Insect Pests of Fruit, Plantation, Medicinal & Aromatic Crops

7. Insect Pests of Fruit, Plantation, Medicinal and Aromatic Crops (HPI 104) 3 (2+1)

General – economic classification of insects; ecology and insect-pest management with reference to fruit, plantation, medicinal and aromatic crops; pest surveillance. Distribution, host range, bio-ecology, injury, integrated management of important insect pests affecting tropical, sub-tropical and temperate fruits, plantation, medicinal and aromatic crops like coconut, areca nut, oil palm, cashew, cacao, tea, coffee, cinchona, rubber, betel vine senna, neem, hemp, belladonna, pyrethrum, camphor, costus, crotalaria, datura, dioscorea, mint, opium, Solanum khasianum and Tephrosia.. Storage insects – distribution, host range, bioecology, injury, integrated management of important insect pests attacking stored fruits, plantation, medicinal and aromatic crops and their processed products. Toxicology insecticide residue problems in fruit, plantation, medicinal and aromatic crops and their tolerance limits.

Practical: *Study of symptoms of damage, collection, identification, preservation, assessment of damage and population of important insect – pests affecting fruits, plantation, medicinal and aromatic crops in field and storage*

Course Overview

Introduction

- Annual loss due to insects pests alone causes Rs. 1.50 lakh crores in India. Indiscriminate usage of pesticides and unscientific approach of insect pest management and leads to outbreak of newer pests, secondary insect pests problem, resurgence resistance, residues in food chain etc. hence an integrated pest management tool are to be taught to the graduates and farming community regarding environmentally friendly, ecologically sustainable, socially acceptable, safer pest management strategies is very very essential.

Overall aim of the course

- To understand the loss caused by various insects, their eco-biology, in details on different horticultural crops
- To develop the skills on various IPM strategies
- To understand the use of newer molecules of pesticides, various trap, biocontrol agents, application methods for eco-friendly pest management.

Intended learning outcomes of the course

Knowledge Skills

- To develop knowledge on biology, ecology damage symptom, losses and caused by various insects on horticultural crops
- To improve the skill on usage of IPM tools for scientific pest management

Intellectual skills

- To develop the ability to know the reasons for outbreak, damage, transmission of diseases on different crops.
- To develop intellectual skill on timing of pesticide application, dosage, equipment selection, for effective pest management.
- To understand the consequences of pesticide residues, its impact on environment, and methods to overcome the problem.

Professional and practical skills

- Professionally skilled for modern scientific pest management.

- The candidate will be a suitable person for correct diagnostic service to solve various pest management issues.

- ## Syllabus

Theory: General – economic classification of insects; ecology and insect-pest management with reference to fruit, plantation, medicinal and aromatic crops; pest surveillance. Distribution, host range, bio-ecology, injury, integrated management of important insect pests affecting tropical, sub-tropical and temperate fruits, plantation, medicinal and aromatic crops like coconut, areca nut, oil palm, cashew, cacao, tea, coffee, cinchona, rubber, betel vine senna, neem, hemp, belladonna, pyrethrum, camphor, costus, crotalaria, datura, dioscorea, mint, opium, Solanum khasianum and Tephrosia.. Storage insects – distribution, host range, bioecology, injury, integrated management of important insect pests attacking stored fruits, plantation, medicinal and aromatic crops and their processed products. Toxicology – insecticide residue problems in fruit, plantation, medicinal and aromatic crops and their tolerance limits.

Practical: Study of symptoms of damage, collection, identification, preservation, assessment of damage and population of important insect – pests affecting fruits, plantation, medicinal and aromatic crops in field and storage

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Lecture No. 1

Principles of Applied Entomology

Definition-Applied Entomology

- Economic entomology is the study of insects that are variously related to the welfare of mankind.
- A study of those insects which are variously related to the welfare of mankind (Positively or negatively) is referred as **Applied Entomology** and is almost need to know about various management methods to curtail the activity of injurious insects and to encourage the actions of beneficial insects.

Relationship of insects to man

- Insects form a major category comprising about 2/3 of animal kingdom; affect variously the wellbeing of man. Man gets benefits from insects in many ways; without them, human society could not exist in its present form.e.g.

2. Without pollinating services of bees and other insect, we would have few vegetables, few fruits, no coffee, no tobacco and few flowers.
3. Insects provide us honey, beeswax, silk and many other useful products.
4. Many insects' species are parasites and predators and keep the crop pests under check.
5. Many of them control weeds.
6. Many of them act as scavengers and make the world little cleaner.

7. Insects are the sole or major item of food for many birds, fish and other animals (including man in some part of the world).
8. Some species have used in the treatment of certain diseases, in heredity, evolution, sociology etc.,
9. Insects have aesthetic value. Study of insects is a hobby for some people.

- On the other hand, many insects are abnoxious or destructive.

11. They attack various growing plants, feed on them, injure them and kill them or introduce disease into them.
12. They attack man's possessions-home, clothing; foodgrains and destroy them or contaminate them.
13. They attack man and animals cause annoyance because of their presence, odours, bites or stings and many are vectors of disease of man and animals.

Economics classification of insects

- Based on their relation to man, insects may be classified into two general groups, beneficial and injurious.
- Some insects may be considered natural because man does not feel their effects.

Beneficial Insects: Commercial products derived from insects

A. Honey

- Honey is used extensively as food and in the manufacture of many products.

B. Beeswax

- Bees wax is used extensively by industry in making candles, sealing wax, polishes and certain type of inks, models, dental impressions, cosmetics and other products.

C. Silk

- The silk industry is an ancient one. Several types of silkworms are utilized for production of commercial silk, but the most important is *Bombyx mori* (Mulberry silkworm).

D.Shellac

- It is produced from the secretions of the lac insects *Laccifer lacca*, a type of scale insect occurring on palas, Ber, kusum banyan, etc. These insects form encrustations of 6 to 13 mm thick on the twing of the host plant. These are collected, ground and processed to get shellac.

E. Dyes and other materials

- Several insects have been used in the manufacture of dyes. The cochineal insect, Dactylopius coccus, a scale insect somewhat similar to mealy bugs, is used for the production of cochineal dyes. These insects feed on Opuntia cacti (prickly pear). The dye obtained from these insects is crimson in colour and is produce from the dried bodies of insects. Dyes have also been made from other types of scale insects and from certain cynipid galls.

F. Insects as medicine

- Certain insects have a real medicinal value. Allantoin is a substance isolated from secretions of fly maggots and it has properties of healing deep wounds. Cantharidin is a substance found in the blister beetle, Lytta vesicatoria and is useful internally treating certain urinary diseases and externally as a vesieeant and counter – irritant. 'Specific Medicine Apis' is extracted from honeybees by diagnosing the excited bees in alcohol, and is used against certain disease like urinary irritation, diphtheria etc. The bee venom cures rheumatism and arthritis and is available for hypodermic injection.

G. Use of insect galls

- The galls contain certain valuable products. Some of the galls are of medicinal value: the Aleppo gall of oak has astringent and tonic properties and has been used for about 25 centuries in Europe and West Asian Countries. Other insect galls contain dyes and give inks of permanent nature. The Aleppo gall is used for dyeing wool and hair and ink from it had been used for writing important records in Manasteries in Western Countries.

