Vocational Higher Secondary Education (VHSE)

Second Year

AGRICULTURE CROP HEALTH MANAGEMENT

Reference Book - Teachers' Version

Government of Kerala
Department of Education

State Council of Educational Research and Training (SCERT),
KERALA
2016

Foreword

Dear Teachers

This reference book **(Teachers' Version)** is intended to serve as a transactional aid to facilitate classroom transaction and as a ready reference for teachers of Vocational Higher Secondary Schools. It offers some guidelines for the transaction of the course content and for undertaking the practical work listed in the course content. As the curriculum is activity based, process oriented and rooted in constructivism focusing on the realisation of learning outcomes, it demands higher level proficiency and dedication on the part of teachers for effective transaction.

In the context of the Right- based approach, quality education has to be ensured for all learners. The learner community of Vocational Higher Secondary Education in Kerala should be empowered by providing them with the best education that strengthens their competences to become innovative entrepreneurs who contribute to the knowledge society. The change of course names, modular approach adopted for the organisation of course content, work-based pedagogy and the outcome focused assessment approach paved the way for achieving the vision of Vocational Higher Secondary Education in Kerala. The revised curriculum helps to equip the learners with multiple skills matching technological advancements and to produce skilled workforce for meeting the demands of the emerging industries and service sectors with national and global orientation. The revised curriculum attempts to enhance knowledge, skills and attitudes by giving higher priority and space for the learners to make discussions in small groups, and activities requiring hands-on experience.

The SCERT appreciates the hard work and sincere co-operation of the contributors of this book that includes subject experts, industrialists and the teachers of Vocational Higher Secondary Schools. The development of the teachers' version of reference books has been a joint venture of the State Council of Educational Research and Training (SCERT) and the Directorate of Vocational Higher Secondary Education.

The SCERT welcomes constructive criticism and creative suggestions for the improvement of the book.

With regards,

Dr. J. Prasad
Director
SCERT, Kerala

Contents

ABOUT THE COURSE

Agriculture is the cultivation of plants, fungi and other life forms for food, fibre, biofuel, medicinal and other products used to sustain and enhance human life. Modern agronomy, plant breeding, agro chemicals such as pesticides and fertilizers, and technological improvements have sharply increased yields from cultivation, but at the same time have caused widespread ecological damage and negative human health effects. A major problem faced by the farmers of kerala is the attack by various pest and diseases in all cultivated crops. It is a known fact that the incidents of pest and diseases varies with weather, soil and ecology – and a clear understanding of this variation is inevitable. One of the main reasons for low productivity of crops is the increased incidence of pest and diseases. There is no sufficient mechanism to monitor the incidence of pest and diseases in agro ecological units of the state. Considering the importance of the crop health management Govt. of Kerala has launched major schemes for crop health management in 2013 -14 onwards – (Vide Order No.GO(RT) No.1659/13/AD/NCA dated 19/09/2013 and Govt. of Kerala, Directorate of Agriculture, Circular No. TD(1)42860/13 dated 05/10/2013. The course of study focuses on sound crop health management strategies.

The nation has an acute shortage of such trained personals to cater to the demands of crop production technology and disease management. This vocational course aims at meeting this situation by generating skilled human resources for the total remedies for agri - crop health management. The course is designed in such a way to train students and to have a direct link with farmers at grass root level and give them proper guidance. The course develops the students in to independent crop health consultants at village level or any agri research organization to meet the supervisory level crop health management requirements. As village level consultants, the students with wide subject acquaintance can be resource to farmers in identifying the problem, giving them timely and proper advice and help them in pest control. With the acquired knowledge they can suggest the farmers pick up proper health control methods and modes of application thereby contributing to effective check measures.

OBJECTIVES OF THE COURSE

1. Creating awareness on environmental hazards due to indiscriminate use of pesticides
2. Use of pest and diseases diagnostic tool kit
3. To learn how to pest and disease surveillance system
4. To understand how and where to implement the surveillance system
5. Integrated pest and disease management
6. Awareness of production techniques of various biocontrol agents
7. Mass production of biocontrol agents and management of biocontrol labs
8. Development of new biopesticides
9. Quality control measures of organic and biopesticides
10. Skill development in field level application of safer / new generation pesticides
11. Management of crop health clinic at Panchayat or Village levels
12. Associate with KVKs for supporting surveillance and clinics

Job roles /Career Path

Government / Semi Government	Private Sector	Self Employment
1. Assistant Agricultural Officer 2. Agri Extension Assistant 3. Ware house Keeper 4. Floriculturist (open and protected cultivation) 5. Laboratory Technical Assistant in VHSE 6. Vocational Instructor in VHSE 7. Work superintendent (Dept. of Agriculture) 8. All other posts where basic qualification require is plus two 9. Field or Farm technician (IISR) 10. Field Assistant and Farm supervisor (Farming corporation) 11. Farm Technical Assistant (Plantation corporation Limited) 12. Field Assistant (LEADS) 13. Field Assistant (CTCRI) 14. Field Assistant (FSRS) 15. Field Assistant (VFPCK) 16. Field Assistant (KAU) 17. Technical Assistant (KVK)	1. Field Representative (Fertiliser and Pesticide companies) 2. Self help group coordinator 3. Assistants in Agriculture based media programmes 4. Gardeners / Farm supervisors 5. Technical Assistants in Biocontrol labs 6. Assistants in crop health clinics 7. Pest control supervisor 8. Pest control technician 9. Rice Grower 10. Mango Grower 11. Tuber crop farmer 12. Agri Extension service provider 13. Harvesting machine operator 14. Supply chain field assistant 15. Banana farmer 16. Irrigation/Micro irrigation technician 17. Waste management technician	<u>Production sector</u> 1. Vermicomposting 2. Coir pith composting 3. Azolla cultivation 4. Organic manure production 5. Bio fertilizer production 6. Mass production of biocontrol agents 7. Seed production and processing unit 8. Hiring of agricultural implements 9. Repair of agricultural implements 10. Preparation of botanical pesticides 11. Apiculture 12. Protected cultivation <u>Service sector</u> 1. Training on above sectors 2. Agro-clinics 3. Agricultural consultancy 4. Irrigation services

MAJOR SKILLS (WITH SUB SKILLS)

MODULE3
MAJOR SKILLS

1. Identificaton of pests and their nature of damage
2. Ability to differentiate between damage caused by pathogens and insects
3. Diagnosis and management of pest and disease of major crops of Kerala
4. Preparation and field application of commonly used botanicals
5. Field level application of biofertilizers and biocontrol agents
6. Operation of PP equipments

SUBSKILLS

- Diagnosis of bacterial disease using ooze test
- Differentiate between infectious and non- infectious disease
- On farm mass multiplication and application of Trichoderma
- Diagnosis of pest/ disease of vegetables based on symptoms and adopting suitable integrated management practices
- Differentiate between botanicals, biofertilizers and biocontrol agents
- Preparation and installation of low cost traps

MODULE 4
MAJOR SKILLS

1. Crop health management in Protected Cultivation
2. Judicious selection and application of pesticides for pest management
3. Skill in simple pesticide residue elimination methods
4. Handling agri-related extension softwares

SUBSKILLS

- Differentiate between protected cultivation structures
- Identifies the different components of drip irrigation system
- Identify the types of fertilizers used for fertigation
- Demonstrate the ecofriendly management of common pest and diseases in protected cultivation
- Distinguishes between different types of pesticides
- Calculates correct quantity of pesticides for field level application

LEARNING OUTCOMES OF THE COURSE

After completing the course , the learner

1. identifies the different branches of agriculture and explains the milestones and importance of it.

2.explains the different agrifield techniques like tillage, irrigation, propagation, crop pest management etc.

3. describes and practices the production technology of important crops of Kerala.

4. identifies and diagnoses the causes of damage in plants.

5. manages pests of important crops cultivated in Kerala in an ecofriendly manner (IPDM).

6. classifies the different types of pesticides and quantifies their dosage.

7.practices the field application of pesticide formulations .

8 realizes the concept of biopharmacy and practices the preparation and field application of biopesticides .

9.practices the operation of plant protection equipments.

10. defines and explains the scopes and benefits of Hitech farming.

11.practices crop health management in protected cultivation.

12.practices the simple methods of pesticide residue elimination.

14. describes the different steps in organic certification.

15. practices the different interactive pest and disease diagnostic softwares

COURSE STRUCTURE

ModuleNo	Module Name	No. of Periods
I	**Agri- Field Techniques**	340
II	**Crop Production Technology**	340
III	**Integrated Pest and Disease Management**	340
IV	**Hi-tech Farming**	340

SYLLABUS

MODULE III INTEGRATED PEST AND DISEASE MANAGEMENT

Unit 1 . PEST AND DISEASE DIAGNOSIS (100Hrs)

Pest - definition – classification- insects and non insects and weeds with examples, categories of pests -based on occurrence - based on level of infestation - based on percentage of crop loss they cause with examples, pest outbreak-definition-reasons,Impact of global warming on pest status,Insect – its specific characteristics – classification into bugs, beetles, flies, moths etc. – types of mouthparts -feeding habit -

metamorphosis -young ones- wing characters and destructive stages, disease definition – classification – biotic(Infectious) and abiotic(non infectious) , biotic factors(pathogen) - fungus- bacteria- virus- phytoplasma-algae with examples, abiotic factors –physiological disturbances- nutrient deficiency-air pollutants- lack of moisture- stress , classification of disease based on pathogen- based on mode of spread with examples , diagnosis of disease – signs and symptoms of plant diseases- Koch's postulates – ooze test , disease epidemiology-disease triangle ,plant disease forecasting and its application ,E-Crop doctor and other related softwares for pest and disease diagnosis.

Unit 2. INTEGRATED PEST AND DISEASE MANAGEMENT OF CROPS OF KERALA (150Hrs)

Integrated Pest Management (IPM)- concept-principles of IPM, Economic Threshold Level (ETL)-Economic Injury Level(EIL) , Methods of IPM- Ecological Engineering – cultural methods – mechanical methods-physical methods-legal methods- biological methods- chemical methods , Plant disease management- Integrated Disease Management(IDM)-concept,Weed management –-cultural- mechanical-chemical-biological- Integrated weed management, Integrated Pest and Disease Management (IPDM)- concept- components, Pest surveillance -objectives , Identification of pests and diseases of important crops of Kerala – symptoms- management(IPDM) – rice- coconut-banana- pepper-solanaceous vegetables-cucurbitaceousvegetables- cowpea- bhindi-amaranthus- cardamom- ginger- mango-rubber- cashew- papaya - tea- coffee-tapioca-ornamentals, pests of stored products -identification-nature of damage- management.

Unit 3. AGRO BIOPHARMACY (50 Hrs)

Agro biopharmacy- definition- concept ,Botanicals –preparation- application-neem oil emulsion- neem oil garlic emulsion- neem seed kernel extract- tobacco decoction- hyptis emulsion -andrographis garlic mixture -papaya leaf extract-birds eye chilli cow's urine extract- peruvalam extract- custard apple seed extract,-baking soda turmeric asafoetida mixture- tulsi extract-leaf extract,preparation of permitted fungicides for organic farming- Bordeaux mixture- Bordeaux paste,Preparation of organic nutrient solutions- panchagavya – dasagavya,fish aminoacid, egg amino acid, Biofertilizers – Familiarization and application- *Rhizobium -Azotobacter -Azospirillum- Acetobacter*–azolla-Phosphate solubilising microorganisms-Arbuscular Mycorrhizal Fungus(AMF) - application techniques, biocontrol agents – fungal and bacterial pathogens-AMF-*Trichoderma-Pseudomonas*- Method of production of *Trichoderma* - media preparation-inoculation- formulation-mass multiplication and field application of *Trichoderma*,Entomopathogens – Fungi,bacteria,virus, common pheromone traps used for insect control - Low cost Pheromone traps for fruitfly management.

Unit 4. PLANT PROTECTION EQUIPMENTS (40 Hrs)

Plant Protection(PP) equipments –parts of a sprayer, types of sprayers- manually operated hydraulic sprayers-hand sprayers,hydraulic knapsack sprayer,rocker sprayer, bucket sprayer,manually operated pneumatic sprayers, pneumatic hand sprayers, pneumatic knapsack sprayers,power sprayers,dusters, other PP equipments-Granule applicator- electrostatic sprayer-Fogging machine-rat traps- site specific spraying,maintenance of PP equipments- field problems and remedies.

MODULE IV HITECH FARMING

Unit 1. PROTECTED CULTIVATION (170 Hrs)

Protected cultivation - definition - benefits – scope , Factors emphasizing the need of Hitech Horticulture in Kerala , Different types of protected structures - classification based on structural material –shape of the structure –use of structure –covering material – type of ventilation –environmental control – cost,Important parts of Green House , crops recommended for cultivation in protected cultivation ,Principles and practices to be followed in protected cultivation , Climate control inside green houses-equipments for measuring climatic parameters in green houses – Automation in climate control , micro irrigation system- components , fertigation – characteristics of fertilizers used for fertigation – Advantages and disadvantages of fertigation ,nutritional disorders , Major Pests and disease of greenhouse crops –management, General integrated management procedures –preventive approaches-sanitation and cultural practices-inspection- scouting and surveillance- trap crops or indicator plants, curative approach -biological control – neem based and homemade botanical pesticides for pest management – entomopathogenic fungi useful in protected cultivation – Chemical management – List of pesticides and other options for management of pest and diseases in polyhouses , Crop protection equipments ,Soil less cultivation- hydroponics - aquaponics -advantages and disadvantages.

Unit 2. PESTICIDES AND PESTICIDE RESIDUE MANAGEMENT (100 Hrs)

Pesticides-classification- classification of insecticides-Based on mode of entry- mode of action and chemical nature- common insecticides, fungicides-classification, herbicides-classification,pesticide formulations- solid and liquid - other formulations- pesticide adjuvants, list of new generation pesticides and banned pesticides with substitutes, Calculation of pesticide formulations(Insecticide, fungicide, herbicide), Pesticides and Toxicity – Acute toxicity – Chronic toxicity – Toxicity categories , Pesticide labels and labelling-Legal regulatory measures regarding pesticide handling, Bio magnification-Residual toxicity- Maximum Residue Limit – Waiting Period, Precautions to be taken while handling pesticides, pesticide residue decontamination - simple methods to remove pesticide residues from vegetables

Unit 3. ORGANIC CERTIFICATION (20 Hrs)

Definition- production standards-purpose , Process of organic certification-product labelling, Organic certification in India -Agencies involved,Good Agricultural Practices - definition- objectives- key elements- potential benefits.

Unit 4. ICT ENABLED EXTENSION SERVICES IN AGRICULTURE (50 Hrs)

ICT enabled extension services in Agriculture – Familiarization of popular agri extension related softwares - crop decision support system – pest, disease and nutrient deficiency diagnosis softwares - ICT enabled agriclinics – Kisan Call Centres, Farmer support schemes.

LIST OF PRACTICAL ACTIVITIES

MODULE 3

UNIT 1- PEST AND DISEASE DIAGNOSIS

1. Collect and observe various pests affecting agricultural crops and classify them into different groups
2. Identification of different groups of insects
3. Identification of types of mouthparts of insects and their feeding habits
4. Familiarization with the methods of collection of insects , equipments used for collection and methods of preservation
5. Familiarization with important disease causing organisms and symptoms of diseases seen in major crops
6. Preparation of herbarium showing different disease symptoms in plants
7. Familiarisation with ooze test
8.Familiarisation with disease forcasting models and interactive softwares
9.Familiarisation with pest and disease diagnosis softwares
10.Famialirisation with mechanical weed management- brush cutter.

UNIT 2- INTEGRATED PEST AND DISEASE MANAGEMENT OF CROPS OF KERALA

1.Familiarization with major pests and diseases of crops of Kerala, their symptoms and management- Rice,Coconut,Banana,Pepper, Vegetables,Cardamom, Ginger, Mango, Rubber, Cashew, Cassava, Sweet potato, Tea, Coffee and Ornamentals.
2.Familiarization with important pests of stored products

UNIT 3- AGRO- BIOPHARMACY

1.Preparation and field application of Neem based botanicals – Neem oil emulsion, Neem oil –Garlic emulsion -2%, neem seed kernel extract.
2.Preparation and field application of extracts of plants like Andrographis, Hyptis, Chlerodendron.
3.Preparation and field application of papaya leaf extract, bird chilli-cow's urine extract
4. Preparation and field application of fish amino acid and egg aminoacid.
5.Preparation and field application of permitted fungicides for organic farming-Bordeaux mixture and Bordeaux paste.
6.Familiarization with formulations of bio-fertilizers, practicing seed treatment of rhizobium and its field application.
7.Perparation of organic nutrient solutions- panchagavya and dasagavya.
8.On farm mass multiplication of *Trichoderma* and its field application
9. Field application of *Pseudomonas*
10. Preparation of Yellow or Blue sticky trap and its field installation
11.Method of production of low cost pheromone trap against fruit fly

UNIT 4- PLANT PROTECTION EQUIPMENTS

1.Familiarization with different types of sprayers
2.Operation and maintenance of hand sprayer and pneumatic knapsack sprayer
3. Familiarization with different types of rodent traps

MODULE 4

UNIT I- PROTECTED CULTIVATION

1. Familiarization with different types of protected cultivation structures based on shape, construction and covering material
2. Preparation of growth media used in protected cultivation
3. Familiarization with various equipments used for measuring climatic parameters inside green house
4. Diagnosis and management of common pests and diseases seen in protected cultivation
5. Familarization with irrigation system and fertigation requirements in protected cultivation
5. Visit to commercial Hi-tech farm
6. Familiarization and practicing of Hydroponics

UNIT II- PESTICIDES AND PESTICIDE RESIDUE MANAGEMENT

1. Familiarization with common pesticide formulations
2. Calculation and preparation of insecticideformulations for field application.
3. Familiarization with different new generation pesticides and their formulations available in the market.
4. Calculation of common fungicide formulations for field application.
5. Practicing field application of pesticide sprays.
6. Familiarization and preparation of pesticide label.
7. Practicing simple methods of pesticide residue decontamination from vegetables.

UNIT III- ORGANIC CERTIFICATION

1. Familiarization with the procedure for organic certification in India.

UNIT IV- ICT ENABLED EXTENSION SERVICES IN AGRICULTURE

1. Familiarization and practice of different ICT enabled agriculture related interactive softwares- crop decision support system – pest, disease and nutrient deficiency diagnosis softwares like e-crop doctor, Karshika jalakam , pest doctor, online rubber clinic.
2. Familiarisation with crop health diagnostic centres.
3. Familiarization with various important farmer support schemes.

LEARNING OUTCOMES

MODULE-3

INTEGRATED PEST AND DISEASE MANAGEMENT

UNIT 1

PEST AND DISEASE DIAGNOSIS

The learner:

3.1.1 defines pest and classifies pests as insects ,non-insects and weeds with examples.

3.1.2 categorises the pests based on occurrence ,based on level of infestation based on the percentage of crop loss they cause with examples.

3.1.3defines pest outbreak and narrates the reasons for pest outbreak.

3.1.4analyses and interprets the impact of global warming on pest status.

