution to 10:1. Add 20 ml of soap solution (20gm) before application to the crop. It will facilitate uniform spread of the neem solution. The solution is suitable for the control of pest and fungus attacks.

c. Preparation of Onion Bulb Extract

1 kg chopped onion bulbs are boiled in a container in 1 liter of water and kept it for 24 hrs. Then dilute the filterate with 10 litre of water and spray on infested plants. This is also effective against pests, and diseases.

d. Preparation of Chilli extract

Fifty chilly pods are crushed and boil with 500 ml of water. Dilute in 2 litres of water to the content and filter. Add a suitable emulsifier. The solution is ready for application.

e. Chilli, Garlic and Onion Extract

One teaspoon full of chilli powder, 1 garlic bulb and 2-3 red onions are chopped to make a paste. Mix ingredients with 1 liter of water, and filter and add the emulsifier to the filterate and stir the solution. The mixture is now ready to apply. This solution is effective against insect pests.

8.2. Preparation and application methods of botanical pesticides:- "including Geeti mal" Geeti mal

- Geetimal / Liquid Manure is a foliar spray prepared by collecting the locally available plant resources having bio-pesticide value to minimize the insect pest infestation.
- The plants with titto, taro, piro (bitter, astringent, hot) are used for making Geeti mal.
- In the present context Geetimal is very useful to those areas which are far

from access to chemical fertilizers and chemical pesticides.

- More over the chemical pesticides have havoc side effects on human health, ecosystem, environment and the fertility of the soil that is why Geeti mal should be given more priority.

Materials Required :

(1) Neem (2) Bakino (3) Tithopaati (4) Bann Mara

(5) Lasun/Garlic (6) Chillies/hot pepper (7) Aasuro (8) Khirro

(9) Pyaj/Onion (10) Tulsi/Basil (11) Bojho/Calamusacorus

(12) Lemon grass (13) Mewa ko paat/leaf of papaya

(14) Sayapatri ko paat/marigold leaf

(15) Laliguras ko paat/leaf of rhododendron (16) Aaru ko paat/leaf of peach

(17) Urti ko paat/tobacco leaf (18) Simali (19) Dhaturo

(20) Pirajhar (21) Jaiful/jasmine (22) Ghortafra

(23) Sisnu/stinging nettle (24) Ketuka/Agave

(25) Sajiwan/Jatropa (26) Timur leaf or grains

(27) Aangari (28) Gai/Bhaishi ko gobbar/Cow dung

(29) Gai/ Bhaishi ko Gahut /Cow urine (30) Kharani/Ash

(31) Plastic Drum

Method of preparation Geetimal

- Chop up all the collected materials to 2-3 inches long.
- Now start filling those chopped materials in that drum until half filled.
- Now pack the cow dung and ash in jute sack or in appropriate clothes and put in the middle of that drum.
- Continue filling the remaining materials until 70% of that drum is covered.
- Now add cow urine until it covers all the added materials, if cow urine is not available water also can be added.
- Now store that in warm place and stir once a week.

- It will be ready for use after 3 weeks at warm season (or in terai region) or after 4 weeks in cool season.

Application method of Geeti mal

- For small seedlings / saplings.- Mix 1 part of geetimal with 10 parts of water and spray gently on both sides of leaves.
- For other plants 1 part of geetimal can be mixed with 5 parts of water and can be sprayed like above.
- It would be effective if sprayed once a week.

Efficiency of biological and botanical pesticides including "Geeti mal"

- Efficiency of botanical pesticides dependent upon various factors such as temperature, RH, types of plant, time of application, dose of pesticides, time interval etc.
- Weekly interval of pesticide application is effective.
- Both side of leave is sprayed by pesticides.
- Morning or evening time is best for application.

Efficiency or Efficacy of bio-pesticides & botanical pesticides including "Geeti mal" for the management of Cabbage Aphids, *Brevicorynebrassicae (NARC 2012)*

The pesticides are as follows

- Ramban is a biopesticide of Pongamiapinnata plant origin
- Margosom is a biopesticide of Azadirachtaindica plant origin
- Jeebatu, a Nepalese product, is a mixture of beneficial microorganisms being sold in the Nepalese market as biopesticide.
- Agri-Servo is mineral oil being sold in Nepalese market as a safe product.
- Geeti-Mal is a cocktail mixture locally produced by fermenting locally available succulent plant twigs, stems and leaves with cattle urine.

Efficiency of the following pesticides

Treatment of Pesticides	Number of aphids per plant
Ramban @ 1 ml / liters water	High : 401-800 aphids/plant (moderately

	efficient)
Margosom @ 5 ml / liters water	Very high : > 800 aphids/plant (less efficient)
Jeebatu @ 50 ml / liters water	Very high : > 800 aphids/plant (less efficient)
Agri-Servo @ 10 ml / liters water	Medium : 201-400 aphids/plant (more efficient)
Geeti-Mal @ 1:1 ratio with water	Very high : > 800 aphids/plant (less efficient)

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. Define bio-pesticide.
2. Define geeti mal.