Other useful insects

1. Insects and pollination

- The majority of higher plants are cross-pollinated. They depend on wind and insects for pollination. While wind pollination may be a chance, insect aided pollination is somewhat a sure proposition. Wind pollinated crop produces large quantities of dry pollen while the insect pollinated crop produces less pollen, which is usually sticky and adheres to the bodies of insects that visit for the flower. Some species of plants depend solely on a single of species of insect or type of insect for pollination e.g.a. Smyrnafig pollination by fig wasp.b. Rosaceous plants (apple, pear, cherry, strawberry) chiefly depend on honeybees. Many orchard fruits are mainly insect pollinated. Most important insect pollinator is honeybee. The value of pollinating insects to man is enormous. Every time the bees collect Rs. 100 worth of honey, they make Rs.2000 worth of seeds and fruits by pollinating the follows.

2. Entomophagous insects

- The check (control) exerted upon insect pests by entomolophagous (or insect eating animals) insect is very important factor in keeping down the population of pest species. A classical example of successful control of an insect pest by a predator is the cottony cushion scale, Icerya purchase, a serious pest of orchard in California, by a lady bird beetle (Vedalia beetle) Rodolia cardinals introduced from Australia. In less than 2 years the scale insect was completely controlled. There are several parasitoids and predators, which check the pest population.

3. Insect as weed killers

- Many insects feed and destroy noxious weed plant, e.g.1. Prickly pear (*Opuntia spp*.) was introduced into Australia and by 1925 had spread over 25mil acres. In 1925, the larvae of moth, *Cactobalastis cactorum* were introduced into Australia from Argentina. Now it is almost eradicated with about just 1% of the area it occupied in 1925.2. *Hypericum perforatum* L., Klamathe weed or goat weed was introduced into California in 1900 and by 1940 spread over 2 1/2 mil acres. Chrysomelid, *Chrysolina quadringemina* proved effective and now it is a minor problem.

4. Insects as scavengers

- Insect scavengers are those that feed on decomposing plants or animals or dung. They convert these materials into simpler substances, which are returned to the soil and are available to plants. They also help to remove the unhealthful materials from man's surroundings.
- Wood boring beetles, termites, carpenter ants and other wood feeders convert fallen trees and logs to soil.
- Dung beetles (Scarabaeidae) and dungflies enhance the decomposition of dung.
- Carrion-feeding insects (blowflies), skin beetles (Dermestids) are helpful in removal of carrion from landscape.

5. Insects improve soil fertility

a. Soil enriched by the excretions and dead bodies of insects.

b. Soil insects improve the physical properties of soil and add its organic content

eg. Spring tails, ants, mole crickets, cicadas (nymphs), termites, beetles, flies etc.

6. Insects as food of man and animals

- Many animals utilize insects as food. Man himself is sometimes insectivorous.
- Many fresh water fish feed on mayflies, stoneflies, caddish flies, mosquito larvae, various aquatic beetles etc.
- Birds that feed largely or entirely upon insects have practical value as predators of insect pests. Eg. Gulls (aquatic bird) checked a cricket outbreak in Utah. Other vertebrates' are toads, frogs; lizards, bats etc.
- Man in many parts of the world utilizes insects as food. Grasshoppers, locusts, crickets, cicadas, large ants, eggs of some large water bugs, grubs of cockochafer beeltes, caterpillars of some Saturnid moths, and larvae and pupae of bees and wasps are eaten by man in different parts of the world. Termites are consumed in some parts of out country.

7. The use of insects in scientific research

- The fruit flies, *Drosophila spp*. Have been extensively used in genetic studies.
- These insects have 1. Short life cycle. 2. Large chromosomes – salivary chromosomes. 3. Great number of easily recognizable hereditary

variations and 4. *Drosophila sp* can be easily reared in large numberat low cost.

- Insect have been used as experimental animal in studies of behavior. Studies on social insects have provided much interesting and valuable information on social organization and behavior.

8. The aesthetic value of insects

- For many people, study of insect provides a stimulating hobby as the study of birds, flowers etc. Artists, jewelers and designers have utilized the beauty of insects for patterns. Some of the butterflies, moths and beetles have provided basic patterns in many types of art.

Harmful insects

- Most types of plants are attacked and injured by insects. The injury is caused by feeding or ovipositing on the plant or serving as vectors of plant disease resulting in yield loss or complete loss of the plant.

1. Injury by feeding

- Phytophagous insects cause damage resulting in defoliation (eg. Leaf eating caterpillars), desapping (sucking pests e.g.aphids, thrips, leaf and planthoppers) etc.
- Injury by oviposition: e.g.Periodical cicadas cause wilting of twings when the eggs are aid. Cowbug on many plants.

- Injury by disease transmission:More than 200 plant diseases are transmitted by insects. e.g. Bhendi yellow vein clearing transmitted by whitefly.

2. Insects attacking stored products

- Many insects damage stored produce by feeding, tunneling or contaminating them.eg. rice moth, potato tuber moth, red flour beetle. Pests of wood: All sorts of wooden structures, such as buildings, furniture, fence; insects damage posts etc. e.g. termites, Pests of fabrics: Fabric pests such as dermestid beetles and clothes moths cause damage to furs, clothing, blankets, rugs etc.

3. Insects attacking man and animals

- Insects attack man and animals directly in four ways.
- **Annoyance**: Bot flies and face flies cause great annoyance to man and cattle.
- **Venomous insects**: Many insects inject toxins into man and animals that cause irritation, swelling, pain and sometimes paralysis. e.g. Bees, Wasps
- **Parasitic insects:** Many parasitic insects live in or on the bodies of man or animals causing irritation, tissue damage or even death. e.g. Chewing lice of birds, sucking lice on mammals.
- **Disease transmission**: Many insects borne disease have a high mortality rate in man and animals. Insects transmit diseases in two. A) As mechanical

vectors (houseflies, blowflies-typhoid, cholera etc). B) As biological vectors (Anopheles – Malaria).

Symptoms and types of damage caused by insect and mite pests

- Any insect that feeds on any part of a plant is termed as a pest. The types and symptoms of damage caused to the plants vary according to the feeding habit and mouthparts of insects. The damages caused by the insects are grouped into direct and indirect damages.

Direct damages

- Injuries caused by biting and chewing insects, piercing and sucking insects, internal feeders, subterranean root feeders and storage pests fall under this category.