3.1.5observes the specific characteristics of insects and classifies them into bugs, beetles and weevils, flies, moths and thrips.

3.1.6identifies and compares the different types of mouth parts of insects , feeding habits , metamorphosis , young ones ,wing characters and their destructive stages.
3.1.7defines disease and classifies disease based on causal factors as biotic(infectious) and abiotic(non infectious).
3.1.8definespathogen (biotic factors) and classifies it as fungus, bacteria, virus, phytoplasma ,algae with examples.
3.1.9describes abiotic factors like physiological disturbances,nutrient deficiency ,air pollutants, lack of moisture and stress.
3.1.10 categorises the diseases based on pathogen and mode of spread with examples.
3.1.11 diagnoses disease based on signs and symptoms , explains Koch's postulates and practises ooze test.
3.1.12defines disease epidemiology and explains disease triangle.
3.1.13defines plant disease forecasting and explains its application.
3.1.14practises E-crop doctor and other related softwares for pest and disease diagnosis.

UNIT 2
INTEGRATED PEST AND DISEASE MANAGEMENT OF CROPS OF KERALA
The learner:
3.2.1 explains the concept and principles of Integrated Pest Management (IPM).
3.2.2 defines Economic Threshold Level (ETL), Economic Injury Level (EIL) and explains the concept.
3.2.3explains the different methods of IPM with examples.
3.2.4defines the concept of plant disease control and Integrated Disease Management (IDM).
3.2.5explains the concept and methods of weed management including Integrated weed management.
3.2.6defines the concept of Integrated Pest and Disease Management (IPDM) and enlists its components.
3.2.7describes the concept of pest surveillance and its objectives
3.2.8 identifies the symptoms of pests and diseases of important crops of Kerala and recommends the management(IPDM)practices.
3.2.9 identifies the pests of stored products , their nature of damage and explains management practices.
UNIT 3
AGRO-BIOPHARMACY
The learner:
3.3.1 definesagro biopharmacy and explains the concept.
3.3.2 prepares botanicals and practises their methods of application.
3.3.3 prepares permitted fungicides for organic farming like Bordeaux mixture and Bordeaux Paste
3.3.4prepares organic nutrient solutions.
3.3.5 defines the biofertilizers and categorises them into biofertilizers for nitrogen, phosphorus and potassium.
3.3.6practises application methods of biofertilizers
3.3.5 identifies the bio control agents
3.3.6 explains the method of laboratory production of Trichoderma including media preparation,inoculation and formulation
3.3.7 practices the mass multiplication of Trichoderma and its field application .

3.3.8 identifies the common entomopathogens
3.3.9 explains the common pheromone traps used for insect control.
3.3.10 practises the methods of production of low cost pheromone traps for fruitfly management.
UNIT 4
PLANT PROTECTION EQUIPMENTS
The learner:
3.4.1identifies and explains the parts of a sprayer.
3.4.2identifies and practices the handling of different types of sprayers.
3.4.3classifies dusters and mentions about other PP equipments.
3.4.4 identifies the different types of rat traps.
3.4.5 practices the maintenance of various PP equipments,analyses the problems and suggest suitable remedial measures

MODULE -4
HITECH FARMING
UNIT 1
PROTECTED CULTIVATION
The learner:
4.1.1 defines protected cultivation and explains the scopes and benefits of protected cultivation
4.1.2 analyses the factors emphasizing the need of Hitech horticulture in Kerala
4.1.3 compares and classifies the different types of protected cultivation structures based onshape of structure,use of structure,covering material ,type of ventillation, environmental control and cost.
4.1.4identifies the different parts of a greenhouse.
4.1.5 enlist the commonly cultivated crops in protected cultivation structures .
4.1.6 explains the principles and practices to be followed in protected cultivation .
4.1.7explains the climate control inside green houses including automation and enlists the equipments for measuring climatic parameters.
4.1.8 explains the micro irrigation system and its components in protected cultivation.
4.1.9 explains fertigation , enlists the characteristics of fertilizers used and advantages and disadvantages of fertigation.
4.1.10 analyses and interprets major pests, diseases and nutritional disorders seen in crops under protected cultivation and their management.
4.1.11 explains preventive approaches adopted in general integrated management for green house crops.
4.1.12explains curative approaches adopted in general integrated management for green house crops.
4.1.13enlists the crop protection equipments in protected cultivation.
4.1.14 defines and explains soil less cultivation practices like hydroponics and aquaponics and enlists its advantage and disadvantages.

UNIT 2
PESTICIDES AND PESTICIDE RESIDUE MANAGEMENT
The learner:

4.2.1categorises pesticides and classifies insecticides based on mode of entry, mode of action and chemical nature and enlists the common insecticides.
4.2.2 compares and classifies the common fungicides and herbicides.
4.2.3compares and categorises different formulations of pesticides and pesticide adjuvants.
4.2.4enlists new generation pesticides and banned pesticides with their substitutes.
4.2.5calculates pesticide formulations for field application.
4.2.6classifies pesticide toxicity into acute and chronic and categorises them.
4.2.6analyses and interprets the labelling of pesticides and identifies pesticide labels and mentions the Legal regulatory measures regarding pesticide handling
4.2.7describes concept of biomagnification, residual toxicity, maximum residue limit and waiting period.
4.2.8analyses and recommends the precautions to be taken while handling pesticides.
4.2.9describes and practices simple methods to decontaminate pesticide residue from vegetables.

UNIT 3

ORGANIC CERTIFICATION

The learner:

4.3.1 defines organic certification ,enlists the production standards and explains the purpose of organic certification
4.3.3 narrates the process of organic certification and describes product labelling.
4.3.4 describes organic certification in India and enlists the organic certification agencies
4.3.5defines Good Agricultural Practices(GAP) and explains its objectives and principles.

UNIT 4

ICT ENABLED EXTENSION SERVICES IN AGRICULTURE

The learner:

4.4.1 narrates the importance of Information communication technology (ICT) in Agriculture
4.4.2 practices the common holistic, specific and diagnosticinformation systems.
4.4.3 practices various kiosk based and mobile phone based information systems.
4.4.4 narrates other areas of ICT in agriculture.
4.4.5identifies the various farmer support schemes in Kerala

SCHEME OF WORK

MODULE 3

June	Pest and disease diagnosis	68
July	Pest and disease diagnosis IPDM of major crops	32 36
August	IPDM of major crops	68
September	IPDM of major crops Agro Biopharmacy	46 22

October	Agro Biopharmacy Plant Protection equipments	28 40
	Total	340

MODULE 4

November	Protected cultivation	68
December	Protected cultivation	68
January	Protected cultivation Pesticides and pesticide residue elimination	34 34
February	Pesticides and pesticide residue elimination Organic certification	66 2
March	Organic certification ICT enabled extension services in Agriculture	18 50
	Total	340

STRUCTURE OF MODULE 3

Unit No.	**Unit Name**	**Periods (hrs)**
1.	Pest and disease diagnosis	100
2.	IPDM of major crops	150
3.	AgroBiopharmacy	50
4.	Plant Protection equipments	40
	Total	**340**

STRUCTURE OF MODULE 4

Unit No.	**Unit Name**	**Periods(hrs)**
1.	Protected cultivation	170
2.	Pesticides and pesticide residue management	100
3.	Organic certification	20
4.	ICT enabled extension services in agriculture	50
	Total	340

CLASS ROOM ACTIVITIES

- Group discussion
- Quiz
- Preparation of Posters and Charts
- Project and workshops
- Exhibitions
- Multimedia presentation
- Panel discussion
- Interview with invited experts/ farmers in the classroom
- Workshop
- Role play
- General discussion
- Brainstorming
- Debate
- Slide show
- Assignment
- Animated CDs
- Seminar

PRACTICAL ACTIVITIES (General)

- Indoor practical work in labs and outside field
- Field visits
- Production cum training centre
- On the job training
- Interaction with successful farmers at the farm site
- Curriculum oriented case studies
- Demonstration

OVERVIEW OFMODULE 3
INTEGRATED PEST AND DISEASE MANAGEMENT

Agriculture is influenced by an array of biotic and abiotic stresses which have to be managed through multipronged strategies. A strategic science based approach is needed to address the plant health risks and issues that affect productivity. The looming threat of climate change may further exacerbate the crop losses due to pests. The integrity of agro-ecosystem is vital for sustainable agriculture. Intensive use of ecosystems to enhance productivity can affect agro-ecosystems through soil erosion, water depletion/ contamination, biodiversity loss and disruption in flow of ecosystem services which will have a bearing on plant health and bio-security.

Indiscriminate use of chemical pesticides has been causing widespread environmental pollution, resistance, resurgence of insect pests and is impacting food safety. Plant Health Management is vital for Sustainable Agriculture, food security, food safety, agro-based industries and economy of a country.

Incorporation of bio-fertilizers particularly mycorrhizae in agricultural practices play a vital role in promotion of soil health and uptake of important macro and micronutrients by the crops. Biological control through parasitoids, predators and

microbials constitute a significant component in holistic management of insects and diseases as well as abiotic stresses.

This module goes through different aspects of Integrated pest and disease management like pest and disease diagnosis, IPDM of crops of Kerala, agrobiopharmacy and handling of plant protection equipments.

Unit 1
Pest And Disease Diagnosis

It is estimated that in our country about 30% of crop production is being lost due to the incidence of pests and diseases. If pests and diseases could be detected as early as possible, using symptomatic and other means appropriate preventive action can be taken. Inorder to effectively tackle the problems caused by pests, its identification, diagnosis and nature of damage should be known. It is required to keep watch for suspected pests and diseases by taking samples and observing symptoms. The specific characteristics of insects, mouth parts and feeding habits should be understood for their proper control. The concept of infectious and non-infectious diseases and the various agents causing them is essential. The diagnosis of plant diseases using signs, symptoms and specific tests need to be familiarized for the management of pests.

Unit II
Integrated pest and disease management(IPDM) of crops of Kerala.

The over reliance and indiscriminate use of chemical pesticides has resulted in a series of problems in agro-ecosystem mainly the development of resistance in insects to insecticides, pest resurgence, outbreak of secondary pests into primary nature, environmental contamination and residue hazards , destruction of natural enemies etc. In this context , the integrated approach to pest management becomes relevant. Identification of different pests, their nature of damage and symptoms caused by them are to be familiarized for better and precise plant protection. New trends in pest management like ecological engineering, AESA are also included.

Unit III
Agro-biopharmacy

An outlet for supply of organic inputs is referred to as Agro-Bio pharmacy. The organic inputs include nutrient supplying materials like organic manures, biofertilizers and growth promoting organic mixtures like panchagavya, fish amino acid, egg aminoacid, plant protection inputs like botanicals, bio pesticides, pheromone traps, Yellow traps, light traps. The method of preparation, mass production, packing, storage, marketing and field application of some important organic mixtures, biopesticides will be covered.

Unit IV

Plant protection Equipments

The objective of pest management is to keep the pest under check. Pesticide application plays an important role in pest management. The success of any pest control operation depends on the proper technique of application and the equipment used for applying it. The students are to be familiarized with different plant protection equipments like sprayers, dusters and other PP equipments like granular applicator, controlled droplet applicator , fogging machine and rat traps.The components and working principles of important equipments are to be covered. Field level application of pesticides using these equipments and their maintenance is to be practiced

UNIT GRID
Module: III **Unit: 1**

Periods:100

Ideas/concepts/skills	**Learning outcomes**	**Suggested activities**	**Assessment**
Pest – Definition-classification into insects , non-insects and weeds with examples SKILLS Observation Classification Collection	***The learner*** defines pest and classifes pests as insects, non-insect pests and weeds with examples	General discussion (W), Brainstorming (W) Powerpoint presentation (G) Specimens(I)	Notes Diagrams Collection Discussion points with consolidation
Categories of pests based on occurrence,based on level of infestation ,based on percentage of crop loss SKILLS Classification Observation Communication	***The learner*** categorises the pests based on occurrence,level of infestation , percentage of crop loss they cause	General discussion (W) Brain storming (W) Collection Field visit	Discussion points with consolidation Notes Reports Charts Scrap book Focus group discussion
Pest outbreak-definition-reasons SKILLS Observation Communication	***The learner*** defines pest outbreak and narrates the reasons for pest outbreak	General discussion (W) Brain storming (W) Field Visit Literature collection Seminar	Discussion points with consolidation Notes SeminarReport Paper cuttings
Impact of global warming on pest status SKILLS Observation Reference Skills	***The learner*** Analyses and interprets the impact of global warming on pest status	General discussion (W) Brain storming (W) Review from mass media presentation	Discussion points with consolidation Notes Reports
Insect–its specific characteristics – classification into bugs, beetles and weevils, flies, moths and thrips	***The learner*** observes the specific characteristics of insects and classifies them into bugs, beetles	Collection Group discussion Model preparation(G)	Notes Insect Box Charts Collection Photos

SKILLS Observation Comparison Classification Collection Instrumental Skills Reference Skills Practical Skills	and weevils, flies, moths and thrips		Animations Videos Diagrams
Identification of different types of mouth parts of insects , feeding habits , metamorphosis , young ones ,wing characters and their destructive stages SKILLS Observation Comparison Classification Collection Instrumental Skills Reference Skills Practical Skills	***The learner*** Identifies and compares the different types of mouth parts of insects , feeding habits , metamorphosis , young ones ,wing characters and their destructive stages	Collection Group discussion Model preparation(G)	Notes Insect Box Charts Collection Photos Animations Videos Diagrams
Disease -definition – classification- causal factors – biotic(Infectious) and abiotic(non infectious) SKILLS Observation Classification Identification Reference Skills	***The learner*** defines disease and classifies the disease based on causal factors as biotic and abiotic.	Brainstorming(W) Discussion(G) Field visit	Notes Field diary Tabulation Scrap book
Biotic factors(Pathogen) -definition - fungus, bacteria, virus, phytoplasma ,algae with examples SKILLS Observation Classification Collection Practical Skills Reference Skills	***The learner*** defines biotic factors(pathogen) and classifies it as fungus, bacteria, virus,phytoplasma and algae with examples	Picture reading Brainstorming Discussions AV show	Notes Seminar Scrap book
Abiotic factors– physiological disturbances, nutrient	***The learner*** describesabiotic factors like physiological	Brainstorming(W) Discussion(G) Field visit	Notes Report

deficiency ,environmental pollution, lack of moisture and stress SKILLS Observation Classification Collection Practical Skills Reference Skills	disturbances,nutrient deficiency ,environmental pollution, lack of moisture and stress	Assignment Flash cards	
Classification of disease based on pathogen and mode of spread with examples SKILLS Observation Collection Classification Reference Skills	***The learner*** categorises the disease based on pathogen and mode of spread with examples	Classification Tabulation Videos Pictures	Notes Tables
Diagnosis of disease based on signs and symptoms -Koch's postulates - ooze test SKILLs Observation Classification Collection Practical Skills Reference Skills	***The learner*** diagnoses disease based on signs and symptoms ,explains Koch's postulates and practises ooze test	Field visit Classification Tabulation Videos Pictures Collection	Field diary Notes Tables CD Herbarium
Disease epidemiology-Disease triangle SKILLs Observation Reference skill	***The learner*** defines disease epidemiology and explains the disease triangle	Discussion	Notes Venn diagram
Disease forecasting -its application SKILLS Observation Reference skill	*The learner* defines disease forecasting and explain its application	Discussion Brain storming Collection of paper cuttings	Notes Reports Collage Charts
E-crop doctor and other related softwares for pest and disease diagnosis SKILLS Practical skill Reference skill	***The learner*** practises E-crop doctor and other related softwares for pest and disease diagnosis.	Practise of softwares	Notes Response to interactive media

Module: III **Unit: 2** **Periods: 150**

Ideas/concepts/skills	Learning outcomes	Suggested activities	Assessment
Integrated Pest Management (IPM),-concept –principles of IPM SKILLS Observation Reference Skills	***The learner*** explains the concept and principles of Integrated Pest Management (IPM)	Field visit Discussion Brain storming	Notes
Economic Threshold Level (ETL), Economic Injury Level (EIL) SKILLS Observation Reference Skills Collection	***The learner*** defines Economic Threshold Level (ETL), Economic Injury Level (EIL) and explains the concepts.	Discussion Brain storming Field visit Collection of paper cuttings Analysis	Notes Field diary Reports Album
Methods of IPM-ecological engineering-cultural-mechanical-physical, legal , biological and chemical SKILLS Observation Classification Practical Skills Reference Skills	***The learner*** explains the different methods of IPM with examples	Field Visit Tabulation Videos Pictures Powerpoint presentation Seminar Focus group discussions	Notes Tables Photographs Reports Assignment
Plant disease control-Integrated Disease Management (IDM) SKILLS Observation Reference Skills	***The learner*** defines the concept of plant disease control and Integrated Disease Management (IDM)	Field visit Discussion Brain storming	Notes Field diary
Weed management-mechanical-cultural-chemical-biological-integrated weed management SKILLS Observation Collection Classification	***The learner*** Explains the concept and methods of weed management including IWM	Field Visit Discussion Power point presentation Seminar	Report Pictures Photographs Assignment

Practical Skills Reference Skills			
Integrated Pest and Disease Management (IPDM) –concept-components SKILLS Observation Reference Skills	***The learner*** defines the concept of Integrated Pest and Disease Management (IPDM) and enlists itscomponents	Field visit Discussion Brain storming Field activity	Notes Field diary
Pest surveillance-objectives	***The learner*** describes the concept of pest surveillance and its objectives	Field visit Collection	Field diary Specimens
Identification of the pest and diseases of important crops of Kerala-symptoms,-management(IPDM) (Rice, coconut, banana, pepper, solanaceous vegetables, cucurbitaceous vegetables, cowpea, bhindi, amaranthus, cardamom, ginger, mango, rubber, cashew, papaya, tea, coffee,tapioca, ornamentals) SKILLS Observation Collection Classification Practical Skills Reference Skills	***The learner*** identifies the common symptoms of pests and diseases of important crops of Kerala and recommends the management practices(IPDM)	Field visit Brain storming Discussion Videos Pictures Power point presentation Seminar Collection of pests and diseases	Herbarium Report Notes CD Assignment Specimens
Pests of stored products-identification- nature of damage-management	***The learner*** identifies the pests of stored products, their nature of damage and explains management practices	Collection of stored pests and damaged specimens Powerpoint presentation Literature collection	Specimens Notes CD Album