2. Short (Answer question)

1. Write down the three names of bio-pesticide and organic pesticides.
2. Discuss the biological and botanical pesticides including geeti mal.

3. Long (Answer question)

1. Discuss the preparation and application methods of botanical pesticides.
2. Write the procedure for the preparation of geeti mal.

UNIT 9
IPM Farmer's Field Schools

A. Objective

- To impart the knowledge of IPM Farmer's Field Schools**.**

B. Content elaboration

9.1. Step and processes of IPM FFS

Four Major Principles of IPM FFS:

1. Grow a healthy crop
   - Resistant varieties, proper fertilizers, water and soil management etc.
   - Healthy crop can resist diseases and compensate for damage
2. Observe fields regularly
   - To assess crop development, disease, insect pest population and natural enemies
3. Conserve natural enemies of crop pests
   - Abundance of natural enemies in the field
   - Avoid the use of pesticides that kill natural enemies
4. Farmers understand ecology and become experts in their own field
   - Make decisions based on observations and analysis of the field situation

Step in conducting FFS (Classical Approach)

- Conduct ground working activities
- Training of Facilitators
- Regular FFS meeting
- Evaluate PTDs
- Field Days
- Graduations
- Farmer run FFS
- Follow up by facilitators

Processes of IPM FFS

1. Agro-ecosystem Analysis (AESA)
    a. Field visit / Field Observations
        - Go to the field in subgroups (5 farmers per subgroup)
        - Choose 10 plants randomly
        - Observe plant, pests, natural enemies, diseases, weeds, weather etc
    b. Drawing
        - Each subgroup presents their observations and analysis in drawing
        - Plant, Weather, Disease symptom, Pests, Natural enemies, Water level
    c. Presentation and Discussion
        - Each subgroup presents their analysis
        - Group Discussion
        - Decision about pest control measure is made
        - Facilitator will facilitate the discussion
2. Supporting IPM Field Studies
    a. IPM validation trials
        - IPM Practices Vs Farmer Practices
        - Conducted on 100 m2 plot, each 500 m2
    b. Crop Compensation
        - To demonstrate that crop plants can compensate for some damage by producing new leaves or shoots
    c. Field cages
        - To demonstrate how natural enemies keep pest population under control
    d. Plastic bagging
        - To demonstrate how enclosing cacao pod with the plastic bag can prevent attack from pod borer

e. Side-grafting
   - Farmers learn how to make a side-grafting on cacao

f. Use of insect traps
   - Farmers learn how to monitor insect population using traps
   - Insect zoo
   - To study life cycle of insects
   - To study feeding behavior of insects
   - To study predator and parasitoids

3. Group Dynamics
   - A variety of team building games and exercise employed during the training
   - To foster togetherness within the group
   - To sharpen farmer communication and organizing skills

2. Ballot Box
   - FFS starts with a ballot-box pretest of knowledge and ends with a posttest
   - A simple tool to measure the level of a farmer's knowledge on an agroe-cosystem
   - Question focus on:
     - Recognition of pests, natural enemies, diseases
     - Recognition of damage from pests and diseases
     - Management of pests and diseases etc

4. Field Day
   - At the end of FFS season
   - To show the results of FFS to other farmers, agricultural staff, local government officials
     - IPM plot Vs Farmer Practice plot
     - Other field experiments
     - Insect zoo (pests and natural enemies)

9.2. Role of farmer's groups in sustainability of FFS

Sustainability: Capacity remains at the local level so that farmers are able to run farmer field schools themselves. Some role of farmer's groups in sustainability of FFS are as follows.

- Learning is more because in group they work by the principle of "doing is better than hearing or seeing" which creates faith in the farmer and good method of non formal education.
- Farmers should be experts which is best role of farmers groups in sustainability of FFS.
- Can make decision quick
- Production is high which consequently help to increase income of farmer as well as sustainability of nation.
- Group profile of member
- Clear objectives, goals of the group, mission, vision etc shows sustainability.
- Good management and discipline
- Responsible facilitators
- Equal rights and mutual understanding
- Ability to mobilize local resources
- Group cost sharing
- Linkage with other project
- Good documentation
- Dynamic trend

Farmers are the source of knowledge; Farmers adopt technologies based on their context—involve farmers in a more participatory way. Farmers decide the pace of implementation and what should be done. The school stresses the importance of using local resources to reduce dependency on external resources.

C. Learning process and support materials

The learning process includes the participation of student group work, presentation and skill development, written methods etc.

D. Assessment

1. Very short (Answer question)

1. Define IPM FFS.

2. Short (Answer question)

1. State the basic principle of farmer field school.
2. State the steps of conducting FFS.

3. Long (Answer question)

1. Write down Step and processes of conducting IPM FFS.
2. What might be the role of farmer's groups in sustainability of FFS.

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