Damages caused by insects having biting and chewing type of mouth parts:

37. Defoliation (eg) Hairy Caterpillars
38. Scrapping and skeleonization (eg)Epilachna in brinjal
39. Feeding on terminal buds (eg) Brinjal shoot borer
40. Not ching the edges of leaves (eg) Ash weevil on brinjal
41. Shot holes on leaves (eg) Flea beele, Tortoise beetle
42. Windowing (eg) Spodoptera in Banana
43. Irregular holes on leaves (eg) Grass hopper
44. Leaf rolling, twisting and webbing (eg) Mangoleaf twisting weevil

45. Feeding on flowers and buds (eg) Moringa bud worm
46. Flower webbing (eg) Jasmine webber
47. Partial feeding on grain or seeds (Eg.) lab lab pod borer

Damage caused by insects having piercing and sucking type of mouth parts:

48. Chlorosis (eg.) aphids on Groundnut
49. Speckling (eg.) Banana tingids
50. Silvering (eg.) Onion thrips
51. Mosaic (eg.) Bhendi aphids
52. Hopper burn (eg.) Bhendi jassid
53. Crinkling and curling of leaves (eg.) chilli thrips
54. Upward and downward curling of leaves (eg.) Chilli aphids
55. Downward cupping of leaves (eg.) Brinjal aphids
56. Elongation of petioles (Eg) Chilli yellow mite
57. Distortion and clustering of leaves (eg.) Mealy bug on coconut
58. Tissue proliferation (Eg.) Mealy bug on Hibicus
59. Shoot drying (eg.) Tea mosquito bug on neem
60. Flower and fruit drop/shedding (eg) Mango hoppers
61. Scab/corky/ outgrowth (eg.) Tea mosquito bug on guava
62. Fruit ratting and discolouration (eg.) Citrus Fruit sucking moth
63. Pod/grain shriveling (eg) Pod bug on lablab

Damage caused by internal feeders

64. Stem, shoot, boll, fruit and capsule boring (eg.) Pomegranate fruit borer
65. Leaf mining (eg.) Citrus leaf miner
66. Gall formation (eg.) Mango leaf gall
67. Frothing and gummosis (eg) Spittle bug on jack
68. Oozing out of sap (eg.) Coconut red palm weevil
69. Flower discolouration (eg.) Jasmine bud worm

Damages caused by subterranean pests

70. Removal of sown seeds (eg) Ants on amaranthus
71. Wilting of plants due to feeding on roots (eg) Root grub on cauliflower
72. Tunnelling in vines and tubers (eg) Potato tuber moth
73. Boring, tunneling and emptying of pods (eg) Sweet potato weevil
74. Chlorosis and devitalisation (eg) Root mealy bug

Damage caused by stored product pests

75. Internal feeding of grains (eg) Pulse beetle
76. Surface scrapping of grains (eg) Corcyramoth
77. Caking of flour (eg) Red flour beetle

Indirect damages

78. Oviposition injury (eg) Cicada, Cowbug
79. Making harvest difficult (eg) Red antson mango, lablab Aphids
80. Contamination and loss of quality (eg) Brinjal fruit borer
81. Making nests or cases out of plant parts (eg) Leaf cutter bee

82. Insect carriers (eg) Homopterans (Mealy bug) carried by ants

83. Transmission of plant disease by insects Virus – (1) Whitefly (eg) Bhendi Vein clearing (2) Thrips (eg) Tomato spotted with (3) MLO (Microplasma like Organisms) Leaf hoppers (eg) Brinjal little leaf.

Introduction-Field of entomology

- The field of entomology may be divided into 2 major aspects.

2. Fundamental Entomology or General Entomology
3. Applied Entomology or Economic Entomology

Fundamental Entomology

- Fundamental Entomology deals with the basic or academic aspects of the Science of Entomology.
- It includes morphology, anatomy, physiology and taxonomy of the insects.
- In this case we study the subject for gaining knowledge on Entomology irrespective of whether it is useful or harmful.

Applied Entomology or Economic Entomology

- Applied Entomology or Economic Entomology deals with the usefulness of the Science of Entomology for the benefit of mankind. Applied entomology covers the study of insects which are either beneficial or harmful to human beings.

- It deals with the ways in which beneficial insects like predators, parasitoids, pollinators or productive insects like honey bees, silkworm and lac insect can be best exploited for our welfare.
- Applied entomology also studies the methods in which harmful insects or pests can be managed without causing significant damage or loss to us.
- In fundamental entomology insects are classified based on their structure into families and orders etc. in applied entomology insects can be classified based on their economic importance *i.e.*, whether they are useful or harmful.

Assessment of insect population and damages in horticultural crops

Need

1. To know the extent of pest load and their damage.
2. To workout economic injury level (EIL) and economic threshold level (ETL). C) To estimate yield loss. d) To decide the timing of control measures in order to avoid indiscrimate use of insecticide.

- EIL: Cost of control measures = Loss by insect
- ETL: Level at which, control measures to be taken to avoid the insect population / damage reaching EIL.

1. Mango

- Select five trees (one at the center and four from the corners of the field) and assess the pest population / damage as follows.

2. Citrus:

- Select five trees (one at the centre and four from the corners of the field) and assess the pest population/damage as follows.

3. Pomegranate

- Select five trees (one at the centre and four from the corners of the field) and assess the pest damage as follows.

4. Brinjal

- Select 50 plants at random from one acre leaving the borders, and record the observations on pest population and/or damage at weekly interval starting from 7 days after planting (DAT) up to last picking of the fruits.

5. Bhendi

- Select 50 plants at random from one acre leaving the borders, and record the observations on pest population and / or damage at weekly interval starting from 7 days after planting (DAT) up to last picking of the fruits.

6.Tomato

- Select 50 plants at random from one acre leaving the borders, and record the observations on pest population and/or damage at weekly interval starting from 7 days after planting (DAT) up to last picking of the fruits.

7. Rose

- Select 10 plants at random and assess the pest population/damage as follows.

8. Jasmine

- Select five plants (one at the centre and four from the corners of the field) and assess the pest population/damage on follows.

Lecture - 2 Economic classification of insects

Economic classification of insects

- Insects can be classified as follows based on their economic importance.

This classification us according to TVR Ayyar.

Insects of no economic importance

- There are many insects found in forests, and agricultural lands which neither cause harm nor benefit us.
- They are classified under this category.
- Human beings came into existence 1 million years ago.
- Insects which constitute 70-90% of all animals present in this world came into existence 250- 500 million years ago.

Insects of economic importance

A. Injurious insects

a) Pests of cultivated plants (Crop pests)

- Each cultivated plant harbors many insects pests which feed on them reduce the yield of the3 crop.
- Field crops and horticultural crops are attacked by many insect species. (eg) cotton bollworm, Rice stem bores.

b) Storage pests

- Insects feed on stored products and cause economic loss. (eg) Rice weevil, Pulse beetle.

c) Pest attacking cattle and domestic animals

- Cattle are affected by pests like Horse fly, Fleshfly, Flese and Lice. They suck blood and sometimes eat the flash.

d) House hold and disease carrying insects

- House hold pests include cockroach, ants, etc. Disease carrying insects are mosquitoes, houseflies, bed bugs, fleas etc.

B. Beneficial insects

a) Productive insects

i) Silk worm

- The silk worm filament secreted from the salivary gland of the larva helps us in producing silk.

ii) Honey bee

- Provides us with honey and many other byproducts like bees wax and royal jelly.

iii) Lac insects

- The secretion from the body of these scale insects is called lac. Useful in making vanishes and polishes.

iv) Insects useful as drugs, food, ornaments etc,

(a) As medicine eg. Sting of honey bees- remedy for rhenmatism and arthritis

- Eanthoridin - extracted from blister beetle –useful as hair tonic.

(b) As food - for animals and human being.

- For animals- aquatic insects used as fish food.
- Grass hoppers, termites, pupae of moths.
- They have been used as food by human beings in different parts of the world.