Module: III **Unit: 3** **Periods: 50**

Ideas/concepts/skills	Learning outcomes	Suggested activities	Assessment
Agro Biopharmacy - definition-concept SKILLS Observation Collection	***The learner*** defines agro biopharmacy and explains the concept	General discussion (W), Brainstorming (W) Literaturecollection Debate	Notes Discussion points with consolidation Reports
Botanicals- preparation-methods of application SKILLS Practical skill Reference skill	***The learner*** prepares botanicals and practises their methods of application	General discussion (W) Brain storming (W) Preparation of botanicals Field application	Discussion points with consolidation Notes Prepared products
Preparation ofpermitted fungicides for organic farming- Bordeaux mixture and Bordeaux paste SKILLS Practical skill Reference skill	***The learner*** prepares permitted fungicides for organic farming like Bordeaux mixture and Bordeaux paste	General discussion (W) Brain storming (W) Preparation Field application	Discussion points with consolidation Notes Prepared products
preparation of organic nutrient solutions- panchagavya and dasagavya SKILLS Practical skill Reference skill	***The learner*** prepares organic nutrient solutions like panchagavya and dasagavya	General discussion (W) Preparation Field application	Discussion points with consolidation Notes Prepared products
Biofertilizers - familiarisation - biofertilizers for nitrogen, phosphorus and potassium SKILLS Practical skill Reference skill	***The learner*** Defines biofertilizers and categorises them into biofertilizers for nitrogen, phosphorus and potassium.	General discussion (W) Brain storming (W) Power point presentation Seminar Videos	Discussion points with consolidation Notes Seminar Report CD
Biofertilizers	***The learner*** practises the	General discussion	Discussion

application methods	application methods of biofertilizers	(W) Brain storming (W) Preparation Field application	points with consolidation Notes Prepared products
Bio control agents-fungal and bacterial pathogens-AMF-Trichoderma-Pseudomonas	***The learner*** identifies the bio control agents	General discussion (W), Brainstorming (W) Powerpoint presentation (G) Formulations	Notes Discussion points with consolidation
Method of production of Trichoderma including media preparation-inoculation-formulation SKILLS Observation Classification Collection	***The learner*** Explains the method of production of Trichoderma including media preparation,inoculation and formulation	Flow chart preparation Videos	Flow chart CD
Mass multiplication of Trichoderma - field application . SKILLS Observation Classification Collection	***The learner*** practices the mass multiplication of Trichoderma and its field application .	General discussion (W) Brain storming (W Videos Field level preparation and application	Discussion points with consolidation Notes CD
Entomopathogens – fungi,bacteria,virus SKILLS Observation Classification Collection	***The learner*** identifies the common entomopathogens	Assignments Powerpoint presentations	Discussion points with consolidation Report CD
Common pheromone traps used for insect control- Low cost pheromone trap for fruit fly management SKILLS Observation Classification Collection	***The learner*** explains the common pheromone traps used for insect control and practices the method of production of low cost pheromone traps for fruit management	General discussion (W) Field Level preparation Videos Photographs	Notes Diagrams Discussion points with consolidation Prepared products

Module: III **Unit: 4** **Periods: 40**

Ideas/concepts/skills	Learning outcomes	Suggested activities	Assessment
Different plant protection equipments- classification SKILLS Identification Classification Instrumental skill	***The learner*** classifies and enlists the different plant protection equipments	General discussion (W), Powerpoint presentation (G) Seminar (I)	Notes Diagrams Picture Album Consolidated discussion points
Types of sprayers- classification based on type of energy used SKILLS Identification Classification	***The learner*** classifies the different types of sprayers based on type of energy used	General discussion (W) Powerpoint presentation (G) Seminar Assignment	Consolidated discussion points Notes Report
Parts of a sprayer SKILLS Identification Operational skill	***The learner*** identifies and explains parts of a sprayer	Pictures Demonstration Discussion	Notes Album Sketches
Different types of sprayers – identification and handling SKILLS Identification Classification	***The learner*** identifies and practices the handling of different types of sprayers	General discussion (W) Demonstration Videos Pictures	Discussion points with consolidation Notes Sketches
Different types of dusters- identification and handling SKILLS Classification Identification Operational skill	***The learner*** classifies dusters and practises the handling of different types of dusters	General discussion (W) Demonstration Videos Pictures	Discussion points with consolidation Notes Sketches
Maintenance of various PP equipments, problems of PP equipments - remedies SKILLS Observation Communication Operational skill	***The learner*** practices the maintenance of various PP equipments andanalyses the problems and suggest suitable remedies.	General discussion (W) Field Visit Videos Powerpoint	Discussion points with consolidation Notes Report

UNIT IN DETAIL

PEST

Definition

"Pest has been defined as any organism detrimental to man and his property in causing damages significant of economic importance".

PEST -Derived from French word 'Peste' and Latin term 'Pestis' meaning plague or contagious disease.

Different Pest Groups

1. **Insect pests**
   - Beetles, weevils
   - Caterpillars (Moths & Butterflies)
   - Bugs, Aphids, Whiteflies, Mealy bugs
   - Flies
   - Grass hoppers, Crickets
   - Stored grain pests etc.

2. **Non-insect pests**
   - Rats
   - Mites
   - Nematodes
   - Slugs & Snails
   - Birds

3. **Diseases**
   - Fungal diseases
   - Bacterial diseases
   - Viral diseases
   - Mycoplasmal / Phytoplasmal diseases
   - Physiological disorders

4. **Flowering parasites**

   Striga, Orobanchae, Cuscuta, Loranthes

5. Weeds
   - Dicot weeds
   - Monocot weeds
   - Annuals weeds
   - Perennial weeds
   - Aquatic weeds
   - Upland weeds
   - Others

Classification of different pest groups

a) Vertebrates

Phylum	Class	Characters	Examples	Nature of Damage
1) Chordata	Mammalia	Hairy,fourfooted, milk secreting	Rats, squirrel, rabbit,monkey	Eat plant parts, flowers, seeds and fruits
2) Chordata	Aves	Wings,feathers and beak	Sparrow,parrot, pigeon, crow etc	They eat grains, seeds, fruits etc

b) Invertebrates

Phylum	Class	Characters	Examples	Nature of damage
1)Arthropoda	Hexapoda	Body divided into head, thorax and abdomen. Three pair of legs and wings.	Beetles, butterflies,moths, bugs, flies etc	Adults or immature stages damage plants by chewing of external parts or sucking plant sap. They also bore in to fruit, seed, and bud or feed on plant stem or mine leaf surface
2)Arthropoda	Arachnida	Minute creatures with an oval or elongate oval body, head and thorax fused to form cephalothorax, Abdomen distinct, four pairs of walking legs and no antennae.	Red spider mites,tea mites eryophyid mites	They pierce through the plant tissue with their sharp mouth parts for sucking the sap and destroying chlorophyll. As a result of feeding, discolouration of leaves or galls appears.
3)Arthropoda	Crustacea	Hard limy chitinous exoskeleton, two pairs of antennae.	Crabs	Cut basal portions of rice seedlings, make holes on field bunds thus cause water to drain off.
4) Mollusca	Gastropoda	Soft bodied, non-segmented, no jointed appendages. Body enclosed calcareous	Slugs and snails	They feed on foliage of plants mainly ornamentals like orchids and anthurium

		shell.		
5) Nemata	Nematoda	Tiny cylindrical, elongated un-segmented body with tough cuticle. Some forms are microscopic. size generally less than 2mm.	Root knot nematode, burrowing nematode	They posess a protruding stylet for feeding. They form knots or galls.

CATEGORIES OF PESTS

1.Based on occurrence

- **Regular pests**
- **Occasional pests**
- **Seasonal pests**
- **Persistent pests**
- **Sporadic pests**

2. Based on level of infestation

- **Epidemic pests**
- **Endemic pests**

3. Based on the extent of damage

- **Major Pest**
- **Minor Pest**
- **Negligible Pest**

Percentage of loss caused by different groups of pests

- Weeds - 45%
- Insects - 30%
- Disease - 20%
- Other factors - 5%
- Total 100%

PEST OUTBREAK

Reasons for pest outbreak

- **Deforestation and bringing under cultivation**
- **Destruction of natural enemies**
- **Intensive and extensive cultivation**
- **Introduction of new varieties and crops**
- **Improved agronomic practices**
- **Introduction of new pest in new environment**
- **Accidental introduction of pests from foreign countries (through air/sea ports)**
- **Large scale storage of food grains**

IMPACT OF GLOBAL WARMING ON PEST STATUS

- Due to change in climate, temperature and water availability, the farmers may change the type of crops grown.
- Due to increase in temperature, there can be outbreak of certain insect pests and diseases.
- In forest areas there will be a shift in tree species and also pest species.
- In agriculture lands since cropping pattern is changed ,new crops to suit the climate is introduced and new pests are also introduced.
- When water availability is less, crops will be raised as rainfed. It will be difficult to take up control measures without water.

SPECIFIC CHARACTERS OF INSECT PESTS

- Insects are tracheate arthropods with distinct head, thorax and abdomen, single pair of antennae, a pair of compound eyes, three pairs of walking legs confined to the thorax and two pair of wings.
- The integument is hardened to an exoskeleton covering the body muscles with striated fibres arranged segmentally.
- The head is usually composed of 6 segments fused immovably together.
- Thorax is composed of 3 segments – prothorax, mesothorax and metathorax.
- Abdomen is usually composed of 11 segments.

Additional Information

- The science of Entomology deals with the study of insects.
- The word entomology is derived from two Greek words
  entoma (Insects) and
  logos (to study).

Classification of Insects

Sl No	Order	Insect Group	Mouth parts	Feeding Habits	Metamor phosis	Young ones	Wing Characters	Destructive Stage
1	Coleoptera	Beetle, weevil	Biting and chewing	Chewing	Complete	Grub	Fore wings-elytra Hind wings membraneous	Grub or adult
2	Lepidoptera	Moths, butterflies	Siphoning	Sucking	Complete	Caterpillar	Scaly	Caterpillar
3	Diptera	Flies	Sponging	Sucking	Complete	Maggot	Hind wings as halters	maggot
4	Hemiptera	Bugs,aphids, hoppers	Piercing and sucking	Sucking	Incomplete	Nymph	Membraneous wings	Nymphs and adult
5	Thysanoptera	Thrips	Rasping and sucking	sucking	Incomplete	Nymph	Fringed	Nymphs and adult

Classification of insects as solid feeders and liquid feeders

Solid feeders – They have biting and chewing types of mouths parts.
eg. Beetles, Caterpillars of butterflies, grasshoppers, termites, cockroaches etc.

Liquid feeders - they have sucking type of mouthparts

- Butterflies and moths - adults Sucking/Siphoning type & have a coiled proboscis.
- Bugs (Adults and Nymphs) - Piercing and sucking Type and have a stylet.

- Thrips - Rasping and sucking type
- Flies - Spongy type of mouth part with a hinged proboscis

DISEASE

Disease may be defined as a series of harmful physiological processes caused by continuous irritation of the plant by a primary agent. It is an interaction among the host, parasite and environment.

Additional Information

Plant Pathology(Phytopathology) is the study of the diseases of plants. It is the study of the nature, development and control of plant diseases.

Pathogen – Any organism which cause disease.

Classification of disease based on causal organism

Biotic factors

1) Fungus
2) Bacteria -
3) Virus -
4) Mycoplasma or Phytoplasma and MLOs
5) Algae

Abiotic factors

- Physiological disturbances
- Nutrient deficiency
- Air pollutants
- Lack of moisture
- Stress

Classification of disease based on mode of spread of pathogen

- Air borne
- Water borne
- Soil borne
- Seed borne

DIAGNOSIS OF DISEASE

Symptoms of plant diseases

1.**Necrotic symptoms –** seen as drying of cells, tissues or organs .

2.**Chlorotic symptoms** - These are characterised by loss, suppression or reduction of the normal green colour in plants.

3.**Hypoplastic symptoms –** occur as underdevelopment or stopping of growth of cells, tissues and organs.

4. **Hyperplastic symptoms** - cause over development of cells, tissues and organs.

General symptoms of plant diseases

- Chlorosis / yellowing - eg: yellow dwarf of rice.
- Mosaic - eg: Cassava mosaic disease.
- Little leaf - eg: Little leaf of brinjal.
- Stunting - eg: Grassy stunt of rice.
- Galls and tumors - eg: Club root of crucifers.
- Leaf curl, blistering and puckering - eg: blister blight of tea
- Spots -eg: brown leaf spot of rice.
- Blight - eg: Bacterial leaf blight of rice.

- Anthracnose -eg: anthracnose of bean
- Witches broom - eg: witches broom in mango
- Phyllody - eg: phyllody in sesame
- Damping off - eg: damping off of vegetables
- Dry rot - eg: dry rot of ground nut.
- Wet rot - eg: soft rot of ginger.
- Wilt : eg: fusarial wilt of cotton
- Die back - eg: die back of mango
- Scab - eg: apple scab
- Canker - eg: citrus canker
- Rust - eg: black stem rust of wheat.
- Smut - eg: loose smut of wheat.
- Mildew - eg: downy mildew of grapes

Koch's postulates

Koch's postulates are used to prove whether a plant is affected with a particular disease.

Ooze test

This test is done for field diagnosis to confirm bacterial diseases and separate them from other vascular wilts.

Disease Epidemiology

Disease Epidemiology is a study of the factors affecting the outbreak of an infectious disease.

Disease Triangle

Plant disease is the outcome of the interaction between the plant, the pathogen and the environment.

Essential condition for the development of an epidemic / disease

1.Host related factors
2.Pathogen related factors
3. Environment related factors
4.Time related factors
5. Human activities

Meteoropathology deals with the study of relationship between the weather and epiphytotics.

Plant disease forecasting & it's application

Plant disease forecasting provides early information about the probable occurrence of a disease to facilitate chemical control at appropriate time either to stop pathogen multiplication or further spread of the disease.

Eg. Blitecast for late blight of potato , tomcast for tomato diseases

Softwares for pest and disease diagnosis

1.KAU E-Crop Doctor: *www.celkau.in*
2.Oushadham: *www.ctcri.org*
3.Crop Health Decision Support System: www.kissankerala.net.
4. Karshikajalakam:www.celkau.in.
5. Pest doctor: www.farm extensionmanager.com.
6. Online rubber clinic: clinic.rubberboard.org.in
7. Farm Extension Manager: www.farmextension manager.com

8. KAU Agri-infotech Portal: www. celkau.in
9. TNAU Agritech Portal: www.agritech.tnau.ac.in
10. Online plant Clinic, Govt of Kerala

Unit 2
INTEGRATED PEST AND DISEASE MANAGEMENT OF CROPS OF KERALA

Integrated pest management (IPM)

Integrated pest managementis the use of various control measures like physical, chemical, biological, legal, cultural, mechanical and modern plant protection methods in an integrated and compatible manner so as to reduce the pest population below economic injury level without much disturbance to the ecosystem.

Principles of IPM

- Identification of key pests and beneficial organisms
- Defining the management unit, the Agro-ecosystem(AESA)
- Development of management strategy
- Establishment of Economic thresholds (loss & risks)

Agro EcoSystem Analysis(AESA) is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop.

The basic components of AESA are

- Plant health at different stages (focus on nutrition)
- Built-in compensation abilities of plants(plant tolerance)
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

Economic Threshold Level (ETL)
Economic Injury Level (EIL)

Methods of IPM
1.Ecological engineering for pest management
2. **Cultural methods**
3. Mechanical methods
4. Physical methods
5. Legal methods
6. Biological methods (Bio Control or Biotic Control)
7. Chemical methods

Plant disease control

The control measures are divided in to two,
a.**Prophylactic method**
b.**Curative methods**

Integrated Disease Management (IDM)

Integrated Disease Management is a system that utilises all suitable techniques and methods in a compatible manner and maintains the pathogen population at levels below those causing economic injury.

Weed management

The major principles of weed control are prevention, eradication, control and Management

A. Prevention

B. Eradication

C. Weed management

Mechanical weed control

Tillage:

Hoeing:

Hand weeding:

Digging:

Sickling and mowing:

Burning:

Flooding:

Cultural weed control

Chemical control

Biological control

Additional Information

Summer tillage/off-season tillage

Checks the growth of perennial weed population. Initial tillage before cropping encourages clod formation, which have the weed propagules, and upon drying desiccate the same.

Solarisation

In this method, of hydrothermal disinfection the soil temperature is further raised by 5 – 10 ^{o}C by covering a pre-soaked fallow field with thin transparent plastic sheet. The plastic sheet checks the long wave back radiation from the soil and prevents loss of energy by hindering moisture evaporation.

Stale seedbed

A stale seedbed is one where initial one or two flushes of weeds are destroyed before planting of a crop. A shallow tillage or non- residual herbicide may be used to destroy the dense flush of young weed seedlings. This technique allows the crop to germinate in almost weed-free environment

Blind tillage

The tillage of the soil after sowing a crop before the crop plants emerge is known as blind tillage.

Outstanding examples of biological weed control

- Larvae of *Cactoblastis cactorum*, a moth borer, control prickly pear **Opuntia** sp. *Lantana camera* is controlled by larvae of *Crocidosema lantana*,
- *Cuscutaspp*. is controlled by *Melanagromyza cuscutae*
- *Cyperus rotundus* is controlled by *Bactra verutana* a moth borer
- *Ludiwigia parviflora* is completely denuded by **Altica cynanea** (steel blue beetle)
- Herbivorous fish Tilapia controls algae.

Bio-Herbicides/ Mycoherbicides

Bio herbicides are plant pathogens used to kill the targeted weeds.

Common mycoherbicides

No	Product	Content	Target weed
1.	Devine	A liquid suspension of fungal spores of *Phytophthora palmivora* causes root rot.	Strangler vine in citrus

2.	Collego	wettable powder containing fungal spores of *Colletotrichum gloeosporoides* causes stem and leaf blight	*Joint vetch in rice, soybean*
3.	Bipolaris	A suspension of fungal spores of *Bipolaris sorghicola*	Jhonson grass
4.	Biolophos	A microbial toxin produced as fermentation product of *Steptomyces hygroscopicus*	Non-specific, general vegetation

Integrated weed management

Integrated weed management may be defined as the judicious utilization of a combination of mechanical, cultural , biological and chemical methods of weed management in a planned sequence to bring the weed population below ETL without disturbing the ecosystem

Integrated Pest and Disease Management(IPDM)

IPDM is designed around six basic components.

- Acceptable pest levels – To establish ETL Economic Threshold Levels. Apply management only if the pest population crosses ETL.
- Preventive cultural practices-
- Mechanical control-
- Biological control
- Responsible use:
- Monitoring/Surveillence: It is the backbone of IPDM which includes identification and inspection. This helps to issue forewarning and facilitates proper timing of plant protection measures thereby preventing avoidable losses and environmental contamination.

Pest Surveillance

Surveillance is the regular or repeated collection , analysis and dissemination of uniform plant health information for monitoring and intervening in a timely manner when necessary.