(c) Ornaments, entertainers

- Artists and designers copy colour of butterflies.
- Beetles worm as necklace.
- Insect collection is a hobby

(d) Scientific research

- *Drosophila* and mosquitoes are useful in genetic and toxicological studies respectively.

(II) Helpful insects

(i) Parasitoids

- These are small insects which feed and live on harmful insects by completing their life cycle in a host and kill the host insect.

- Eg.Egg, larval and pupal parasitoids

(ii) Predators

- These are large insects which capture and devour harmful insects.
- Eg.Coccinellids, preying mantids.

(iii)Pollinators

- Many cross pollinated plants depend on insects for pollination and fruit set.
- Eg. Honey bees, aid in pollination of sunflower crop.

(iv)Weed killers

- Insects which feed on weeds kill them thereby killers.
- Eg. Parthenium beetle eats on parthenium. Cochineal insect feeds in Opuntia dillenii.

(v) Soil builders

- Soil insects such as ants, beetles, larval of cutworms, crickets, collum bola, make tunnels in soil and facilitate aeration in soil. They become good manure after death and enrish soil.

(vi) Scavengers

- Insects which feed on dead and decaying matter are called scavengers. They important for maintaining hygine in the surroundings.

- Eg. Carrion bettles, Rove beetles feed on dead animals and plants.

d) House hold and disease carrying insects

- Pests which cause damage to belongings of human being like furniture, wool, paper etc. Eg. Cockroaches, furniture beetle, sliver fish etc.
- Pests which cause painful bite, inject venoms. Eg. Wasps, bees sting us. Hairy caterpillar nettling hairs are poisonous. Mosquitoes, bugs bite, piece and suck blood from us.
- Disease causing Mosquito- Malaria, Filariasis ,dengue fever. Housefly- Typhoid, Cholera, Leprosy, Anthrax

Insect ecology

Websters dictionary meaning

- Totality (or) Pattern of relation between organisms and their environment. A German biologist 'Ernst Haeckel (1869) proposed the term 'ecology'. This deals with total relationship of an animal to both its organic and inorganic environment.

Insect ecology

- Science of insect in relation to their environment.

Habitat ecology

- Study of habitat and its effects on the organism. Autoecology: Study of an individual, its behaviour and the influence of environment on its life cycle.

Syn ecology

- Study of a group of organism which are found as a unit. It is also called **Community ecology.**

Ecosystem

- A self containing habitat in which living organisms and the physiochemical environment interact in an exchange of energe and matter to form a continuing cycle.

Biotic balance

- It is the condition of equilibrium in the population of animals. It is not a static one but oscillating. The population level is determined by I. Reproductive potential and II. Environmental Resistance.

I. Reproductive potential

- The ability of an insect to multiply in a given time in the absence of environmental resistance. Factors that affect the reproductive potential are a) initial population by fecundity. c) Length of developmental period and d) sex ratio.

II. Environmental resistance

- The sum total of all factors in on environment that tends to reduce the rate of multiplication. Factors that affect the environmental resistance are a) Physical b) nutritional, c) host plant and d) biotic.

a) Physical factors

i) Temperature – influence the rate of development and level of distribution – zone of effective temperature – aestivation – hibernation.

ii) Light – Certain life stages respond to light – photoperiodicity,

iii) Moisture – influence distribution and development,

iv) Climate –average physical conditions in a locality – influence rate and development.

b) Nutritional factors

i) Availability of food regulate population abundance.

ii) kind and quality of food influence life cycle.

iii) Host selection – monophagous, polyphagous – chemical factors in host selection.

c) Host Plant associated factors – rapidity of growth, foliage characteristics, taste factors etc.

d) Biotic factors

i) Competition – within and among different species (Inter and intra specific).

ii) Parasites and predators parasites like fungi, bacteria, protozoo, nematodes and various arthropods – predators like birds, mammals, reptiles, amphibions and insects check the population.

iii) Human population trend – Rapidly growing world population – growth rate projected world population – Indian population – resources.

Biotic factor

- Biotic factors of the environment tend to modify the activities of insects. Individuals within a population enter into varied interactions with each other besides interacting with the adjacent population. These interactions may be positive (or) negative according to whether it produces beneficial or harmful effects on the interacting individual (or) population. In the positive interaction, the individuals live adjusting with each other (Mutusalim, commensalisms). The negative interaction leads to competition, parasitism and predation.

i. Competition

- The active demand by two or more individuals of the same species of population. (Intra specific competition) (or) members of two or more species at the same trophic level (Inter specific competition) for a common resource (or) requirement that is actually limiting. Both intra specific and inter specific competition contribute to the density and diversity of a population.

a) Inter specific competition

- Two competing species can't exist in a same place for a long time. Inter specific competiton leads to competitive displacement. (eg) Mediterranian fruit fly in Hawai in 1940. The accidental introduction of oriental fruit fly replaces the Mediterranian fruit fly. Competitive displacement between Nosema apis and mite Acarapis woodi in Honeybee. Tribolium(red flour beetle) eliminate oryzalphilus (saw toothed beetle) both are grown in same flour.

b) Intra specific competition

- If the common resource is abundance, no problem in the individual and if it is limited competition occurs and superior abilities will survive in the end. (eg) a)Aphid – dispersal. b) Cannibolsim in American bollworm, Helicoverpa armigera.

ii. Parasites and predator

- Interaction between predator and prey are different from the parasite and host relationship in that the predator and prey maintain an equilibrium more dynamic than the parasite and its hosts. The parasites in general, when the rate of parasitization is high cause death and resultant elimination of the hosts. But a predator never eliminates the prey completely. Parasite includes fungi, bacteria, protozoa nematodes and other arthropods. Predator includes insect predators, birds, mammals, reptiles, amphibians that check the population.

Abiotic factor (physical factors)

a) Temperature

- It has got a profound influence on the life cycle of insects. a) Temperature influences on the rate of development (or) number of generation (eg) Temperature is an important factor in the life of the bed bugs. The number of generations passed through during a year is directly dependent on the ambient temperature. As many as twelve generations occurs in the tropical and two in cold climate. For the sugarcane stem borer, Chilo infuscatellus, the larval period extend over 16-24 days in summer and 141-171 days in winter. b) Temperature influences the fecundity and rate of egg production. (eg) Cabbage Diamond backmoth lay more number of eggs at 18° C (larval temperature) than 22°C. c) Temperature influences the rate of migration and dispersal. (eg) In Desert lowest (Schistioceva gregaria), migration of swarms occurs at 17°C to 20°C.
- Zone of effective temperature. Normal life activities go on smoothly at a specific temperature (or) at a specific range of temperature. This is called the optimum temperature. The rate of chemical reaction within tissues is modified by temperature. Metabolic processes are influenced by temperature and increase with it upto a maximum and suddly decline at the upper lethal temperature. The extreme temperature alters the insect and the insect entes into diapauses (resting stage). If the resting stage is due to low temperature, than it is called hibernation. If the resting stage is due to high temperature, it is called Aestivation.