Unit 2

Identification and Management of Pests and Diseases of Crops of Kerala

1.Rice

Pests

Rice stem borer,BPH,Gall midge,Leaf folderRice bugCase wormRice swarming caterpillar

Diseases

Blast,Sheath blight,Brown spot,Sheath rot,Foot rot,Tungro and Bacterial leaf blight

IPDM of rice

2.Coconut

Pests

Rhinoceros beetle,Red palm weevil,Leaf eating Caterpillar,Root grub,Coreid bug and Coconut eriophyid mite

Diseases

Bud rotLeaf rot

Stem bleeding,Ganoderma Wilt/ basal stem rot, Root(Wilt)

IPDM of coconut

3.Banana

Pests

Pseudostem weevil, Rhizome weevil, Banana aphid ,Banana leaf caterpillar(sporadic pest)
Nematode-Root knot nematode, burrowing nematode etc

Diseases

Bunchytop,Banana mosaic/Infectious chlorosis,Kokkan/banana bract mosaic,Sigatoka,Panama wilt,Rhizome rot/ tip over

IPDMof banana

4.Pepper

Pests

Pollu beetle, Marginal gall thrips, Scale insects,Nematode-Rootknot nematode, burrowing nematode

Diseases

Quick wilt/ foot rot,Anthracnose/ fungal pollu

IPDM of pepper

5.Solanaceous vegetables

Brinjal

Pests of Brinjal

Shoot and fruit borer,Epilachna beetle,Green jassids,Red spider mite

Diseases of Brinjal

Damping off,Little leaf,Phomopsis blight and fruit rot,Bacterial Wilt

Tomato

Pests of Tomato

Fruit borer,Leaf caterpillar,American Serpentine Leaf Miner(ASLM)

Diseases of tomato

Septoria leaf spot,Powdery mildew,Tomato Spotted Wilt Virus (TSWV)Leaf curl,
Bacterial wilt

Chilli

Pests of chilli

Thrips,Aphid,White fly,Mites

Diseases of chilli

Damping off,Anthracnose and fruit rot of chilli,Leaf curl

IPDM of solanaceous vegetables

6.Cucurbitaceousvegetables

Pests

Fruit fly,Aphid,Green Jassids,Yellow Mites,White fly,Epilachna beetle,Pumpkin beetle,Snake gourd caterpillar,Pumpkin caterpillar

Diseases

Fruit rot,Downy mildew,Powdery mildew,Anthracnose,Fusarium wilt,Mosaic

IPDM OF Cucurbitaceous vegetables

6.Cowpea

Pests of cowpea

Pea aphid,Pod bug,Pod borer,Spotted borer,ASLM

Diseases of cowpea

Collar rot and web blight,Fusarium wilt,Powdery mildew,Anthracnose,Cowpea aphid borne disease,Cowpea bud necrosis

IPDM OF Cowpea

7.Okra

Pests

Fruit and shoot borer,Leaf hopper,Aphid,Root knot nematode

Diseases

Yellow vein mosaic
IPDM of okra
8.Amaranthus
Leaf webber
Diseases
Amaranthus leaf blight
9.Cool season vegetables
PESTS
Cabbage butterfly
DISEASES
Black rot,Damping off,Black leg,Leaf spot,Downy mildew
10.Cardamom
Pestsofcardamom
Cardamom thrips,Shoot/Capsule borer,Hairy caterpillar(sporadic)Rhizome weevil,Root knot Nematode
Diseasesofcardamom
Katte/Mosaic,Azhukal disease,Clump rot or Rhizome rot,Chenthal disease
11.Ginger
Pests ofginger
Leaf roller,Rhizome scale,
Diseases of ginger
Rhizome and Soft Rot,Bacterial Wilt,
12.Mango
Pests of mango
Mango hopper,Mango Fruit Fly,Mango Stem Borer,Shoot midge,Shoot webber
Diseases of mango
Anthracnose,Powdery mildew,Die back
13.Rubber
Pests of rubber
Scale insect,Mealy bug,Stem borer,White grub / Soil grub
Diseases of rubber
Abnormal leaf fall,Powdery Mildew,Pink disease,Patch canker/ Bark Canker
14.**Cashew**
Pests of cashew
Tea mosquito bug,Stem and root borer
Diseases of cashew
Pink disease
15.Papaya
Pests of papaya
Papaya mealy bug
Diseases of papaya
Damping off,Leaf curl
16.Tea
Pests of tea
Nematodes, Mites, Thrips ,Tea mosquito bug
Diseases of Tea
Blister blight

17.Coffee
Diseases of coffee

Coffee berry borer,Shot hole borer ,Mealy bugs
Diseases of coffee
Black rot
18.Tuber crops
Pests of Tapioca
Red spider mites and scale insects,Termites
Diseases of Tapioca
Cassava mosaic disease (CMD),Leaf spot,Bacterial blight
Management of storage pests of cassava
19.Ornamental plants
a.Pests of Anthurium and Orchid-Snails and slugs
b.Pests of Rose-Aphids ,Scales
c.Pests of Jasmine-Bud worm
d.Diseases of Anthurium and Orchid-Bacterial blight,Anthracnose
e.Diseases of Rose-Black spot
f.Diseases of Jasmine-Leaf blight

PESTS of stored products
1. Primary grain pests
2. Secondary grain pests
Managementofstored products pests
Preventive measures
Curative measures

Unit III
Agro-bio pharmacy

Agro- biopharmacy is aimed at providing inputs required for organic agriculture.
Botanicals.
Neem based botanicals

- Azadirachtin (acts as feeding deterrent, growth regulator, repellant and disrupts growth and reproduction of pests)
- Meliantriol (feeding inhibitor)
- Salanin (feeding inhibitor)
- Nimbin and
- Nimbidin.

Neem oil emulsion
Neem oil garlic emulsion (2%)
Neem seed kernel extract
Neem leaf Leaf Extract
Neem Twig NSKE
Neem oil
Neem Cake Neem Cake extract

Tobacco decoction

Nicotine, the alkaloid present in the leaves of tobacco has insecticidal property. This is very effective for controlling aphiamds and other soft-bodied insects (jassids, mealy bugs, hoppers) infesting vegetable crops. Tobacco decoction can be prepared by steeping 500 g of tobacco waste in 4.5 litres of water for 24 hours. Dissolve 120 g of ordinary bar soap separately in another vessel. The soap solution is added to tobacco decoction under violent agitation. Dilute this stock solution 6-7 times before spraying.

Andrographis-Garlic mixture

Papaya leaf extract

Birds eye chilli- cows urine extract

Baking soda- turmeric- asafoetida mixture

Leaf / plant extract -preparation of 5% extract

Preparation of permitted fungicides for organic farming

Bordeaux mixture (1%)

Additional Information

In order to confer sticking qualities to Bordeaux mixture, rosin washing soda mixture, may be added. The addition of the sticker is particularly recommended for sprayings conducted during rainy season.

- 10 litres of water out of 100 litres required for preparing Bordeaux mixture may be kept apart.
- Boil 10 litres of water , preferably in an earthen pot and add 500 g of good quality washing soda (sodium carbonate). Boil again until the solution becomes slightly dark in colour.
- Add one kg of powdered rosin (arpoos) in the boiling washing soda solution. Reduce the flame for avoiding frothing, foaming and spilling over.
- Boil the solution for 5-10 mintes till the black bubbles appear.
- Cool the solution until the temperature reaches below 45 degree Celsius.
- The cooled mixture (10 litres) is then added slowly to the prepared Bordeaux mixture (90 litres) under vigorous stirring

Bordeaux paste(10%)

Preparation of organic nutrient solutions

Panchagavya
Dasagavya
Fish aminoacid
Egg amino acid

Bio-fertilizers

A. Nitrogen fixing bio fertilizers

Rhizobium (Bradyrhizobium and Azorhizobium)
Azotobacter
Azospirillum
Acetobacter
Blue-Green Algae(BGA)
Azolla

B.Phosphorous solubilising microorganisms (PSM)

Vesicular/Arbuscular Mycorrhiza (VAM/AMF)

C.Potassium solubilising biofertilizer

D.Symbion S (*Thiobacillus thioxidans*)is a liquid biofertiliser of Sulphur

E.Biozinc/Zincure- commercial biofertiliser of Zinc.

F.PGPR mix I I

Biological control

Biopesticides includes in a broader sense pesticides of biological origin.They include naturally occurring substances that control pests(biochemical pesticides), microorganisms that control pests(microbial pesticides) and pesticidal substances produced by plants containing added genetic material (plant –incorporated protectants) or PPIs.

Biocontrol agents

Fungal and bacterial pathogens (mycoparasitic and antagonistic)

The micro organisms used in the control of plant pathogens are called as antagonists.

Entomopathogens

The various micro organisms that cause diseases in insects are called entomopathogens. These include bacteria, fungus, virus, protozoans and nematodes.

Entomopathogenic fungi

Entomopathogenic fungi are fungal species that can act as parasites of insects and kill or seriously disable them. They directly infects the insects, softens their chitin by releasing some enzymes. The pathogen fills up the body cavity with hyphae due to which the insect become hard and mummified. They become phototrophic, climb to the tips of the branches and dies in that position.

a. *Lecanicilium lecanii*

It is known as white-halo fungus because of the white mycelia growth on the edges of the infected scale insects. It can be multiplied on medium base on locally available grains and tubers. It is effective in controlling coffee green bug and certain other homopterans.

b. *Beauvaria bassiana*

It is commonly known as white muscardine fungus and occurs naturally in soils throughout the world. It can be mass multiplied on locally available grains and other solid substances. It is effective against thrips, whiteflies, aphids, grasshoppers, diamond back moth of cabbage etc

c.*Metarrhizium anisopliae*

It is commonly known as green muscardine fungus. It is widely distributed soil inhabiting fungus. It is effective against rhinoceros beetle of coconut, termites, leafeating caterpillars, beetles etc.

Entomopathogenic bacteria

a. *Bacillus thuringensis*(B t)

This is a gram positive bacteria and is a most important pathogen extensively studied and tested. When ingested by the insect larvae , the insect body becomes softer and darker in colour. The paralysis of gut takes place because of infection leading to mortality of the larvae in 3 to 4 days. Bt is widely used to control lepidopteran, dipteran and some coleopteran insect pests.

Entomopathogenic virus

Nuclear Polyhedrosis Virus (NPV)

These viruses are highly specific and hence do not affect beneficial insects, and are safe to fish and mammals. When virus is ingested, the insect larvae become diseased, stop feeding and are found hanging in an inverted position. It dies in 5-7 days.

Others include Cytoplasmic Polyhedrosis Virus (CPV), Baculovirus (OIBV).

NPV and CPV are used agaist lepidopteran larva while OBV is used against rhinoceros beetle.

For getting effective control, the microbial insecticide needs to be applied in the early instar stages, preferably in the evening hours and repeated 2-3 times based on the pest incidence.

Entomopathogenic nematodes(EPN)

These are nematodes pathogenic to insect and can be used for biological control.

Eg.*Rhabditis sp*against rice bug, BPH, fruit fly and epilachna

Other traps

- Red palm weevil

Coconut log traps with pineapple or sugarcane activated with yeast or molasses attract and trap floating populations of weevil.

- Banana Rhizome weevil, Pseudostem weevil

Pseudostem, 50 cm long, split longitudinally and inoculated with *Beauveria bassiana* placed in the garden @ 100 traps/ha

- White flies

Yellow Sticky traps@one trap per 5 cents. Empty tins painted yellow outsides and smeared with castor oil are hoisted on poles upside down in the garden. Yellow polythene sheets smeared with castor oil hoisted as flags can also be used.

- Thrips

Blue sticky traps@one trap per 5 cents. Method of preparation is same as above.

- Fruit flies

Banana trap: Take 20 g of ripened banana fruit pulp in 100 ml of water. 10 g melted jaggery and two drops of insecticide Malathion are added. Transfer to a 500 ml polythene closed bottle provided with four holes large enough for the adult flies to enter. These bottles are suspended in trellies.

Fish meal trap: Place 10 g of moistened, powdered dried fish in a coconut shell. Add two drops of Malathion and suspended in trellies.

Rice gruel water trap: Take 20 ml rice gruel water in a coconut shell and add 5 g jaggery, two /three carbosulphan granules and two/three capsules of yeast. The shells containing the preparation are hung in the garden.

Ocimum trap: Take extract of a handful of ocimum leaves. Add some water, 10 g Jaggery and half a gram of Carbosulphan. The shells containing the preparation are hung in the garden.

Parapheromone trap

The traps are used to control mango fruit fly and use methyl eugenol as the attractant. The traps are available as wooden blocks containing the attractant and chemical to kill the insect. The block has to be hung inside a plastic bottle (one litre capacity) with holes using a thread. The holes should be large enough for the fruit flies to enter. The traps are placed at 4 to 5 feet height from the ground level near mango trees and should be protected from rain. The dead flies have to be removed once in a week. These have to be placed @ 1trap for 20 cents.

- Caterpillar

Add 100 g jaggery and 5 ml Quinalphos 25 EC to 500 g of rice bran. Mix them and place in different parts of the garden in small quantities to attract and kill pests like Amaranthus leaf webber, Spodoptera etc

Unit 4

Plant protection Equipments

Sprayers

Sprayers are mechanical appliances which atomises the spray fluid (which may be a suspension, an emulsion or a solution) into a small droplets and eject it with little force for distributing it properly.

Water is not a good carrier for pesticide because of the hydrophobic nature of the target surface. Pesticides may break down by hydrolysis in water and evaporate from the target surface thus becoming light and easily drift.

Classification of sprayers

Sprayers are classified into four categories on the basis of energy employed to atomise and eject the spray fluid . They are

1. hydraulic energy sprayer
2. gaseous energy sprayer
3. centrifugal energy sprayer
4. kinetic energy sprayer

1. **Hydraulic energy sprayers**
   Hydraulic Energy Sprayers are sprayers in which which the spray fluid is pressurised either directly by using a positive displacement pump or by using an air pump to build the air pressure above the spray fluid in the air tight container. The pressurized fluid is then forced through the spray lance, which controls the spray quantity and pattern.
   Some of the hydraulic sprayers are hand sprayers, knapsack hydraulic sprayers, rocker sprayers, bucket sprayers, foot sprayers etc
2. **Gaseous energy sprayer**
   Gaseous Energy Sprayers are sprayers in which high velocity air stream is generated by a blower and directed through a pipe at the end of which the spray fluid will be allowed to trickle by the action of gravity through a diffuser plate.
3. **Centrifugal energy sprayer**
   Centrifugal Energy Sprayers are sprayers in which the spray fluid is fed under low pressure at the centre of a high speed rotating device such as flat, concave or convex disc, a wiremesh cage or bucket, a perforate sieve or cylinder or a brush and is atomised by centrifugal force as it leaves the periphery of the atomiser.The droplets are carried by the air stream generated by the blower of the sprayer or by the prevailing wind, if the sprayer is not provided with a fan.
4. **Kinetic energy sprayer**
   Kinetic Energy Sprayers are sprayers in which the spray fluid flows by gravity to a vibrating or oscillating nozzle which produces a coarse fan shaped spray pattern.This is used for application of herbicides.

Parts of a sprayer

The important parts of a sprayer are tank, pump, agitator, power source, pressure gauge, valves, filter, pressure chamber, hose, spray lance, cut-off device, booms and nozzles.

There are 2 types of pumps.
a) Air pump or Pneumatic pump - These are used in compression sprayers. They force the air in to the air tight spray tank and do not pump the liquid directly. The air compressed in the tank exerts pressure on the spray fluid which is then pushed into the discharge tube.
b) Positive displacement pump - These pumps take in a definite volume of the liquid from the inlet and transfer into the outlet. Most of the hydraulic sprayers have positive displacement pumps

Booms – Usually a lance is provide with only one nozzle. A number of nozzles can be arranged in a horizontal tube called the boom or spray bar. It is normally coupled with power sprayers. Booms are used for treating row crops.

Types of sprayers

A.Manually operated hydraulic sprayers

1.Hand Sprayer

2.Hydraulic Knapsack sprayer

3.Rocker Sprayer

4.Bucket Sprayer

5.Foot Sprayer

B.Manually operated Compression/Pneumatic Sprayers (Sprayers with air pump)

Battery or ULV sprayer

The basic requirements of ULV spraying are

- Narrow and controllable droplet spectrum (100-250 μm for fine sprayers, 50-100 μm for mist sprayers and 0.1 to 50 μm for aerosols)
- The accurately controllable emission rate and
- The non-volatile pesticide formulation of suitable viscosity and density

The rotary atomizer uses centrifugal energy to break the pesticide liquid into droplets. Controlled Droplet Application (CDA) based centrifugal energy nozzles are used for ULV spraying

A power sprayer can be used as a power duster by making the following changes.

- Chemical filler cap is removed to dismantle that strainer with the air pipe.
- The liquid delivery pipe below the chemical tank is dismantled and removed with the shear nozzle.
- The tank is thoroughly cleaned to remove possible traces of moisture left inside.
- The dust agitator tube is fixed at the bottom of the chemical tank.
- This tube has holes at the bottom to prevent the entry of dust into the agitator and clogging it.
- Dust intake tube is inserted into the chemical tank at the discharge and this tube has no. of large size holes on its periphery.
- Dust intake tube and the blower elbow are connected by using the dust outlet pipe, which is a pleated hose.

Dusters

The mechanical appliances that are used for distributing the dust formulations of pesticides are called as dusters.

The manually operated dusters are

(i) package dusters
(ii) plunger dusters
(iii) bellow dusters and
(iv) rotary dusters.

(i) Package dusters

Some pesticide dusts are packed in containers that serve as a hand applicators and can be discarded after use. They are mostly provided with rubber, leather or plastic

materials which on getting squeezed, provides a puff of air that emits the dust in a small cloud. The simplest type of package duster is worked by pressing it between the fingers.

(ii) Plunger dusters

These dusters consists of an air pump of the simple plunger type, a dust chamber, and a discharge assembly consisting of a straight tube or a small exit pipe whose discharge outlet can be increased or decreased by moving a lid provided at the end of the dust chamber. The air from the pump is directed through a tube into the container where it agitates the dust and eject it from a discharge orifice or tube. The amount of dust can be controlled by the speed of the operation of the pump. These are useful for spot application in restricted areas and for controlling ants, poultry pest and pest of farm animals.

(iii) Bellow duster

These dusters may be made from rubber, leather or plastic. On squeezing, it puffs the air that expels the dust in a small cloud. Hand held bellow duster has containers of capacity from 30 g to 500 g. The bellows can be operated either directly by hand or by handle provided for that purpose. The knapsack duster has the container capacity of 2.5 to 5.0 kg.The air blast developed by the bellow draws the dust from the hopper and discharges through the delivery spout intermittently. These dusters are suitable for spot treatments.

(iv) Rotary duster

Rotary duster consists of a blower with a gear box and a hopper. It is operated by rotating the crank. The cranking motion is transmitted through the gear box to the blower. A drive is taken for the dust agitator located in the hopper. The rotary duster may be hand carried type or shoulder mounted or belly carried type. The feed is controlled by a feed control lever, which operates a slide to control the aperture at the bottom of the hopper.

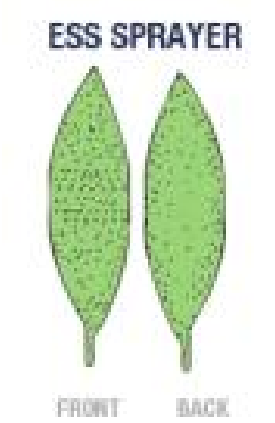
(v) Power dusters

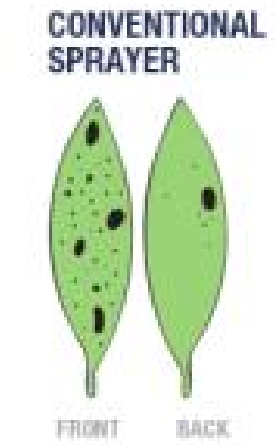
Power dusters resemble the rotary duster is construction, except that the power to drive the blower through the gear box is tapped from an external power source which may be an engine or P.T.O. shaft of the tractor or flywheel of the power tiller. The power operated centrifugal energy knapsack sprayer also can be converted into a power duster, by allowing the dust fluid into the air stream, near the point of attaching the pleated hose, in the blower elbow.

Other PP equipments

Granular applicator

Electrostatic Sprayers





Controlled droplet applicators (CDA's),

They are also called rotary spray nozzles, use centrifugal force rather than hydraulic pressure to form spray droplets. Centrifugal force is supplied by a spinning cup or disc powered by a small electric motor. The spray solution is injected at the bottom of the CDA spinning cup and is forced up grooves inside the cup. The liquid is formed into droplets on teeth at the upper edge of the cup and flung from the teeth in a circular pattern. The rubber drive belt can be placed on one of two pulleys to select the revolutions per minute of the cup. The CDA will operate at 2000 rpm to produce droplets of about 250 microns diameter or at 5000 rpm to produce droplets of about 75 microns diameter.

Site specific spraying

It is the technique of spraying the chemicals only on target. Two types of sprayers are available -Vision guided and GPS guided.In vision guided spraying system, high quality video camera collects crop information from the field and these images or signals will be analysed by the microprocessor and activate individual spray guns accordingly.In GPS guided system, the primary crop data from the field is collected from satellite imagery or remote sensing techniques, analysed by the microprocessor and activate individual spray guns by combining the Global Positioning System and Geographical Information System (GIS).

Rat traps

1. **Automatic traps**
2. **Remote triggered trap** - eg: Box trap or Cage trap.
3. **Pot traps** - eg: Moncompu trap

4. **Snap trap** - "break back traps, 'spring traps' Saw toothed traps" and 'bamboo traps'
5. **Glues**
6.**Kerosene tin trap**

Maintenance of plant protection equipments

Field problems and remedies for plant protection equipments

Assessment Activities
Unit 1
1.Prepare a picture album on the various insects and identify the groups and order to which they belong.

Group	Order

2.You are asked to handle a session on different groups of agriculturally important insects and their characters. Prepare a chart with insect group, order, young ones, type of metamorphosis, mouth parts and wing characters to be used in the session

3.Complete the following table after observing the specimens

Sl. No	Specimen	Crop	Attacking stage of pest	Type of Damage	Type of feeder	Mouthpart	Pest identified
1	Leaf	Brinjal	Grub & Adult	Defoliation	Solid	Chewing	Epilachna beetle
2	Fruit	Bhindi	Caterpillar	Holes on fruit	Solid	Chewing	Fruit & Shoot borer
3	Leaf	Chilly	Nymphs & Adults	Curling of leaves	Liquid	Piercing & Sucking	Thrips
4	Leaf	Rice	Caterpillar	Leaf fold and defoliation	Solid	Chewing	Rice leaf folder
5	Pods	Cow Pea	Nymphs & Adults	Malformed fruits	Liquid	Sucking	cowpea Aphid
6	---------						
7	---------						
8							

4.Submit an insect box with 15 preserved insects representing various orders
5.Prepare an assignment on the concept of Plant Disease Epidemiology and its importance in management of plant diseases
Use the following hints

- Time of attack

- Disease triangle
- Essential conditions of severity
- Possibility of disease forecasting

Unit 2

1.A farmer complaints about storage pest incidence in his farm house storing paddy. Your teacher asked you to prepare an investigatory project regarding the incidence. Prepare a write up including possible pests that may cause damage to the stored paddy and precautions to be taken to avoid such incidence in future.

2.Prepare a herbarium of the major diseases of crops of Kerala(20). Any crop can be selected.

3. Collection of 10 important pests of crops of Kerala.

Unit 3

1.Prepare a seminar report on the various bio agents used in pest management. Use the following hints.

- Suitable caption
- Different bio agents, use
- Application methods
- Factors which limit their use.

Unit 4

Visit a nearby agro service centre and prepare an assignment on the different plant protection equipments you have seen there.

Hints:(Name of equipment, Group to which it belongs, Working principle, Use, Pictures and Maintenance)

List of items in portfolio

Unit 1

- Picture Album showing important group of insects with orders
- Practical log
- Insect Box with 25 preserved specimens
- Chart containing insect group, order, young ones, type of metamorphosis, mouthparts, wing characters
- Assignment on plant disease epidemiology and its importance in the management of plant diseases.

Unit 2

- Herbarium containing preserved specimens of weeds(25 no)
- Seminar report on pest and disease management of various crops with CDs
- Herbarium of 15 disease specimens of different crops
- Insect box with 15 preserved insects causing economic loss to major crops of Kerala

Unit 3

- Field diary on preparation and field application of biofertilisers, *Trichoderma* and *Pseudomonas*
- Setting up of a low cost fruit fly trap, yellow and blue sticky traps.

Unit 4

- Assignment on different plant protection equipments

Extended activities

Unit 1- Pest and disease diagnosis

Creating awareness among people/ farmers in the locality on variouspests and disease diagnosis softwares

Unit 2- Integrated pest and disease management of crops of kerala

Creating awareness among people/ farmers in the locality on the diagnosis and management of pests and diseases of the most commonly cultivated crops in the locality(distribution of leaflets, organizing seminars)

Running of weekly Crop health clinics in school

Unit 3- Agro- biopharmacy

Organizing classes on the relevance of the use of environmentally safe, botanicals, bio-pesticides in crop production

Organizing classes and method demonstration of the preparation of effective botanicals

Preparation and sales of botanicals to the local people

Unit 4- Plant protection equipments

Expo

MODULE 4
OVERVIEW OF MODULE

Speciality agriculture is gaining popularity to yield desired high productivity of crops and economic return. Protected cultivation is one of the speciality agriculture where high input (land, water, seeds and chemicals) use efficiency on account of better protection against abiotic and biotic stress is obtained besides off season production of crops. Recent trends in soil less cultivation (aquaponics and hydroponics) is also covered. Non judicious use of pesticides have an illeffect on the health of non targeted organisms and on environmental health. In this context it is inevitable to understand the illeffects caused and methods to overcome them. This module throws light into one of the important ways of getting healthy, safe and pesticide free agricultural products and ensuring sustainability in production through organic certification. In this era of technological boom many agricultural related extension softwares are available which can help the farmers to make speedy and timely decisions in farming. This module will give the students knowledge on various ICT enabled services.

Unit 1
Protected Cultivation

After the advent of green revolution, more emphasis is laid on the quality of the agricultural product along with the quantity of production to meet the ever-growing food and nutritional requirements. Both these demands can be met when the environment for the plant growth is suitably controlled. The need to protect the crops against unfavourable environmental conditions led to the development of protected agriculture.

Protected cultivation is mainly being considered for the production of Horticultural crops like vegetables and ornamental foliage and flowers. With advancement of technology it has been possible to grow plants without soil with alternate substrates like sphagnum moss, cocopeat, coir dust, perlite, vermiculite,etc. not only horizontally but vertically also which is referred to as hydroponics. The additional advantage of such farming is that it can be done at any space available even in flats. Various types of polyhouse structures, list of crops commonly cultivated, their agronomic practices and plant protection methods are discussed. Precision agriculture is a farming management concept based on observing measuring and responding to inter and intra field variability in crops. The holy grail of precision agriculture is an ability to define a decision support system for whole farm management with the goal of optimizing returns on inputs while preserving resources.

Unit 2

Pesticides & pesticide residue management

The residue left in food products long after their application is pesticide residue. Continuous Ingestion of such food stuffs may even lead to diseases like cancer due to the accumulation of such chemicals in our body tissues. People are conscious about the ill effects of pesticide residue in the present scenario of deadly diseases. Hence it is essential to make the people aware of different practical methods to eliminate the residues from agricultural products. This unit gives an insight into such aspects

Unit 3
Organic certification

Organic certification addresses a growing worldwide demand for organic food. To assure quality and prevent fraud organic certification is necessary. For organic producers certification identifies suppliers of products . Since organic certification regulates and facilitates the sale of organic products it can definitely it is a definite solution for tackling the illeffects arosen due to the indiscriminate use of pesticides and other chemical inputs in agriculture.

Unit 4

ICT enabled extension services in agriculture

In present scenario of Agriculture farmers need accumulation and integration of knowledge and information from diverse sources. Inorder to make credential, accurate and rational decisions farm managers need speedy access to advise on agricultural problems which should be timely, reliable and consistent. The unit gives an overview on ICT enabled extension services related to agriculture such as popular agri extension related softwares, decision support systems , pest, disease and nutrient deficiency diagnose softwares, ICT enabled crop health clinics and farmer support schemes

UNIT GRID

Module: 4 **Unit: 1** **Periods: 200hrs**

Ideas/concepts/skills	**Learning outcomes**	**Suggested activities**	**Assessment**
Protected cultivation - definition - Benefits – scope **SKILLS** Collection skill Reference skill	*The learner* defines protected cultivation Explains the scope and benefits of protected	General discussion (W), Collection of paper cuttings (I)	Notes Collection Discussion points with consolidation

	cultivation		
Factors emphasizing the need of Hitech horticulture in Kerala **SKILLS** Reference skill	*The learner:* Analyse the factors emphasizing the need of Hitech horticulture in Kerala	Brainstorming (W) Collection of paper cuttings (I) Information from media	Collection/report Discussion points with consolidation Chart
Different types of protected cultivation structures based on shape of structure,type of cladding material used, structural material used ,shape of structure, ventilation and environmental control **SKILLS** Collection skill Reference skill	*The learner:* Compares and classifies the different types of protected cultivation structures based on type of cladding material used, structural material used ,shape of structure, ventilation and environmental control	General discussion(W), CollectingPictures Powerpoint Photographs Models	Discussion points with Consolidation Picture album Notes
Important parts of a greenhouse	*The learner :* Identifies the important parts of a greenhouse	Powerpoint Visit to a hitech farm	Report Presentation Chart Notes
List of crops commonly cultivated in protected cultivation	*The learner :* Enlist the commonly cultivated crops in protected cultivation structures	Survey Collection of Paper cuttings Visit to a hitech farm	Notes Report
Principles and practices followed in protected cultivation	*The learner :* Explains the practices in protected cultivation	Collection Powerpoint Visit to a hitech farm Group discussion(G) Model preparation(G) Seminar(I) Videos	Notes Report Chart
Drip irrigation system and its components in	*The learner* Explains the drip irrigation system	Visit Videos Model	Notes model

protected cultivation	and its components in protected cultivation		
Fertigation , characteristics of fertilizers used , advantages and disadvantages of fertigation	*The learner* Explains fertigation , characteristics of fertilizers used , advantages and disadvantages of fertigation	Specimens Field visit Survey to fertilizer shop	Notes Field Reports notes
Major pest, disease and nutritional disorders seen in crops under protected cultivation and their management	*The learner* Analyse and interpret major pest, disease and nutritional disorders seen in crops under protected cultivation and their management	Videos Powerpoint Seminar Photographs Field Visit	Notes Report
Soil less cultivation- Hydroponics , Aquaponics	*The learner* Defines and explains soil less cultivation practices like hydroponics , aquaponics	Paper cuttings Videos Chart	Notes Chart
Precision farming	*The learner* Defines precision farming	Paper cuttings Videos Chart	Notes Chart

Module 4 **Unit 2** **(100 hrs)**

Ideas/concepts/skills	Learning outcomes	Suggested activities	Assessment
Pesticides- Classification– classification of insecticides, based on mode of entry, mode of action and chemical nature- common	***The learner*** categorises pestisides and classifies insecticides based on mode of entry, mode of action and chemical nature and enlists common	Chart Assignment AV show Power point presentation Literature collection	Chart Notes Scrap book Report

insecticides SKILLS Observation Collection Classification Practical Skills Reference Skills	insecticides		
Fungicides-classification Herbicides-classification SKILLS Observation Classification Collection Practical Skills Reference Skills	***The learner*** compares and classifies common fungicides and herbicides	Chart Assignment Power point presentation Literature collection Survey	Chart Notes Scrap book Report
Formulations of pesticides- solid, liquid and other formulations, pesticide adjuvants SKILLS Observation Classification Collection Practical Skills Reference Skills	***The learner*** compares and categorises different formulations of pesticides and pesticide adjuvants	Survey Chart Power point presentation	Reports Chart
New generation pesticides and banned pesticides with their substitutes SKILLS Observation Classification Collection Reference Skills	***The learner*** enlists new generation pesticides and banned pesticides with their substitutes	Survey Chart	Report Chart
Calculation of pesticide formulations for field application SKILLS Computation skills Observation	***The learner:*** calculates pesticide formulations for field application	Solving problems	Notes
Different types of pesticide toxicity-	***The learner:*** classifies pesticide	Collection of labels	Picture album chart

categories SKILLS Collection Classification	toxicity into acute and chronic and categorises them	Chart	
Pesticide labels and labelling-legal regulatory measures regarding pesticide handling SKILLS Collection Observation	***The learner :*** analyse and interprets the labeling of pesticides and mentions legal regulatory measures regarding pesticide handling	Collection of labels Discussion Presentation	Picture album Report
Biomagnification- RT, MRL,WP SKILLS Collection Observation Reference Skills	***The learner :*** describes concept of biomagnification, RT ,MRL,WP	Collection of literature Power point presentation Seminar Information from Media	Report CD Notes
Precautions to be taken while handling pesticides SKILLS Collection Observation Analytical skills	***The learner :*** analyses and recommends precautions to be taken while handling pesticides	Brain storming Brochure preparation	Brochure
Simple methods to eliminate pesticide residues from vegetables SKILLS Collection Observation Practical skills	***The learner*** describes and practices simple methods to eliminate pesticide residues from vegetables	Literature collection from media Demonstration	Reports

Module 4 **Unit 3** **Period 20 hours**

Ideas/concepts/skills	**Learning outcomes**	**Suggested activities**	**Assessment**
Organic certification – Definition Observation Collection Reference Skills	*The learner* defines organic certification	Group discussion Debate Literature collection	Consolidation points Notes
Production standards, Purpose	*The learner* enlists the production	Seminar Assignment	Report

of organic certification Observation Collection Classification Reference Skills	standards and explains the purpose process of organic certification	Powerpoint presentation	Flow chart
Process of organic certification,Product labeling Observation Collection Classification Practical Reference Skills	*The learner* narrates the process of organic certification and describes product labeling	Literature collection Data collection from mass media	Report Chart Notes
Organic certification in India and organic certification agencies	*The learner* describes organic certification in India and enlists the organic certification agencies	Visit to organic produce outlet Collection of information from mass media	
Good Agricultural Practices(GAP)-definition	*The learner:* defines Good Agricultural Practices(GAP)	Assignment Collection of information from mass media Powerpoint presentation	Report Notes
Objectives and Principles of GAP	*The learner :* explains the objectives and principles of GAP	Assignment Collection of information from mass media Powerpoint presentation	Report Notes

Module: IV Unit: 4 Periods:50 hrs

Ideas/concepts/skills	**Learning outcomes**	**Suggested activities**	**Assessment**
Importance of Information and Communication Technology (ICT) in Agriculture	***The learner*** narrates the importance of Information and communication technology (ICT) in Agriculture	Brainstorming	Consolidation points
Information and	***The learner*** practices various	Practice	Report

decision support system	crop decision support system		
Pest disease and nutrient deficiency diagnosis softwares	***The learner:*** practices various pest disease and nutrient deficiency diagnosis softwares	Diagnosing Pest disease and nutrient deficiency based questions using software	Report
ICT enabled agriclinics and kissan call centres	***The learner:*** identifies ICT enabled agriclinics and kissan call centres	Discussion	Notes
Farmer support schemes in Kerala	The learner: identifies various farmer support schemes in Kerala	Powerpoint presentation	Report

Protected cultivation can be defined as a cropping technique wherein the micro climate surrounding the plant body is controlled partially or fully as per the requirement of the crop species.The cultivation of crops is done in a climatologically isolated structure. Here, climatic factors such as solar radiation, temperature,CO2 concentration, humidity and air movements are controlled.

Benefits of protected cultivation

Scope of protected cultivation

Factors emphasizing the need of hitech horticulture in Kerala

Important parts of Green House

1. Roof: transparent cover of a green house.
2. Gable: transparent wall of a green house
3. Cladding material: transparent material mounted on the walls and roof of a green house.
4. Gutter: collects and drains rain water and snow which is placed at an elevated level between two spans
5. Column: vertical structure carrying the green house structure
6. Purlin: a member who connects cladding supporting bars to the columns
7. Ridge: highest horizontal section in top of the roof
8. Girder: horizontal structure connecting columns on gutter height
9. Bracings: To support the structure against wind
10. Arches: Member supporting covering materials
11. Foundation pipe: Connection between the structure and ground
12. Automatic climate control systems
13. Fertigation unit

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4.3 Different types of protected structures

Classification of protected structures

4.3.1 Based on the structural material

4.3.2Based on shape of the structure

4.3.3Based on the use of structure

4.3.4Based on the type of covering material

4.3.5Based on the type of ventilation

4.3.6 Based on environmental control

Crops recommended for cultivation in protected cultivation

Vegetables	Tomato, cherry tomato, salad cucumber,onion,cabbage, cauliflower,yardlongbean,bellpepper,chilly,okra,radish,broccoli, melons, Frenchbean,amaranthus, palak,lettuce,egg plant
Fruits	Strawberry, grapes,citrus,banana, watermelon
Ornamental plants	Rose,Gerbera,Carnation,Orchids,Anthurium, Chrysanthemum, Potted plants,Lilly
Others	Tobacco, nurseries, fresh herbs

Principles and practices to be followed in greenhouse vegetable cultivation

Orientation:

Size of the greenhouse:

Spacing between greenhouses:

Height of greenhouse:

Land preparation

Planting

Fertigation

Intercultivation

Plant protection

Plant protection is a very important aspect with respect to protected cultivation. Pest or disease incidence in one crop may severely affect the entire crops. The various strategies are:-

- Cultural methods:-
- Mechanical and physical methods:-
- Biological control:-

Media preparation

Soil sterilization

Requirement for 1008m^2 green house

- Formalin- 80lit
- Water- 800lit
- Plastic barrel – 200lit capacity

Climate Control inside the green house

Equipments for measuring climatic parameters

Sl No	Parameter	Measuring equipments
1	Light/Radiation	Radiation meter, Lux meter
2	Temperature	Glass thermometer, IR thermometer, Bimetal thermometer,
3	Relative Humidity	Psychrometer,Hygrometer,Electric moisture meter
4	CO2 concentration	CO2 meter,CO2 analyser
5	Wind speed	Anemometer
6	Wind Direction	Wind vane
7	Rain/Precipitation	Rain gauge, Rain indicator

Automation in climate control

Irrigation

Microirrigation can be considered as an efficient irrigation method which is economically usable, technically feasible and socially acceptable.Drip Irrigation is the common method of irrigation used in protected cultivation.