b) Light

- The radiant energy, termed light is one of the most important ecological factors affecting many aspects of the insect life. Several vital phenomena of the insect biology (eg) feeding, growth, development, diapuse, survival and ethology are profoundly influenced by light. Photoperiodism: Daily and seasonal duration of light has profound effect on the production of sexual form in Aphids. Short day length is influencing sexual forms, while long day length is influencing asexual forms (parthenogenetic) viviparous reproduction. Photoperiods also influence growth, metabolism and daily rhythm of activity (feeding, flying, mating and oviposition). The light influences on the inception and completion of diapauses.
- Daily rhythm of activity: It has been observed that many species of insects are not equally active throughout the 24 hr of the day. Some are primarily nocturnal (dark active); other are diurnal (day active) and still other which are referred to as crepuscular (dusk active) are active mainly at dawn and dusk.

c. Relative humidity

- Termites are a group of insects for which atmospheric humidity is an important ecological factor. They usually move towards a zone of high humidity, when subjected to the slightest desiccation. Humidity is high, rice brown plant hopper multiplication is more. Certain entomogenous fungi requires very high humidity for multiplication and spread (eg) white halo fungus, Verticillum lecanii attack on coffee green bug.

d. Rainfall

- For normal emergence of adults rainfall is a must (also it is essential for pupation) for insect like cutworms, Helicoverpa armigiera, Spodoptetra litura. If it is excess, grubs like white grubs will come out of environment where they are subject to predation. Excess rainfall control aphids and Diamond backmoth.

e. Wind

- It helps more in the dispersal of insect species besides interfering with their normal feeding, mating and multiplication. (eg) with the help of wind current Helicorerpa adult moth fly upto 90 km. Another examples is the spreads of eriophyid mite in coconut.

f.Soil type

- Type of soil play a role in multiplication of insects. (eg) wireworms multiply even in heavy clay soil (poor drainage) with lesser drainage, Whereas white grub multiply very well in loose sandy soil (light) with better drainage.

g)Water

- Standing (stagnated) water helps in multiplication of insect like mosquitoes. Running streams are preferred by black flies and caddish flies.

h) Tropographic factors

- Besides mountain, large areas under water viz., sea etc also act as physical for the spread of the insect.

Ecology related terminology

i. **Habitat** is the place where the organism lives.

ii. **Population** denotes groups of individuals of any kind of organism. Insect populations are groups of individuals set in a frame that is limited in time and space.

iii. **Community** in the ecological sense includes all the populations of a given area. Community can also be defined as interacting 'web' of populations where individuals in a population feed upon and in turn are fed upon by individuals of other populations (Fig. 1)

iv. Ecosystem

- • Ecosystem or ecological system is the functioning together of community and the nonliving environment where continuous exchange of matter and energy takes place.
- • In other words ecosystem is the assemblage of elements, communities and physical environment.

- • Ecosystem is the ultimate unit for study in ecology as they are composed of living organisms and the nonliving environment.
- Examples of natural ecosystem: Ponds, lakes and forests ecosystem (Fig.2)

v. Biosphere is the term used for all of the earth's ecosystems functioning together on the global scale.

Living Genes Cells Organs Organisms Populations Communities

components

+

Nonliving components Matter Energy Biosphere

= Biosystems

- Gene Cell Organ Organism Population Ecosystem
- Figure 3. Flow of matter and energy in an ecosystem

Agro ecosystem is largely created and maintained to satisfy human wants or needs. It is not a natural ecosystem but is man made. Agro ecosystem is the basic unit of pest management - a branch of applied ecology.

A typical agroecosysyetm (Fig. 4) is composed of

i. more or less uniform crop-plant population

ii. Weed communities

iii. Animal communities (including insects)

iv. Microbiotic communities

v. and the physical environment the react with.

Unique features of Agroecosystem

- Dominated by plants selected by man
- No species diversity and no intraspecific diversity. Genetically uniform
- Phenological events like germination, flowering occur simultaneously
- Lack of temporal continuity - due to various agricultural operations carried out by man like ploughing, weeding, pesticide application etc.
- Plants contain imported genetic material
- Nutrients are added
- Outbreak of pests, weeds and diseases occur frequently

Balance of Nature

- Balance of Nature is defined as the natural tendency of plant and animal population resulting from natural regulative processes in an undisturbed ecosystem (environment) to neither decline in numbers to extinction nor increase to indefinite density.
- In unmanaged ecosystems, a state of balance exists or will be reached, that is species interact with each other and with their physical environment in such a way that on average, individuals are able only to replace themselves. Each species in the community achieves a certain status that becomes fixed for a period of time and is resistant to change which is termed as the balance of nature.
- When man begins to manage creating new ecosystem (agroecosystem) where natural ecosystem existed previously, the balance is altered. The exceptionally strong forces react in opposition to our imposed change toward a return to the original system (e.g. outbreak of a pest is one of the

forces). So insect pests are not ecological aberrations. Their activities counter wants and needs of human populations.

Factors that determine insect abundance

i) Biotic potential

- It is the innate ability of the population to reproduce and survive. It depends on the inherited properties of the insect i.e., reproduction and survival. **Potential natality** is the reproductive rate of the individuals in an optimal environment. Survival rate depends on the feeding habits and protection to young ones (Eg. Viviparity). Generally insects with high reproductive rate tend to have low survival rate and vice versa.
- Insect pests with high reproductive rate and low survival rate are called **r strategists** named after the statistical parameter r, the symbol for growth rate coefficient. Such pests succeed because of sheer numbers. Eg. Aphids.
- K strategists reproduce slowly but effectively compete for environmental resources and so their survival rate is high. (K letter denotes flattened portion of growth curve) Eg. Codling moth of apple.
- Birth rate or natality is measured as the total number of eggs laid per female per unit time. Factors determining birth rate are fecundity, fertility and sex ratio.
- Death rate or mortality denotes the number of insects dying over a period.

Example of High reproductive rate

- A single moth of Earias vitella (Bhendi fruit borer) lays about 200 eggs per female. Life cycle is completed in 1 month

After 1 month 200 adults

100 male + 100 female

100 x 200 = 20,000 eggs

After 2nd month 10,000 x 200 = 2,000,000 eggs

After 1 year 2,000,000,000,000,000,000,000,000 adults

(*i.e.*, 2 followed by 24 zeroes)

- If a single moth can produce this much, they will cover 24.32 above earth surface in 1 year. But in reality only a fraction of progeny completes life cycle due to environmental resistance.

Environmental resistance is the physical and biological restraints that prevent a species from realizing its Biotic potential. Environmental resistance may be of 2 types.

1. Biotic factors - includes

a) Competition (interspecific and intraspecific)

b) Natural enemies (predators, parasites and pathogens)

2. Abiotic factors

a) Temperature

b) Light

c) Moisture and water

d) Substratum and medium

Bioresources in ecosystem

- Ecosystem comprises of biological communities and non-living environment. Eg. Agro ecosystem, pond ecosystem, etc.). B**ioresources refers to the biodiversity of various organisms living in that ecosystem.**
- Eg. The different pests of cotton, its natural enemies, hyperparasitoids, microbes, etc. are referred to the bioresources in cotton ecosystem.
- **The ecosystem should have more bioresources.** Such ecosystem will be more stable. Insecticides will deplete the bioresources in ecosystem and make it less stable and prone to pest outbreak.
- **Natural control will be high when bioresources** (e.g. Parasitoids and Predators) are more.