The main components of a micro irrigation system are

1.Water Source

2.Pumpset

3.Main and submain pipes

4.Lateral pipes

5.Filters

- Primary Filters- Sand filters &Hydrocyclon filters
- Secondary filters- Screen filters & Disc filters

6.Drippers

a.Online dripper
b.Inline Dripper

7. Pressure Guage

8. Misters / Foggers

FERTIGATION

Characteristics of fertilizers used for fertigation

Commonly used fertilizers in greenhouse

Nutritional disorders of crops:

Plant protection in polyhouses

Common pests in polyhouse crops:

Insect and mite pest management in crops under protected environment
Diseases in polyhouse crops:

General integrated management procedures

1. **Preventive approaches**

2. Curative approaches
Crop protection equipments

a. Manually operated spraying equipments
   Hand rotary duster, knap sack sprayer, rocker sprayer
b. Power operated spraying equipments
   Single piston, Double piston, HTP and ULV sprayer

Sticker spreaders

Sticker is a spray additive which can improve the performance of biopesticides, micro nutrients and pesticide sprays.

Advantages of stickers

- Helps better spread, retention and penetration over plant surface
- Increases the effectiveness of pesticides

- Reduces the amount of dosage per usage
- Helps to increase crop yield
  Eg.Stickers- Suruchi Rain
  Eg. Spreaders- Silvet Gold

ArcGIS:
Monitoring software for Polyhouse/greenhouse

Soil less cultivation

Hydroponics

Basic material needed for setting up a hydroponic system

1. **Container**
2. **Covering material**
3. **Nutrient solution**
4. **Seedling medium**

Setting up a hydroponic system

- To begin the box for planting, fillit first about ¾ full of the nutrient solution.
- Then prepare the pots for planting. Place a piece of netting on the bottomof the pots.
- This helps prevent the seedling medium from coming down and separating the root system.
- It also helps in the uptake of oxygenand the absorption of the nutrient solution.
- Net tray rather than pots can be used to plant large root plants such as onions or radishes.
- The pots about three fourth full of seedling medium.
- Then place the pots into the perforated lid of the box
- Check to make sure that the pots are placed so that the solution is 2-3 cm above the bottom of each pot. Sow the seeds and cover lightly with more smoked rice hull
- Remember to cover the box with the netting to prevent insect invasion. When it is raining, cover it with plastic to keep out the rainwater. Leave the plants to grow with little care.
- As the plants grow the roots develop in the box. The roots which are exposed to the air are called the roots and the roots which are submerged are called the WN roots.
- The success of the hydroponic system is dependent on the rapid growth and quantity of these O roots.

Basic requirements for a hydroponic system

a. Light
b. Oxygen -Nutrient Ratio
c. Nutrient Strength
d. Growth Medium
e. pH - Alkalinity And Acidity

f. Temperature
g. Air
h. Water Quality

Crops cultivated

Almost any plants can be grown. Leafy vegetables such as lettuce, tomatoes, cucumbers, peas, strawberry, and herbs.

AQUAPONICS

In Kerala aquaponics farms are established in Idukki, Ernakulam, Kozhikode. Kerala State fisheries department has drawn up plans to use aquaponics system with Thilapia to help the newly launched efforts to produce safe to eat vegetables

Precision farming/ satellite farming

This is a farming management concept based on observing, measuring and responding to inter and intra field variability in crops. The highlight of precision farming will be the ability to define the Decision Support System (DSS) for whole farm management with the goal of optimizing returns on inputs while preserving resources.

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Assessment Activity
Prepare a comparison chart between hydroponics and aquaponics

List of portfolio items

1. Consolidation points based on the discussion on scope and benefits of protected cultivation considering present scenario of Kerala Agriculture.
2. Chart on factors emphasising the need of Hitech horticulture in Kerala.
3. Picture album on different protected cultivation structures based on type of cladding material used, structural material used ,shape of structure, ventilation and environmental control
4. Model of any protected cultivation structure with drip irrigation system
5. Filled up questionare based on interview with Hitech farmer giving overview of his farm
6. Field visit report on hitech farm
7. Chart on comparing hydroponics and aquaponics

Unit 2

Pesticides and pesticide residue elimination

Pesticides:Definition

Classification of Pesticides

- Insecticides – used for killing insects. eg - Ekalux
- Fungicides – used for killing insects. eg - Mancozeb
- Acaricides – used for killing mites. eg - Dicofol
- Weedicides/ Herbicides – used for destroying weeds eg- Glyphosate
- Nematicides – used for killing nematodes eg:- Carbosulphan

- Molluscides – used for killing slugs and snails, eg. Metaldehyde
- Rodenticides – used for killing rodents. eg:- Zinc phosphide
- Antibiotics – These are substances which are produced by micro organisms and which act against micro organisms. eg:- Streptomycin.

Additional Information

Naturally occurring insecticides like nicotine were used in the earlier period. Use of modern insecticides commenced in the year 1867. Paris green was used against Colorado potato beetle. The insecticidal properties of D.D.T. was discovered by Paul Muller in 1939. It marked a milestone in the history of insect control. Insecticidal property of B.H.C. was discovered in 1943

Insecticides

Classification of Insecticides

Insecticides are classified into certain groups.

- based on mode of entry.
- based on mode of action.
- based on chemical nature.

Based on mode of entry into insect system, insecticides are of four types.

- Stomach poison
- Systemic poison
- Contact poison
- Fumigants.

Advantages of a systemic insecticides	**Disadvantages of systemic Insecticides**
Not subjected to weathering.	Some of the systemic insecticides are highly toxic to higher animals and it causes pest resurgence
The toxicant is translocated in the apical direction, hence the fresh plant growths do not require application of pesticide for a long time.	
Safer to natural enemies	Insect has to feed sufficiently longer period to get lethal dose

Based on mode of action, insecticides are of four types

- Physical poison

- Protoplasmic poison
- Respiratory poison
- Nerve poison or Neuro toxicant

Based on chemical nature, insecticides are of two types

- Inorganic
- Organic

Organic insecticides of plant origin

Nicotine -

Pyrethroids

Rotenones -

Azadirachtin –

Organic insecticides of animal origin

Neries toxin

Synthetic Organic Chemicals (Modern synthetic chemicals)

- ✓ Organochlorines – eg. D.D.T., B.H.C., Dicofol
- ✓ Organophosphorus compound – eg. Ekalux, Malathion, Rogor

- ✓ Carbmates – eg. Carbaryl, Carbosulphan
- ✓ Synthetic pyrethroids – Eg. Permethrin, Cypermethrin etc.
- ✓ Fixed soaps and oils – eg. Fish oil soap
- ✓ Fumigants – eg. – Aluminium phosphide
- ✓ Other miscellaneous organic compounds.

New generation pesticides

- **Neonicotinoids** eg: Imidacloprids, Acetamiprid
- **Nereis toxin analogues** eg: Cartap hydrochloride(effective against borers, leaf eaters and sucking insects)
- **Spinosyns and spinosoids** eg: spinosad
- **Avermectins:** eg: Emamectin(effective against leaf eating caterpillar, leaf miners, thrips)
- **Ivermectins**: antiparasitic used against nematodes and ectoparasites in animals
- **Milbemycins**: Acaricide
- **Phenyl pyrazoles**: eg: Fipronil (lepidopterans and orthopterans)
- **Oxadiazines**: Indoxacarb- considered as "reduced risk pesticide". Used in cockroach baites
- **Anthranilic diamides**: Flubendiamide (leaf miners, feeders, borers)

Chlorantraniliprole- reduced risk insecticide which is non toxic to birds and fish, effective against leaf feeders and borers of rice and vegetables.

Insect growth regulators

- Chitin synthesis inhibitors
- Juvenile hormone mimics
- Moulting hormone agonists

Insect chemosterilants: It is a chemical compound which causes reproductive sterility in an organism

Attractants: Attractants are chemicals which will induce movement towards their source. When insects come they may be killed by insecticides. Eg. Methyl euginol for male Daccus dorsalis (Oriental fruit flies)

Pheromones : It is a chemical produced by an organism which is capable of changing the behavior of another organism of the same species**.**

Insect repellants: These are chemicals which cause insects to move away from the source. Action is opposite to that of attractants. Eg. Naphthalene, Neem oil etc.

Antifeedants: A chemical agent that causes a pest to stop eating that substance eg: Neem

Cypermethrin is a constituent of insecticidal chalk preparation to control household pest

Fungicides

Fungicides are chemical agents that kills or inhibits the development of the fungus spore or mycelium.

Antibiotics- Antibiotics are substances which are produced by micro-organisms and which act against other micro-organisms. Most antibiotics known are products of actinomycetes and some are from fungi and bacteria. The important antibiotics for the control of plant diseases are Streptocyclin (antibacterial), Aureofungin (antifungal) *etc*.

Fungicides are divided in to two,

- **Inorganic –** contains no carbon eg; Bordeaux mixture, Bordeaux paste, cheshunt compound, Sulphur, copper oxychloride *etc*.
- **Organic compounds –** contains carbon. eg synthetic organic fungicides like Carbendazim, Ziram, Mancozeb *etc*.

Herbicides: Chemicals used for weed control.

Classification of herbicides

- based on point of application.
- based on mode of action
- based on time of application
- based on selectivity

Based on the point of application

- Soil herbicides
- Foliar herbicides
- Aquatic herbicides.

Based on mode of action

Contact herbicides : They kill the plant or the plant part that comes into contact with the chemical. To be effective,the herbicide must cover the foliage . The underground roots, rhizomes etc. may not be damaged by the contact herbicide. Hence these plant parts may regenerate. Eg.Paraquat, Propanil etc.

Systemic / Translocated herbicides: - These herbicides enter a plant and move within

Common names	Commercial formulations and concentration	Recommended dose, kg ai/ha	Product per ha	Crops recommended	Hints on time and method of application

the plant and kill the tissues at a distance from the point of entry (application). They enter the plant usually through leaves, stems, root etc. These systemic herbicides are effective in destroying roots of perennial weeds. The systemic herbicides move through the vascular system to the growing point of roots and shoots. eg: 2,4 –D, Glyphosate, Dalapon

Based on time application

Pre-plant herbicides - These herbicides are applied to the soil before the crop is planted as they are likely to produce a toxic effect on emerging crop seedlings eg : Calcium cynamide ,vapam

Pre-emergent herbicides – These herbicides are applied after sowing, but before the actual emergence of the crops or weeds. Eg. Butachlor ,diuron,atrazine,oxyflurfan etc

Post-emergent herbicides – These herbicides are applied after the emergence of the weeds. eg. Paraguat, Glyphosate

Based on selectivity

Selective herbicides - They are selective in action and kill plants of only certain species while plants of all other species survive. eg. 2,4-D (effective on broad leaved plants) , dalapon(controls grassy weeds)

Non-selective herbicide – They include chemicals which are not selective and controls plants of all species . eg. Paraquat ,glyphosate

a. **Selective herbicides**					
2,4-D sodium salt	Fernoxone 80% WSP	0.8-1.0	1.0- 1.2 kg	Rice - for control of broad leaved weeds and sedges	Apply at 20-25 DAS / DAT
Butachlor	Machete 5% G			Rice - wet sown and transplanted	Broadcast evenly on soil surface at 7 DAS or at 4- 8 DAT
Oxyfluorfen	Goal 23.5% EC	0.15	0.641	Rice – dry sown Banana	0-3 DAS Pre-emergent spray
Cyhalofop butyl	Clincher 10% EC	0.08	800 ml	Rice - for control of *Echinochloa* sp.	Spray 18-20 DAS
Diuron	Klass 80% WP	1.50 - 3.00	1.9 - 3.8 kg	Banana Pineapple	Pre-emergence spray or directed spray when tank-mix with paraquat
b. **Non–selective herbicides**					
Glyphosate	Roundup 41%SL Glycel 41% SL Weed All 41%SL	0.8	2.01	Do	Do

Formulations

Insecticide manufactured in pure form is called technical grade material or active ingredient (a.i).

Formulation is the processing of a pesticide compound by any method which will improve the properties of storage, handling and safety of the pesticide.

Types of formulations

Formulations are of mainly two types

- Dry/ solid formulations
- Liquid formulations

Dry/ solid formulations

1) Dust (D or DP- Dustable Powder) - eg. Sevin 10% Dust

Disadvantage of dust formulations - it causes drift problem (may be carried away by wind). So it is better to apply in the morning when plants are wet with dew drops.
2) Granules (G) or (GR) - eg:- Quinalphos 5%GR .,Carbosulphan 6% G.
Advantages of granules are,

- No problem of drift, granules can be broadcasted so water is not required,
- No residue problem so it is less harmful to natural enemies.

Disadvantages are,

- granular formulations are not as effective as others to crawling insects
- If the concentration is more scorching on burning of leaf occur.

3) Wettable Powder (W.P.)
4) Water Dispersible Powder (W.D.P) - It is like wettable powder. But during spraying agitation is required, otherwise it settle down to bottom.
5) Water soluble Powder (S.P) or (WSP) -the formulation is water soluble.
6) Tracking powders
These are used for monitoring and controlling rodents and insects. For rodent control, it consists of finely ground dust combined with stomach poison. Rodents pick it up on their feet and fur while walking and ingest it when they clean themselves.
7) Wettable granules/ water dispersable granules (WG/WDG)
Once in water , the granules break apart into fine particles similar to wettable powders. This requires constant agitation to keep it suspended in water.
Eg. Fipronil 80 WG
Liquid formulations

1) Emulsifiable Concentrate (E.C) - It contains toxicant + solvent + emulsifying agent. When E.C is sprayed, solvent evaporates leaving deposits of toxicant
2) Ultra low Volume concentrates (U.L.V) - The technical grade material is dissolved in minimum quantity of solvent so that there is no need of further dilution.
3) Oil Solution - It is an oil concentrate which diluted with water before application
4) Invert emulsions
5) Solution concentrates(SC)/ Soluble liquids (SL)-Spinosad 2.5% SC
6)Flowables (F)/ FLowable suspensions (FS)-Eg: Imdachlorpid 48% FS

7)Foggingconcentrates
These are used in public health programmes for controlling adult flies and mosquitoes.
Other formulations
Aerosols - Minute particles suspended in air, as a fog or mist. Toxicant is dissolved in liquefied gas and released through small hole. So toxicant particles float in air with evaporation of released gas. These are the most common of all formulations for home use and are available as ready to use (RTU) low concentration solutions
Fumigants - Insecticides in gaseous state. Usually formulated liquid under pressure, sometimes available in the form tablets. eg:- Celphos tablets, used in godowns. Fumigants are used for the control of stored product pests, soil insects, nematodes, weed seeds, rodents etc. eg: Aluminium phosphide. eg:- Celphos tablets, used in godowns

Insecticide Cum Fertilizer Mixture - This is formulated by mixing granules with chemical fertilizers. It gives nutrients as well as protects plant.

Micro en-Capsulated Materials - Insecticides are wrapped in tiny beads made up of poly vinyl or plastic covering when applied insecticides are released at a slow rate for a long time. The plastic coating breaks down and slowly releases the toxicant. Dry or liquid pesticides are covered with plastic coating. This is mixed with water and sprayed

Slow release insecticides: These are very recent formulations.The pesticide incorporated in strips volatalises slowly and control pests over a long period of time. In India, simple adhesive strips are used in UV traps for killing flies, mosquitoes and other flying insects.

Water soluble packets: Precise amounts of wettable Powder or soluble powder formulations are packaged in special type of plastic bags. When these bags are dropped in water inside spray tanks, plastic dissolves and contents are released.

Pesticide Adjuvants

A pesticide adjuvant may be defined as any substance that when combined with a pesticide increases its sticking, spreading or wetting qualities, makes it safer, aids in its dilution or uniform dispersion and increases its toxicity to the target pests.

- **Sticking Agents** - These substances have the function of increasing the retention of spray or dust deposits on plants. eg - milk products, blood albumin and gelatin.
- **Spreaders and Wetters** - These are substances that lower the surface tension of a spray and therefore increase its spreading and penetrating power.
- **Emulsifying Agents** - Many pesticides are not soluble in water. Since these organic solvents will not normally mix and stay dispersed in water substances known as emulsifiers must be used with them to form stable, milky suspensions of the pesticide. Such a spray is called an emulsion. Emulsifying agents reduce the tendency of an emulsion to break up into its component parts.

- **Safeners or Correctives** - These are substances that are added to sprays to prevent loss of effectiveness or to reduce the danger of foliage injury.
- **Synergists** - These are compounds when used in conjunction with a pesticide; increase the toxicity of the mixture over the sum of the toxicities of its components. Some synergists in use are piperonyl butoxide, and sulfoxide.
- **Diluents or Carriers** - A carrier may be any material used to dilute or decrease the amount of active ingredient in any spray or dust. Sulphur is valuable both as a diluent and as a fungicide in many dust formulations.

List of banned pesticides with substitutes

Sl. No	**Name of chemical banned**	**Present Recommendation**	**Substitute chemicals recommended against banned chemical**
1	Endosulfan	Not recommended by KAU	1.Carbaryl 50%WP 2.Quinalphos 25%EC
2	Carbofuran (Red)	**Rice** Stem Borer, Gall Midge, BPH, GLH, Hispa, Nematodes	1.Carbosulfan 6 % G 2.Cartap hydrochloride 4% G 3. Quinalphos 5% G 4.Fipronil 0.3% G 5.Chlorantraniliprole 0.4% G 6.Thiamethoxam 25% WG 7.Flubendiamide 39.35% SC 8.Flubendiamide 20% WG 9.Imidacloprid 17.8% SL 10. Acephate 75 SP
		Banana Aphid (Vector of virus diseases)	Dimethoate 30 EC
		Nematodes	Carbosulfan 6% G
		Brinjal (sucking pests	1.Azadirachtin 1%EC 2.Azadirachtin 0.03 %EC 3. Spinosad 45% SC
		Cardamom Nematodes	Carbosulfan
3	**Phorate (Red)**	Rice(Stem Borer, Gall Midge, BPH,	1.Carbosulfan 6% G 2.Cartap hydrochloride 4% G

		GLH, Hispa, Nematodes)	3.Quinalphos 5% G 4.Fipronil 0.3% GR 5.Chlorantraniliprole 0.4% G 6.Thiamethoxam 25% WG 7.Flubendiamide 39.35% SC 8.Flubendiamide 20% WG
4	**Methyl Parathion** (Red)	**Rice (**BPH, Thrips, Hoppers, bugs, leaf folder)	1. Quinalphos 5%G 2.Quinalphos 25 % EC 3.Carbaryl 5% DP 4.Carbaryl 85%WP 5.Chlorpyrifos 20% EC 6.Fipronil 5%SC 7.Thiamethoxam 25% WG 8 Acephate 75 SP
		For stem borer and folder	1. Cartap hydrochloride 4% G 2. Cartap hydrochloride 50% SP 3. Fipronil 80% WG 4. Chlorantraniliprole 18.5%SC 5. Chlorantraniliprole 0.4% Gr 6. Flubendiamide 39.35% SC 7. Flubendiamide 20% WG 8. Imidacloprid 17.8% SL 9 Acephate 75 SP
5	**Monocrotophos**	**Rice** (BPH, Stem borer, Leaf Folder)	1. Quinalphos 5%G 2. Quinalphos 25 % EC 3. Carbaryl 5% DP 4. Carbaryl 85%WP 5. Chlorpyrifos 20% EC 6. Fipronil 5%SC 7. Thiamethoxam 25% WG 8 Acephate 75 SP
		For Stem borer and leaf folder	1 Cartap hydrochloride 50% SP 2 Fipronil 80% WG Yellow 3 Chlorantraniliprole 18.5%SC 4 Chlorantraniliprole 0.4% G 5 Flubendiamide 39.35% SC 6 Flubendiamide 20% WG 7 Acephate 75 SP 8 Cartap hydrochloride 4% G
		Cardamom (Thrips & pod	1.Quinalphos 25% EC 2.Phenthoate 50%EC

		borer)	3.Diafenthiuron 50%WP 4.Dimethoate 30% EC
6	**Triazophos** (Yellow)	Rice Leaf folder	1.Cartap hydrochloride 4% G 2.Cartap hydrochloride 50% SP 3.Fipronil 80% WG 4.Chlorantraniliprole 18.5%SC 5.Chlorantraniliprole 0.4% Gr 6.Flubendiamide 39.35% SC 7.Flubendiamide 20% WG 8.Spinosad 45 SC
Fungicides			
7	**Methoxy Ethyl Mercuric chloride** (MEMC)		Not yet evolved ,but 1% BM can be used
8	**Ediphenphos** (Red)	Rice blast	1. Carpropamid 27.8% SE 2.Carbendazim 50%WP 3.Isoprothiolane 40%EC 4.Kresoxim Methyl 44.3%SC 5. Tebuconazole 25.9%EC
		Rice sheath blight	1.Carbendazim 50%WP 2.Kresoxim Methyl 44.3%SC 3. Tebuconazole 25.9%EC 4. Pencycuron 22.9%SC 5.Flusilazole 40%EC 6. Hexaconazole 5%EC 7.Iprodione 50%WP
		Brown leaf spot	1.Carbendazim 50%WP 2. Propineb70%WP
		Rice sheath rot	1.Carbendazim 50%WP 2. Carboxin 75%WP
	Tricyclazole Yellow	Rice blast	1.Carbendazim 50%WP 2. biocontrol with Pseudomonas
	Oxythioquinox	Tobaco and Green peas powdery mildew	Not yet evolved
Herbicides			
	Paraquat (Yellow)	Non crop	1.Glyphosate 41%SL

		situation	
	Anilophos(Yellow)	Rice	1. Butachlor 50%EC 2.Pretilachlor 50%EC
	Atrazin (Blue)	Sugarcane	1.Diuron 80%WP
	Thiobencarb (Blue)	Rice	1. Butachlor 50%EC 2.Pretilachlor 50%EC

Pesticide calculation

Insecticides

Calculation of quantity of commercial formulation required for given area

a) For all formulations except granules

$$\text{Quantity of commercial formulation} = \frac{\text{Quantity of spray fluid x Concentration of spray fluid}}{\text{Concentration of commercial formulation}}$$

b) For granular formulation

$$\text{Quantity of commercial formulation} = \frac{\text{Rate of Application per Ha x Area in Ha X100}}{\text{Concentration of Commercial Formulation}}$$

Fungicides

For calculations the active ingredient concentration of all commercial fungicides is taken as 100%

Quantity of commercial formulation = Volume of spray fluid X Recommended conc. of spray fluid in %

Weedicides

$$\textbf{Quantity of herbicide required} = \frac{\textbf{Rate of application in kg ai / ha x Area in ha X100}}{\textbf{Strength of commercial product}}$$

Pesticides and Toxicity

Acute toxicity

It refers to the pesticide's ability to cause injury/ adverse effects to man or animal from a single exposure/dose or from multiple exposures in a short span of time(less than 24 hrs) by any of the four routes ie. Oral, dermal, inhalation or eyes. It is measured as LD 50 or LC 50 values.

LD 50 (Lethal Dose) value: of an organism is the amount of poison per unit weight of the organism required to kill 50 % of the population and is usually expressed as milligram per kilogram(mg/kg) body weight.

LC 50 (Lethal Concentration) value: is the concentration of the chemical in the external medium required to kill 50 % of the test population. This value is used when the exact dose given to the insect cannot be determined.

LT 50 (Lethal Time)value : is the time required for 50% mortality of the test organism at a specified dose or concentration.

In some case the rate of knock down rather than kill is measured as a criterion of toxicity. In such cases the KD 50 (Knock down dose) or KT 50 (Knock Time)is used.

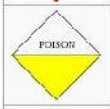
Chronic toxicity

Chronic toxicity refers to the adverse health effect of a pesticide upon repeated exposure often at low levels over long period.

The harmful effects are known as chronic effects which include birth defect, toxicity to foetus, production of malignant or benign tumours, genetic change, blood disorder, nerve disorder, impaired liver function, endocrine disruption, reproduction effects etc.

Toxicity Categories

Based on the toxicity to higher animals, pesticides are classified into four categories

Label	Name	Level of toxicity	Oral lethal dose mg per kg body weight of test animal	Listed chemicals
	Red label	Extremely toxic	1-50	Monocrotophos, zinc phosphide, ethyl mercury acetate, and others
	Yellow label	Highly toxic	51-500	Endosulfan, carbaryl,[2] quinalphos,[2] and others.
	Blue label	Moderately toxic	501-5000	Malathion, thiram, glyphosate,[2] and others.
	Green label	Slightly toxic	More than 5000	Mancozeb, oxyfluorfen, mosquito repellant oils and liquids, and most other household insecticides

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Pesticide Labels and labelling

According to the provisions of the Insecticides Act, 1968, it is mandatory that all pesticides should possess a label. Every pesticide manufactured/ formulated in India should be packed in a safe container and provided with a label displayimg all the relevant information regarding the pesticide.

1.Name of the pesticide

There are 3 distinct names for every pesticide.

i)Common name (Generic Name): It is a name given to a pesticide to identify it globally. The common name should give an indication about the chemical identity of the product. Eg: Mancozeb, Quinalphos,Imidacloprid

ii)Trade Name, brand name or commercial name; It is the name given by the manufacturer / formulator of the product highlighting their interests.

Common name	Trade names
Quinalphos	Ekalux, Flash, Vazra
Hexaconazole	Contaf
Glyphosate	Roundup

iii)Chemical name(scientific name): It is the name given to a pesticide indicating clearly the chemical nature of the product. Eg: Carbaryl- 1-Naphthyl –methyl- carbamate

Legal regulatory measures regarding pesticide handling

According to the Insecticide act 1968, Insecticide rules 1971 and its amendments in 1977, no person is permitted to stock, exhibit for sale or distributes any insecticide unless it is packed and labeled in accordance with the provisions of the act

Additional Information

In India, the pesticides regulations are governed under the following Acts/Rules:

1 The Insecticides Act 1968 and Rules 1971
2 Prevention of Food Adulteration Act 1954
3 The Environment (Protection) Act 1986
4 The Factories Act 1948
5 Bureau of Indian Standards Act
6 Air (Prevention & Control of Pollution) Act 1981
7 Water (Prevention & Control of Pollution) Act 1974
8 Hazardous Waste (Management & Handling) Rules 1989

However, on April 24, 2008, the Union Cabinet gave its approval for the introduction of the Pesticides Management Bill 2008, which will replace the

existing Insecticide Act 1968.

The Bill aims at improving the quality of pesticides available to Indian farmers and introducing new, safe and efficacious pesticides. The Bill seeks more effective regulation of import, manufacture, export, sale, transport, distribution and use of pesticides to prevent the risk to human beings, animals, or environment and to de-license retail sale of household insecticides. Besides, the Bill is also promoting a detailed categorisation of offences and punishments for greater deterrence to violators and timely disposal of time-barred pesticides in an environmentally-safe manner.

Biomagnification

Biomagnification is the bioaccumulation of a substance up the food chain by transfer of residues of the substance in smaller organisms that are food for larger organisms in the chain. It occurs when a chemical becomes more and more concentrated as it moves up through a food chain.

Eg. DDT, cyclodienes, like aldrin, endrin, chlordane, heptachlor

For the biomagnification to occur, the pollutant must be

- long-lived,
- mobile,
- soluble in fats and
- Biologically active.

Bio magnification Hazards

There are three main types of hazards associated with fresh produce

- Biological hazards (caused by food borne microorganisms)
- Chemical hazards (Pesticides, fertilisers , antibiotics , heavy metals, oils ..)
- Physical hazards (foreign bodies like residual soil and stone , remains of packaging, glass and sharp objects)

Ill effects of biomagnification

- Insect resistance to pesticides,
- Shell-thinning in birds, particularly carnivorous birds.
- Life threatening diseases

Residual toxicity:

Residual toxicity is the presence of pesticide residue in any specified substances in food, agricultural commodities, or animal feed resulting from the use of a pesticide.

The term includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products, and impurities considered to be of toxicological significance. The concentration is generally expressed in parts per million (ppm) or parts per billion (ppb).

The toxicity of a pesticide is its capacity to cause injury to a living system, may be a human body, or parts of the body (such as the lungs or the respiratory system); a pond, a forest and those creatures that live there.

The toxicity of a pesticide is dependent on a number of factors.

1. Dose: It is the quantity of a pesticide that a surface, plant, or animal is exposed to.
2. Time: How often the exposure occurs.

Thus, the how much of the substance is involved and how often the exposure to the substance occurs gives rise to two different types of toxicity - acute and chronic toxicity.

Maximum residue limits (MRL):

Maximum residue limit may be defined as the maximum levels of pesticide residue present in or on a produce when pesticide is used under supervision following good agricultural practices (GAP). The concentration is expressed in milligrams of pesticide residue per kilogram of the commodity.

Under the Prevention of food adulteration Act, MRL or Tolerance Limits (TLs) are fixed considering MRLs based on supervised trials conducted in India as well as the dietary habits of

Pesticide residues on crops are monitored through the use of **Maximum Residue Limits** (MRL), which are based on the analysis of the quantity of a given chemical remaining on food product samples.

Waiting period - is the time gap between the application of a pesticide and harvest of a produce to reduce its toxicity to a safe level. It is the period of time given for a pesticide to degrade and reduce its level of toxicity to a safer level after its application. Waiting period depends on the chemical, crop treated, dose and method of application.

Pesticide	Crops	WP
Quinalphos	Bhindi	3 days
	Bittergourd	5 days
	Black pepper	12 days

Precautions to be taken while handling plant protection chemicals

Most of the poisoning results from careless handling of pesticides. Accidents can be avoided if safety measures are strictly followed.

1. Keep the insecticide in closed and properly labeled container in a dry and cool place, away from food, fodder *etc*. and in a place where children and animals cannot reach.
2. Use insecticide according to the instructions given on the container or leaflet and adhere to the dosages recommended.

3. Children or domestic pets should not be allowed near the mixing place and do not mix the chemicals near open wells used for drinking purposes.
4. Persons handling insecticide should avoid contact of the insecticide with their skin and inhalation of dust, vapours or mist. The minimum precaution of wearing rubber gloves and covering the eyes and nose should be taken.
5. The operators must not smoke, eat or drink anything while applying the chemical.
6. Empty bottles should be destroyed immediately after use by burying in soil.
7. After finishing the work they should take a bath or wash their hands and face with soap and water thoroughly and change their cloths.
8. The cloths worn by them during spraying operations should be washed properly and seperately.
9. Spraying or dusting must not be done when the wind is high.
10. Clogged nozzles or hoses must not be blown out with mouth for clearing.
11. Workers regularly engaged in spraying oprations must under go frequent medical checkups.
12. If any symptoms of poisoning is noticed immediately contact doctor

Pesticide residue elimination

The following practices/ treatments were evaluated for their efficacy in removing residues of the insecticides detected in fruits and vegetables.

- Common salt 2% (20 g of common salt dissolved in one litre of water)
- Tamarind 2% (20 g of preserved tamarind pulp extracted in one litre of water)
- Vinegar 2% (20 ml of vinegar diluted in one litre of water)
- Slaked lime 2% (20 g of hydrated lime dissolved in one litre of water)
- Baking soda 2% (20 g of baking soda ($NaHCO_3$) dissolved in one litre of water)
- Turmeric 1% (10 g of turmeric powder dissolved in one litre of water)
- Scrubbing for 2 minutes
- Washing in water and steaming for 10 minutes
- Washing in water for 10 minutes.
- Peeling/Removal of skin of fruits and vegetables
- Use of u.v radiation

Fruits of the crops harvested can be dipped in the decontaminating solutions for 20 minutes and then washed in running water.

Pesticide residuedecontamination.

1.Coriander leaf

Cut band remove roots with basal portion of the stem and keep in the refrigerator inside a plastic container covering the leaves with tissue paper or wide threaded cloth. Immerse in diluted vinegar(20 ml of vinegar in one litre of water). Or salt solution (20 g salt in one litre of water)for10 minutes and wash in water repeatedly before use.

2.**Carrot, Drumstick, Beetroot**

Wash repeatedly and keep in a container with holes overnight for draining water. Wipe off moisture and keep in the fridge covering thew vegetables with cotton cloth. Scrape off the skin and wash again before use.

3.**Curry leaf, Mint leaf, Chillies add other Capsicum spp**

Immerse in diluted vinegar(20 ml of vinegar in one litre of water),tamarind water (20g tamarind in one litre water and filtered) or tamarind paste mixed in water(two table spoon tamarind paste in one litreof water) for ten minutes . Wash repeatedly and keep in a container with holes overnight for draining water. Keep in the refrigerator inside a plastic container covering the leaves with tissue paper or wide threaded cloth. Remove the stalks of chillies and other capsicum spp. before keeping in fridge.

4.**Cowpea, Bean, Snake gourd,Bitter gourd, Bhindi**

Wash repeatedly by scrubbing the surface using a soft scrub pad. Immerse in diluted vinegar, tamarind or tamarind paste water for ten minutes. Wash again repeatedly, wipe off moisture and keep in the fridge.

5.**Amaranthus**

Cut and remove roots with basal portion of the stem and Immerse in diluted vinegar, tamarind or tamarind paste water for ten minutes. Wash again repeatedly, wipe off moisture and keep in the fridge.

6.**Gooseberry, Coccinia**

Immerse the fruits in diluted vinegar, tamarind or tamarind paste water for ten minutes. Wash again repeatedly, wipe off moisture and keep in the fridge.

7.Cabbage, Onion

Remove outer skins/leaves and wash repeatedly in water before use. (the vegetables can be kept in containers with holes for short durations if fridge is not available)

Definition
Organic certification is a certification process for producers of organic food and other organic agricultural products. In general, any business directly involved in food production can be certified, including seed suppliers, farmers, food processors, retailers and restaurants.

Unit 3
Organic Certification
Certification is a procedure by which a third party gives a written assurance that a product, causes or service is in conformity with certain standards

Production standards for organic certification

Organic standards are defined as minimum production practices including storage, transportation, processing, handling, packing and labelling requirements which must be followed for certifying the products as organic.

1.avoidanceof synthetic chemical inputs(e.g. fertilizer, pesticides, antibiotics, food additives), irradiation, and the use of sewage sludge
2. avoidance of genetically modified seeds
3. use of farmland that has been free from prohibited chemical inputs for a number of years (often, three or more)
4. for livestock, adhering to specific requirements for feed, housing, and breeding
5. keeping detailed written production and sales records (audit trail)
6. maintaining strict physical separation of organic products from non-certified products
7. undergoing periodic on-site inspections.

Purpose of certification

- Organic certification addresses a growing worldwide demand for organic food.
- It is intended to assure quality and prevent fraud.
- Organic certification improves the image of organic agriculture and provides transparency in certification. For gaining consumer's confidence, valid organic certification is an essential pre-requisite for marketing especially in the export market.
- Generally organic certification involves many standards, inspection and certification.

Process of organic certification

Certification process focuses on the methods and materials used in production. There are two main requirements.
1. The methods and materials used in production must meet organic standards.
2. There must be clear and ongoing documentation of these methods and materials.

To certify a farm, the farmer is typically required to engage in a number of new activities, in addition to normal farming operations:

- **Study** the organic standards, which cover in specific detail what is and is not allowed for every aspect of farming, including storage, transport and sale.
- **Compliance —** farm facilities and production methods must comply with the standards, which may involve modifying facilities, sourcing and changing suppliers, etc.
- **Documentation —** extensive paperwork is required, detailing farm history and current set-up, and usually including results of soil and water tests.

- **Planning —** a written annual production plan must be submitted, detailing everything from seed to sale: seed sources, field and crop locations, fertilization and pest control activities, harvest methods, storage locations, etc.
- **Inspection —** annual on-farm inspections are required, with a physical tour, examination of records, and an oral interview.
- **Fee —** an annual inspection/certification fee (currently starting at $400–$2,000/year, in the US and Canada, depending on the agency and the size of the operation). There are financial assistance programs for qualifying certified operations.[3]
- **Record-keeping —** written, day-to-day farming and marketing records, covering all activities, must be available for inspection at any time.

For first-time farm certification, the soil must meet basic requirements of being free from use of prohibited substances (synthetic chemicals, etc.) for a number of years. A conventional farm must adhere to organic standards for this period, often two to three years. This is known as being in *transition*. Transitional crops are not considered fully organic. The time between the start of organic management and certification of crops and/or animal husbandry is known as the conversion period. The whole farm, including livestock, should be converted according to the standards over a period of three years.

Product Labelling

Being able to put the word "organic" on a food product is a valuable marketing advantage in today's consumer market. Certification is intended to protect consumers from misuse of the term, and make buying organics easy. However, the organic labelling is made possible by certification.
In many countries organic legislation defines **three levels of organics**. Products made entirely with certified organic ingredients and methods can be labelled **"100% organic".** Products with 95% organic ingredients can use the word **"organic"**. Bothmay also display organic seal. A third category, containing a minimum of 70%organic ingredients, can be labelled **"made with organic ingredients".** In addition,products may also display the logo of the certification body that approved them.

Organic certification in India
To provide a focused and well directed development of organic agriculture and quality products, Ministry of Commerce and Industry, Government of India, launched a National Program on Organic Production (NPOP) in the year 2000, which was formally notified in October 2001 under the Foreign Trade & Development Act (FTDR Act). This

document provides information on standards for organic production, systems criteria, and procedures for accreditation of Inspection and Certification
bodies, the national organic logo and the regulations governing its use. The standards and procedures have been formulated in harmony with international standards such as those of Codex and IFOAM.
These make it mandatory that all certification bodies whether international or foreign operating in the 150 country must be accredited by an Accreditation Agency.

ORGANIC LOGO A trademark – "India Organic" will be granted on the basis of compliance with the National Standards for Organic Production (NSOP). Communicating the genuineness as well as the origin of the product, this trademark is owned by the Government of India. Only such exporters, manufacturers and processors whose products are duly certified by the accredited inspection and certification agencies, will be granted the licence to use of the logo which would be governed by a set of regulations.

"India Organic"- Symbolizing the rhythm of cosmic and earth forces represented by the blue and brown waves of force and energy, 'India Organic' logo celebrates the essence of nature.