Population dynamics and role of biotic factors

Attributes of a population

i. Density: Population size per unit area

ii. Birth rate (Natality): Rate at which new individuals are added to the population by reproduction

iii. Death rate (Mortality): The rate at which individuals are lost by death.

iv. Dispersal: The rate at which individuals immigrate into and emigrate out of the population.

v. Dispersion: the way in which individuals are distributed in space. It may be of 3 types.

a) Random distribution

b) Uniform distribution

c) Clumped distribution

vi. Age distribution: the population of individuals of different ages in the group.

vii. Genetic characteristics: adaptive ness, reproductive fitness, persistence.

viii. Population growth form: the way in which population changes / grows as a result of natality, mortality, and dispersal.

Population dynamics

- Populations grow in two contrasting ways. They are

i. J- shaped growth form (Fig. 1a)

ii. S- Shaped or sigmoid growth form (Fig. 1b)

N K

Density

Time

- Fig. 1a. J- Shaped growth form Fig. 1b. S - Shaped growth form. In the J - shaped growth form, the population density increases in exponential or geometric fashion; for example 2,4,8,16,32 ... and so on until the population runs out of some resource or encounters some limitation (limit N, Fig. 1a). Growth then comes to a more or less abrupt halt and density declines rapidly. Populations with this kind of growth form are unstable.

Their reproductive rate is high and survival rate is less and so they are r strategists. A factor other than density regulates the population. (Eg. Aphids).

- In the S-shaped growth pattern (Fig. 2) the rate of increase of density decreases as the population increases and levels off at an upper asymptote level K, called the carrying capacity, or maximum sustainable density. Their reproductive rate is less and survival rate is more. So they are K strategists. This pattern has more stability since the population regulates itself. (Eg. Hymenopterans).
- The population growth rate or change is worked out using the formula,

$$Nt = N_o e^{(b-d)\,t} - E_t + I_t$$

Where

Nt = number at the end of a short time period

N_o = number at the beginning of a short time period

e = base of natural logarithm = 2.7183

b= birth rate

d= death rate

t= time period

E= emigration

I = immigration.

Life table: Life tables are tabular statements showing the number of insects dying over a period of time and accounting for their deaths.

Lecture No. 3
Pests-Categories, causes for outbreak of pests

Definition-Pest

- Any organism detrimental to man his property (or) Any form of plant or animal life or any pathogenic agent injurious or potentially injurious to plants, plant products, livestock or man.

Definition-Insect pests

- Insects sufficiently numerous to cause economic loss is called **insect pest.**

Categories of pests

1. **Regular pests:** Occurring more frequently on a crop having close association with the crop. (eg) Brinjal shoot and fruit borer.
2. **Occasional pests:** Occurring infrequently with no close association with a particular crop (eg) Snake gourd semilooper.
3. **Seasonal pests:** Occurring during a particular part of the year. (eg) Red Hariy Caterpillar (RHC) in groundnut.
4. **Pesistent pests:** Occurring on a crop almost throughout the year (eg) thrips on chillies.
5. **Sporadic pests:** Occurring in a few isolated localities (eg) coconut slug caterpillar.
6. **Epidemic pests:** Occurring in severe form in a region or locality at a particular season (eg) RHC in groundnut in Bhavan Taluk.

7. **Endemic pests:** Occurring regularly and confined to a particular area or locality (eg) rice gall midge in Madurai dist.

Causes for outbreak of pests

1. Destruction of forest or bringing forest area under cultivation – shift to cultivated crops. (eg) Hairy caterpillar attack on crop plants near forest areas.
2. Indiscriminate use of pesticides leads to destruction of natural enemies, pest resistance,pest resurgence. (eg) Synthetic pyrethroids on sucking pests.
3. Intensive cultivation (eg) Diamond backmoth on cauliflower in plains and extensive cultivation (eg) monoculture of rice leads to out break of leaf folder.
4. Introduction of new crops (eg) gurkin crop leads more fruit fly incidence and improved strains (eg) many high yielding varieties are more susceptible to insects.
5. Improved agronomic practices (eg) higher 'N', close spacing, weed control etc. improved crop growth and reduced competition for food to the insects.
6. Introduction of new pest in a new area (eg) apple woolly aphid.
7. Accidental introduction of foreign pests (eg) potato tuber moth, cyst nematode of potato, spiraling white fly on guava.
8. Large scale storage of food grains (eg) outbreak of stored product pests, rat problem.

Pest management concept

History

- The term pest management comparatively new, although the ideas from which it is derived have been developed over many decades.

2. In the late 19th century, S.A. Forbes of the University of Illinois suggested an ecological approach and combinations of control measures for insect control.
3. The value of monitoring pest population by sampling was realized by the early 20th century.
4. During the 1940s R.F.Smith developed an outline of Supervised control in California.
5. B.R. Bartlett in 1956 coined the term integrated control.
6. Shortly after word V.M.Stern R.F.Smith, R.Van den Bosch and K.S.Hagen published on article on the integrated control concept.
7. In 1961, the Australian entomologists, P.W.Geier and L.R. Clark coined the pharse Pest Management for programmes in which control methods fit into the biology of the pest species.
8. Johanson 1978 in his article Principles of insect control has outlined a brief summary of the concepts on which pest management is based. 8) Brader (1979) quoted most suitable definition.

- "Pest management is a system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in on compatible manner as possible and maintains pest populations of level below those causing economic injury".

Aims (or) objectives

1. To reduce the crop damage.
2. To prevent the insect to use the crops as breeding and feeding site by suitable technique.
3. To utilize two or more control techniques together in an integrated fashion.
4. To make maximum use of natural mortality factors.
5. To apply specific control measures only as and where necessary.

Pest management strategies

- A pest management strategy is the overall plan to eliminate a pest problem. The particular strategy developed depends on the particular life system of the pest and crop involved.

2. Do nothing: When pest densities are below the economic threshold, 'do nothing' is the stratergy to follow. Otherwise a net loss occurs from pest management.
3. Reduce pest population number: Usually employment in a therapeutic manner when densities actually reach the economic threshold or in a preventing manner based on a history of problem.
4. Reduce the crop susceptibility to pest injury. This is most effective and environmentally desirable strategy. The tactics involved are HPR (hose plant resistance) and ecological management.
5. Combine reduced population numbers with reduced crop susceptibility – combination of objectives of all the above strategies to produce a pest

management programme with several tacties. The use of multiple strategies and tacties is a basic principle in developing insect pest management programmes.

Lecture No. 4.
Methods of pest control

1. Natural control

The check in population is due to natural agencies like climatic, Natural enemies, Topographic, Resistance of plants to insects.

2. Applied control

- Planned and organized by man to eliminate or reduce the number of insects and the damage. This includes Prophylactic or preventive measures and Curative or direct measures.
- Prophylacitc: Field sanitation, Crop rotation, resistant varieties, Preventive treatment. Curative:

3. Cultural methods – tillage, time of planting, pruning, fertilization, water management sanitation and trap crops.
4. Growing resistant varieties.
5. Mechanical methods – hand destruction, exclusion and trapping
6. Physical methods – heat, cold, humidity, energy and sound
7. Biological methods – parasitoids, predators and pathogens
8. Chemical methods – attractants, repellents, insecticides, sterilants and growth inhibitors.
9. Genetic methods – male sterile techniques.
10. Regulatory methods – quarantines, legislation

Integrated pest management

- Integrated pest management is defined as the Optimization of pest control in an economically and ecologically sound manner.
- It is a judicious combination of feasible pest management components to keep insects below economic injury level.