Six accreditation agencies in India

1. Agriculture Processed Food Products Exports Development Authority (APEDA).
2. Coffee Board.
3. Spices Board.
4. Coconut Development Board.
5. Tea Board.
6. Directorate of Cashew and Cocoa Development.

APEDA has recognized the following Inspection Certification bodies, all of these are able to certify based on the NPOP:

- BVQ1 (India) Pvt. Ltd (Mumbai)
- E cocert (Aurangabad)
- IMO control private limited (Bangalore)
- Indian organic certification agency (Indocert, Aluva)
- International Resources for farmer trade members
- Lacon quality certification Pvt. Ltd (Theepany, Kerala)
- National organic certification Association Pvt. Ltd (Pune)
- One Cert Asia Agri Certification Pvt. Ltd (Jaipur)
- SGS India Pvt. Ltd (Gurgaon)
- Skal International (Bangalore

Good Agricultural Practices (GAP)

There are numerous systems that growers can adopt to ensure safe food production, w*hich* include Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Hazard Analysis Critical Control Points (HACCP), Good Hygiene

Definition

Good Agricultural Practicesis acollection of principles to apply for on-farm production and post-production processes which results in safe and healthy food and non-food agricultural products. GAP are specific methods which, when applied to agriculture , create food for consumers or further processing that is safe and wholesome.

Objectives

1. Ensuring safety and quality of produce in the food chain
2. Improving natural resources use, workers health and working conditions,
3. Creating new market opportunities for farmers and exporters in developing countries.

Principles of Good Agricultural Practices for Selected Agricultural Components

1. Soil

Good practices related to soil include maintaining or improving soil organic matter through crop rotations, manure application, pasture management and other land use practices, conservation tillage practices

2. Crop Protection

Use resistant cultivars and varieties, adopt organic control practices, apply pest and disease forecasting techniques, promote integrated pest management (IPM)

3. Water

Good practices related to water will include those that maximize water infiltration and practices that avoid contamination of water resources

4. Crop and Fodder Production

Good practices related to crop and fodder production will include selection of cultivars and varieties with high productivity, quality, market acceptability and nutritional value, disease and stress resistance et

5. Harvest and On-farm Processing and Storage

Good practices related to harvest and on-farm processing and storage will include

- clean and safe handling for on-farm processing of products
- use recommended detergents and clean water for washing

- store food products under hygienic environmental conditions
- pack food produce for transport in clean and appropriate containers
- training of staff for giving awareness on personal health and hygine
- proper maintenance of equipment.

Unit 4

ICT enabled extension services in agriculture

Importance of ICT in Agriculture

ICT stands for " Information and Communication Technology". It refers to technologies that provide access to information through telecommunication.

A. Holistic Information Systems:

1. Harithakeralam: *www.celkau.in.*
2. Kissan Kerala Information System: *www.kissankerala.net*
3. Karshikajalakam: www.celkau.in
4. Farm Extension Manager: *www.farmextension manager.com*
5. KAU Agri-infotech Portal: *www. celkau.in.*
6. TNAU Portal: *www.agritech.tnau.ac.in*
7. AGMARKNET Portal:

B. Specific Information Systems:

1. Flowering plants of Kerala:
2. Fruitipedia: . www.fruitipedia.com
3. Flowers of India: www.flowersofindia.net
4. ATMA Kerala: www.atmakerala.in
5. Farmer advisory and KM system for Hi - tech agriculture: www.keralahitechagri.in.

C. Diagnostic and Calculation Tools

1. Crop Health Decision Support System: www.kissankerala.net.
2. Karshikajalakam: www.kissankerala.net.
3. Pest doctor: www.farmextensionmanager.com.
4. Online rubber clinic: clinic.rubberboard.org.in
5. Fertilizer Calculator: www.farmextensionmanager.com.
6. KAU Fertulator: www.celkau.in
7. Soil based plant nutrient management information system: www.keralasoilfertility.net
8. Pesticide calculation: www.farmextensionmanager.com
9. KAU E - Crop Doctor: www.celkau.in
10. Credit Calculator: www.farmextensionmanager.com

D. Kiosk Based Information Systems:

1. Agricultural Kiosk:
2. Nelkrishi.com:

Vegetable cultivation: www.celkau.in.

Types of Mobile Applications

A. **Data Logging and Management**: Apps under this category assist farmers in maintaining data records associated with farm activities Many farm management apps perform basic cost calculations as well.

B. **Location based Apps:**These apps use map and location details for their operations. These apps are essentially used as Market finder apps for farmers to sell their produce.

C. **Agriculture Specific Calculation Apps:** These are specially designed apps from experts in agriculture. They contain pre - fed data and values according to which calculations are performed regarding agriculture information.

E. **News and Information Specific**: This is the most common app category for any domain. Apps that provide news and information are highly useful and popular among users. In agriculture also many apps like Farm progress, Ag Weather tools etc. serve the purpose of delivering information relevant to agriculture stakeholders. From farmers' perspective, there are many apps that provide seed price, equipment price and similar information.

F. Another major section of informative apps are the weather information apps (Skymet, Accuweather, etc.). In some apps, weather forecast is provided with advisory messages as well. As a result, these apps become an additional knowledge tool for the users and help them perform activities in a well informed environment.

ASSESSMENT ACTIVITIES

Unit 1

1.Conduct a field visit to a high-tech farm and prepare a report on practices followed in a hitech farm.

Hints (pests , diseases and nutritional disorders , way of management)

2.Interview a hitech farmer and fill the prepared questionnare.(Questions should cover all aspects which will give a detailed overview of his farm)

3.Conduct a group discussion on scope and benefits of protected cultivation considering present scenario of Kerala Agriculture

4.Prepare a chart on the factors emphasising the need of Hitech horticulture in Kerala.

5.Prepare a picture album showing different protected cultivation structures based on type of cladding material used, structural material used ,shape of structure, ventilation and environmental control

Unit 2

1. Prepare a chart on classification of insecticides based on mode of entry, mode of action and chemical nature

2. Survey to a pesticide shop to get familiarized with the pesticides, pesticide labels and their formulations available in the market and prepare the list of pesticides with their price.

3. Prepare a chart on different types of formulations of pesticides

4. Prepare a chart showing list of new generation pesticides and banned pesticides with their substitutes

5. Picture album of ten different labels of pesticides and classify them according to their toxicity

6.Prepare a brochure to create awareness on chemical and bio magnification hazards.

7.Prepare an article on safe practices in handling pesticides for a leading Agricultural magazine

Unit 3

1. Group discussion on concepts and relevance of organic certification
2. Seminar on Organic certification (purpose of organic certification, organic certification agencies, process of organic certification)
3. Visit to an organic produce outlet to collect details on product labelling
4. Assignment on organic certification in India
5. Assignment on Good Agricultural Practices (concepts, objectives, key elements, potential benefits)

Unit 4

1. Brain storming on importance of Information communication technology (ICT) in Agriculture.

2. Powerpoint presentation on different popular agri extension related softwares and various farmer support schemes in Kerala.
3. Visit to the near by Krishi bhavan and list out the various ongoing farmer support schemes. Also observe the activities of agri clinic at the Krishi bhavan and prepare a report.

LIST OF ITEMS IN PORTFOLIO

Unit 1

1. Consolidation points based on the discussion on scope and benefits of protected cultivation considering present scenario of Kerala Agriculture.
2. Chart on factors emphasising the need of Hitech horticulture in Kerala.
3. Picture album on different protected cultivation structures based on type of cladding material used, structural material used ,shape of structure, ventilation and environmental control
4. Model of any protected cultivation structure with drip irrigation system
5. Filled up questionare based on interview with Hitech farmer giving overview of his farm
6. Field visit report on hitech farm
7. Chart on comparing hydroponics and aquaponics

Unit 2

1. Chart on classification of insecticides based on mode of entry, mode of action and chemical nature
2. Survey report on the pesticides, pesticide labels and their formulations available in the market
3. Chart on different types of formulations of pesticides
4. Chart on list of new generation pesticides and banned pesticides with their substitutes
5. Picture album of labels of insecticides
6. Assignment on ill effects of pesticide use quoting any incident and the significance of terms like MRL, WP and RT
7. Brochure on precautions to be taken while handling pesticides and ways to eliminate pesticide residues from vegetables

Unit 3

1. Consolidation points based on the discussion on concepts and relevance of organic certification
2. Seminar report on Organic certification (purpose of organic certification, organic certification agencies, process of organic certification)
3. Field visit report on product labelling
4. Assignment on organic certification in India

5. Assignment on Good Agricultural Practices (concepts, objectives, key elements, potential benefits

Unit 4

1. Consolidation points on importance of Information communication technology (ICT) in Agriculture
2. Seminar report

List of extended activities

Unit 1

Giving propaganda on the relevance of protected cultivation and about low cost protected cultivation structures

Preparation and sales of botanicals to the local people

Unit 2

Conducting seminars on the illeffects of indiscriminate pesticide use

Distriubution of leaflets showing simple methods to remove pesticide residues from vegetables

Unit 3

Undertaking organic vegetable framing in nearby houses

Setting up organic garden in any nearby office

Taking classes on organic certification highlighting the environmental benefits and high market price of organic certified products

Unit4

1. Conducting workshops on the use of ICT enabled agriculture related softwares
2. Updating farmers about various farmer support schemes

ON THE JOB TRAINING

OJT refers to that component of vocational curricula which takes placein a real job situation under the supervision of an expert or in- plant supervisor. It provides participation in the actual production of goodsand services. It prepares the student psychologically in developing entrepreneurship qualities.It helps in continuous evaluation of the student's work and knowledge.The student is exposed to the latest technology and equipments. The student finds the real feelings in taking instructions from the supervisor. It provides the student overall exposure and the use of material and machinery. It leads to increased production of goods and services to the employers at less cost.

Time : End of each module
Duration : 15 days per year

List of possible OJT Centres

GENERAL

1. Various institutions under Kerala Agricultural University(Colleges, research stations)
2. Krishi Vigyan Kendras (KVKs)
3. Krishi Bhavans
4. Central Government Institutions like CTCRI, CPCRI, IISR etc.
5. VFPCK centres
6. State Horticulture Mission
7. Master Farmer's Fields
8. Various Commodity Boards, Government of Kerala
9. District Seed Farms
10. Extension Training Centres
11. Various NGOs like Thanal, PASSS, Mithra Niketan, MSSRF
12. Various Private Nurseries (Atmanilayam Nursery Gardens
13. Cheruvarakkonam,Kuzhippallam Botanical Gardens Nellimoodu,
14. Beena Nursery Vithura, Dreamland Garden Mukkoodu, kollam).
15. Regional Agricultural Training and Testing Centres
16. Agro service centres
17. Soil testing labs
18. Safal markets
19. HORTICROP
20. Private Retail Malls

District wise OJT Centers

1. Thiruvananthapuram

• Jawaharlal Nehru Tropical Botanical Garden and Research Institute (JNTBGRI), Palode
• Biotechnology and Model Floriculture Centre (BMFC), Kazhakkuttom
• Rubber Board
• Various NGOs like Thanal, PASSS, Mithra Niketan
• Various Private Nurseries (Atmanilayam Nursery Gardens Cheruvarakkonam, Kuzhippallam Botanical Gardens Nellimoodu, Beena Nursery Vithura)
• VFPCK - Thiruvananthapuram
• RATTC – Vellayani

2. Kollam

• KVK Sadanandapuram, Kottarakkara
• FSRS Sadanandapuram, Kottarakkara
• District Seed Farm, Kottukkal, Anchal

• State Seed Farm, Kottarakkara
• Cashew Farm, Kottarakkara
• Extensiion Training Centre (ETC), Kottarakkara
• Agro Industries, Neduvathoor, Kottarakkara
• Institute of Watershed Development Management Kerala (IWDMK), Chadayamangalam
• Agro Fruits, Elambal, Punalur
• Dreamland Garden, Mukkoodu, Kollam
• Soil Testing Lab, Kureepuzha
• Kripa Mushroom Farm, Kulakkada
• Biogas Training Centre, KNNMVHSS (AC & ABC), Pavithreswaram, Puthur.

3. Pathanamthitta
• Pazhakulam Agroservice Society (PASS), Adoor
• State Seed Farm, Munnalam, Adoor
• Sugarcane Breeding Farm, Kadakkad, Pandalam
• Bodhana Social Service Society, Thiruvalla
• KVK, Thelliyoor, Pathanamthitta
• Seed Farm, Pandalam

4. Alappuzha
• CPCRI, Kayamkulam
• Rice Research Station (RRS), Monkombu
• Seed Farm, Veeyapuram
• Bee keeping and Training Centre, Kottalammude
• KVK, Kayamkulam
• State Seed Farm, Mavelikkara
• RARS, Kayamkulam

5. Kottayam
• District Agriculture Farm, Kozha
• KVK, Kumarakom
• RARS, Kumarakom
• VFPCK, Ettumanoor
• JEYES Farm, Neendoor
• Chaithanya (NGO), Kottayam

6. Idukki
• Bapuji KVK, Santhanpara
• Cardomom Research Station, Myladumpara
• VFPCK, Thodupuzha, Adimali, Munnar, Kanthalloor, Vattavada

• Spice Board, Idukki

7. Ernakulam
• Aromatic and Medicinal Plants Research Station (AMPRS),Odakkali.
• Pineapple Research Station, Vazhakkulam
• Coconut Development Board, Neriamangalam
• Spices Board, Kochi
• Nadukkara Agroprocessing Society (NAPC), Nadukkara
• RATTC, Vytilla
• Kinfra Park, Nellad
• Parasite Breeding Station, Vytilla
• Hafi orchids, Kalamassery
• Sevashram (NGO), Ankamaly
• Aiswarya Farm (NGO, Kalady
• Grandma Pickles, Muvattupuza.

8. Thrissur
• KVK, Mannuthy
• State Biocontrol Lab, Mannuthy
• Cashew Research Station, Madakkathara
• Pineapple Research Station, Madakkathara
• Banana Research Station, Kannara
• Central Training Institute, Mannuthy
• State Seed Farm, Pananchery and Nadavarambu
• National Rose Garden, Vellanikkara
• TEEOSE Gardens, Madakkathara
• RAYIRATH Gardens, Pattikkad

9. Palakkad
• IRTC, Mundur
• Integrated Seed Development Farm, Eruthiampathy
• Precision Farm, Perumatti
• Sugarcane Breeding Research Institute (Sub center), Puthur
• Seed Processing Plants, VFPCK, Alathoor
• High Tech Diary Farm, Malampuzha,Dhoni

10. Malappuram
• RARS, Aanakkayam

11. Kozhikode
• Koothali Farm
• IISR Kozhikode
• KVK, Peruvannamoozhy, Kozhikode

• Fruit Processing Center, Balussery

12. Kannur

• KVK Kannur
• Pepper Research Station, Panniyur
• District Agricultural Farm, Thaliparamabu
• Private Nurseries
• Coconut Nursery, Polayad
• Kinathy Farms, Kuthiparambu
• Soil Testing Lab, Thaliparambu
• Seed Farm, Vengad
• Germplasm collection center, Kannur
• Agromachinery Center, Chelod
• High Tech Farms, Pinarayi
• RAIDCO, Kannur.

13. Kasaragod

• CPCRI, Kasaragod
• KVK, Kasaragod
• College of Agriculture, Padannakkad
• RARS, Pilicode
• Agricultural Farm, Nileswar
• State Seed Farm, Karanthakad, Kasaragod
• Cashew Progeny Orchard, Gwalimukham
• Private nurseries
• Jenny flowers, Kasaragod
• Mechirath Nursery, Kasaragod

14. Wayanad

• MSSRF, Kalpille
• RARS, Ambalavayal
• KVK, Ambalavayal
• Wayanad Social Service Society, Mananathavady
• Private Nurseries
• Hitech Farms

LIST OF REFERENCES

1.NairMadhavan.G.2015.Chemical and biopesticides for crop protection-A Handbook for Technical officers. Department of agriculture, Kerala.
2.Peethambaran ,C. K. , Reghunath.P.2014. Surveillance based pest and disease management in crop plants.Department of Agriculture, Kerala.
3. Sunil V. G. , Pathrose B.2015. Application of ICT in Agriculture: A handbook. ICAR-KVK Malapuram.

4. Hakeem A.V. M., Pathrose.B., Nair.H.M.2014. Green house management operations.Farm Information Bureau, Department of Agriculture, Government of Kerala.
5. Susheela.P.2015. Design and management of Hi-tech cultivation in Kerala- A Practical Guide.Kerala Agricultural University.
6. KAU. 2011. Package of Practices Recommendations 'Crops'Thirteenth edition, Directorate of extension, Kerala Agricultural University, Thrissur. 278pp.

7. Nair, M.R.G.K., 1999. A Monograph on Crop Pests of Kerala and their Control, Directorate of Extension, Kerala Agricultural University, Thrissur. 227 pp.
8. Rangaswami,G. Mahadevan. A, 2002, Diseases of Crop Plants in India. 3rd edition.Prentice-Hall of India Pvt. Ltd., New Delhi. 498 pp.
9. Prathapan.K., Jose.M. V.J.2014.Harithagrihakrishi sahayi . State Horticultural Mission. 128pp.
10. Subhagan.S.R.,Dhalin.D. 2013. Elements of Plant Protection. Folio, Thiruvananthapuram. 291pp.
11 Chadha .M.L.2015. New age protected cultivation- (July-December).SimpleHydroponics for safe and healthy vegetable growing.. Vol II 10-13pp.
12. Reghunath P., Gokulapalan C., Umamaheswaran K., 2001. Samyojitha keedaroganiyanthranam, State Institute of Languages, Trivandrum, 220pp.
13. Santhakumari. P.2009, Sasyasamrakshanam, State Institute of Languages, Trivandrum,
14. Rangaswami.G., Mahadevan.A.2002, Diseases of Crop Plants in India. 3rd edition.Prentice-Hall of India Pvt. Ltd. New Delhi. 498 pp
15. Chattopadhyay .S. B. 1991.Principles and Procedures of Plant Protection. Oxford andIBH Publishing Co. Pvt. Ltd. New Delhi. .443pp.
16.Agrios.G.N.2005.Plant Pathology 5th edition.Elsevier
17.Geroge W. W 1986. Fundamentals of pesticides A self-instruction Guide. Thomas publication P.O. Box 9335. Frenocalifornia.
18.Sree Ramulu, U. S. 1979. Chemistry of Insecticides and Fungicides. Oxford and IBH Publishing House Co. New Delhi.
19.Singh R.S., 2002. Introduction to Principles of Plant Pathology. Oxford and IBH Publishing Co Pvt Ltd, New Delhi. 358pp
20.Visalakshi .A., Peethambaran .C.K., 2003, Keedanasinikal, State Institute of Languages, Thiruvananthapuram. 245pp

Websites

1. *www. dacnet.nic.in*
2. *www.niphm.gov.in*
3. *www. cdpr.ca.gov.in*

4. *www.ispc.co.in*
5. *www.tnauagritechportal*
6. *www. agriinfo.in*
7. *www.keralaagriculture.gov.in/html/institution/insti.html*
8. *www.cibrc.nic.in*
9. *www.ppqs.gov.in*