Components of pest management

1. Bio-ecology of pests

- Knowledge on the life cycle of the pest gives not only an idea about the duration and development of the insect, but also it enables to identify the weak link in the insect's growth to direct the management technology (*S. litura* – egg mass and larvae remain together on the under surface of leaves which facilities the collection and destruction of the larvae (or) spray chemicals with less quantity.

2. Pest Surveillance and Monitoring

- This can be done through light / pheromone trap / sticky trap, which help the timely application of pest suppression strategies.

3. Cultural control

- It is concerned with the use of farming or cultural practices associated with the crop production to make environment less favourable for the survival, growth and reproduction of pest species. It is used for suppresioning pest population both by direct effect – killing of the pests or by indirect effect – by providing condition favourable for the natural enemies of pests. This includes crop rotation, crop refuge destruction, tillage, time of planting, pruning, fertilization, water management, sanitation, trap crops.

4. Growing resistant varieties

- The phenomenon of plant resistance is inherited quality that enables a plant to avoid, tolerate or recover from the effects of oviposition or feeding that would cause greater damage to other genotypes of the some species under similar environmental conditions.

5. Mechanical methods

- This involves use of mechanical force or manual labour either for destruction or exclusion of pests.

6. Physical methods

- This method envisages use of physical factors for eradication of insect pests. Modification of physical factors in the environment to minimize or prevent pest problems is making the environment to minimize or prevent pest problems is making the environment unsuitable for the entry and survival of insect.

7. Biological methods

- Biological control of pest may be defined as the eradication (or) suppression of insects by encouragement, artificial introduction or increase of their natural enemies such as parasites, predators and disease causing organism. De Bach (1964) defined the biological control as the "the action of parasite, predators or pathogens in maintaining another organisms population density at a lower average than would occur in their absence".

8. Chemical methods

- Chemical control includes the use of various chemicals that bring about control of pest either by toxic properties that cause death to the insect or by other effects like changing the behaviour, imparting sterility, impairing development (or) causing metabolic disorders to the insects.

9. Genetic method (or) Sterility methods

- This method envisages the use of sterile insects to bring down the population of pests (eg.male sterile technique-Male pupae are sterilized with cobalt – 60 and released. Here insects are used against the members of their own species to reduce population levels and for this reason, the approach often is called **autocidal control.**

10. Regulatory methods

i. Preventing entry and establishment of foreign plant and animal pest in a country.

ii. Eradicating, containing or suppression pests already established in a limited area.

11. Integrated Pest Management (IPM)

- Refers to an ecological approach in Pest Management in which all available techniques are consolidated in unified programme, so that pest populations can be managed in such a manner that economic damage is avoided and side effects are minimized.

Lecture No. 5
Integrated pest management

1. Basis for IPM

- It is estimated that losses caused by insects accounts to nearly Rs.50, 000/- crores annually. When the concept of green revolution came, the areas of assured irrigation were identified and technologies were developed to increase production in the assured irrigation areas. Another change was the introduction of high yielding crop varieties. The varieties had very high potential and with the high inputs of fertilizer, water and pesticides they could yield substantially very high yields. But with the introduction of high yielding varieties, there were many problems of pests and diseases.
- The application of potential synthetic pesticides could control the pests and diseases in the initial stage. The farmers entice enormous monitory return. So the farmers still intensified the cultivation, they went in for higher inputs, they could get higher yield for 2 or 3 years. But, at one stage, the pest became to react i.e. there is always a competition between plant, pest and human. The pests overcome the stress and able to produce biotypes and became resistant. The insecticides that initially controlled the pest were not able to control the pest subsequently. Then the farmers increased the dosage and interval is shortened and combination of pesticides was used.

- All these means lead to aggravation of pests. The farmers and Scientists wanted to evolve new methods and strategies. Now people thought to evolve new methods which are ecologically sound, safe i.e. input should be appropriate, pesticide should be proper, also introduced cultural methods, physical methods, need based methods based in ETL, how resistant varieties can be introduced, how biological agents can be introduced and other non conventional methods including botanicals, attractants repellents, etc. So they wanted to integrate the possible methods either for a single pest or for all pests of a crop. This is the basis for IPM.

1.1. IPM definition

- Integrated Pest Management (IPM) is a system that, in the context of associated environment and population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economic injury. FAO (1967).

• Tools or components of integrated pest management

Inputs/Requirements	IPM	**Components of IPM**
Ecology of pest Pest surveillance and monitoring ETL	Host plant resistance	Physical methods of pest control Mechanical methods Mechanical methods Cultural methods Biological methods Parasitoids Virus Predators Fungi Microbes Bacteria Botanicals Protozova Chemical control method

		Genetic/Biotechnological approach Behavioural method Pheromone Allelochemical Legal method

2. Components of organic pest management

The following components may be included in organic method of pest management

1. Ecology based pest management and Habitat diversification
2. Use of resistant varieties
3. Wide hybridization
4. Physical methods of pest management
5. Mechanical methods of pest management
6. Use of plant products / botanicals
7. Use of insect pheromones
8. Biological control of pests
9. Use of synthetic organics permissible for use in organic agriculture
10. Using farmers wisdom in organic farming

2. 1. Ecology based pest management

- Various eco-friendly tactics of pest management have to be integrated so as to avoid the use of chemical pesticides. The knowledge of interaction among plant, pest, natural enemies and environment is essential for effective pest management. When the balance of nature is disturbed by man made interventions, nature strikes back in the form of pest outbreaks. Some examples of pest outbreaks are as follows

2. Whiteflies in brinjal
3. *Helicoverpa armigera* in bhendi
4. Slug caterpillar in coconut
5. Eriophyid mite on coconut

- Moreover the pest status changes over years due to interaction of various biotic and abiotic factors. One has to thoroughly understand the reasons for outbreak of pests and their changing status and plan the management practices accordingly so as to prevent further outbreaks.

2. 2. Habitat diversification

- Habitat diversification makes the agricultural environment unfavourable for growth, multiplication and establishment of insect pest populations.
- The following are some approaches by which the pest population can be brought down.

2. 2. 1. Intercropping system

- Intercropping system has been found favourable in reducing the population and damage caused by many insect pests due to one or more of the following reasons.
- Pest outbreak less in mixed stands due to crop diversity than in sole stands
- Availability of alternate prey
- Decreased colonization and reproduction in pests
- Chemical repellency, masking, feeding inhibition by odours from non-host plants.

- Act as physical barrier to plants.
- The following table gives a few examples of intercropping system where reduction in damage level was noticed

Table 1. Effect of intercropping system on pest levels

Sl. No.	Crop		Pest reduced
	Sole crop	**Intercrop**	
1.	Cauliflower	onion	Diamond back moth
2.	Cauliflower	Mustard	Diamond back moth
3.	Onion	Agathi	Thrips
4.	Banana	Marigold	Nematodes
5.	Brinjal	*Solanum nigrum*	Whiteflies

- Interplanting maize in cotton fields increased the population of Araneae, coccinellidae and Chrysopidae by 62.8-115.7% compared with control fields. Maize also acted as a trap crop for *H. armigera* reducing the second generation eggs and damage to bhendi. Hence it is highly important that appropriate intercropping systems have to be evolved where reduction in pest level occurs.

2. 2. 2. Trap cropping

- Crops that are grown to attract insects or other organisms like nematodes to protect target crops from pest attack. This is achieved by
- Either preventing the pests from reaching the crop or
- Concentrating them in a certain part of the field where they can be economically destroyed

Table 2. List of successful examples of trap crop

Sl. No.	Main Crop	Trap crop	Pest
1.	cauliflower	Mustard	Diamond back moth
2.	Tomato	African marigold	*Helicoverpa*
3.	Bhendi	Castor	*Spodoptera*

- Growing mustard as trap crop 2 rows per 25 cabbage rows for the management of diamond back moth. First mustard crop is sown 15 days prior to cabbage planting or 20 days old mustard seedlings are planted. Growing castor along the border of cotton field and irrigation channels act as indicator or trap crop for *Spodoptera litura*. Planting 40 day old African tall marigold and 25 day old tomato seedlings (1:16 rows) simultaneously reduces *Helicoverpa* damage.
- Growing trap crops like marigold which attract pests like American bollworm to lay eggs, barrier crops like maize/jowar to prevent migration of sucking pests like aphids and guard crops like castor which attracts *Spodoptera litura* in cotton fields was reported by Murthy and Venkateshwarulu (1998).

2. 2. 3. Fertilizer management

- Plant growth is dependent on the nutritional status of the soil which in turn has indirect effect on pests. High levels of N fertilizer always favour insects and makes plants more susceptible to insect infestation (Rathore and Lal, 1994). On the other hand lower potassium supply favours the development of insects, while optimum and high K has depressant effects (Dale, 1988).

- The following table (Table 3) shows the role of nutrient management on pest levels.

Table 3. Effects of host plant nutrition on insect pests

Sl. No.	Host plant	Insect	Response
1.	Rice	Thrips, GLH, Whorl maggot, Leaf folder	High K application reduces pest incidence
2.		Leaf folder, gall midge, BPH, Yellow stem borer, WBPH	High N levels increases pest population and damage
3.	Wheat	Cutworm *(Mythimna separata)*	Increased N increases incidence
4.	Sorghum	Shootfly	High P reduced incidence
5.	Cotton	Pink boll worm, leafhopper	High N increased incidence
6.	Chickpea	*Helicoverpa armigera*	N increased infestation while P and K reduced

2. 2. 4. Planting dates and crop duration

- Planting dates should be so adjusted that the susceptible stage of crop synchronizes with the most inactive period or lowest pest population. The plantings should be also based on information on pest monitoring, as the data varies with location. Crop maturity also plays an important role in pest avoidance. The following table (table 4) shows the importance of planting dates on pest population and damage

Table 4. Role of planting dates on pest population and damage

Sl. No.	Host plant	Insect	Response	Reference
1.	Rice	Leaf folder	Early palnted rice (upto 3rd week of June) suppressed population	Dhaliwal *et al*. (1988)
2.		BPH	Planting in end of July in Kharif and Early in Rabi escapes attack in AP	Krishnaiah *et al*. (1986)
3.		Gallmidge	Lowest incidence iof planted in Aug or Oct	Uthamasamy and Karuppuchamy (1986)
4.	Sorghum	Shootfly	Advancing sowing date (Sept - Oct) decreased incidence	Kotikal and Panchbavi (1991)
5.	Cotton	Leafhopper	Higher incidence in late sown crop	Dhawan *et al*. (1990)
6.	Chickpea	*H. armigera*	For every 10 day delay in sowing 4.02% increase in pod damage	Devendra Prasad *et al*. (1989)
7.	Tomato	Whitefly (*B.tabaci*)	Incidence less if planted within Jul- Nov	Saikia abd Muniappa (1989)
8.	Chillies	Thrips	Late planted crop severely affected by thrips and leaf curl virus	Bagle (1992)

2. 2. 5. Planting density

- Plant nutrient status, interplant spacing, canopy structure, etc., affect insect behaviour in searching food, shelter and oviposition site. It also affects natural enemy population. The effect of plant density on pest population is shown in Table 5.

Table 5. Effect of plant density on pest population

Sl. No.	Crop	Spacing/ density	Insect	Response	Reference
1.	Rice	Dense planting	Leaf folder, BPH	High incidence	Kushwaha and Sharma (1981)

					Kalode and Krishnaiah (1991)
2.	Chickpea	Dense plant population	*H.armigera*	High incidence	Yadav (1987)
3.		Less dense population	*Aphis craccivora*	High incidence	Lal *et al* (1989)
4.	Sugarcane	Dense seed rate	Topshoot borer	Low incidence	Singla and Duhra, 1990
			Early shoot borer	High incidence	

2.2.6. Destruction of alternate host plants

- Many insects use a wide range of cultivated plants especially weeds as alternate hosts for off season carry-over of population. Matteson et al. (1984) reported that weeds around the crop can alter the proportion of harmful and beneficial insects that are present and increase or decrease crop damage.

Table 6. Alternate hosts to be removed to reduce damage by pests

Sl. No.	Crop	Pest	Alternate host to be removed	Reference
1.	Groundnut	Thrips *(Caliothrips indicus)*	*Achyranthus aspera*	Mohan Daniel *et al.* (1984)
2.	Rice	Gallmidge	Wild rice *(O.nivara)*	Kalode and Krishnaiah (1991)
3.		GLH	*Leersia hexandra*	
			Echinochloa colonum	
			E.crusgalli	
			C.dactylon	
4.		WBPH	*Chleres barbata*	
5.	Sorghum	Earhead midge	Grassy weeds	Prem Kishore (1987)

- Destruction of off types and volunteer plants, thinning and topping, pruning and defoliation and summer ploughing are other cultural methods which can reduce pest load in field.

2. 2. 7. Water management

- Availability of water in requisite amount at the appropriate time is crucial for proper growth of crop. Hence, water affects the associated insects by many ways such as nutritional quality and quantity, partitioning of nutrients between vegetative growth and reproduction etc.
- The following table shows the effect of irrigation on pest population / damage.

Table 7. Effect of irrigation on pest population / damage.

Sl.No	Crop	Insect	Response	Reference
1.	Rice	Mealy bug	Continuous ponding of 5cm water reduced incidence	Gopalan et al. (1987)
2.	Rice	Caseworm and BPH	Draining of water to field capacity reduces incidence	Thomas (1986)
3.	Fruit tree nursery	Termite	Copious irrigation reduces incidence	Butani (1987)
4.	Groundnut	Aphids	Copious irrigation increased incidence	Rao et al. (1991)

2. 2. 8. Crop rotation

- Sustainable systems of agricultural production are seen in areas where proper mixtures of crops and varieties are adopted in a given agroecosystem. Monocultures and overlapping crop seasons are more prone to severe outbreak of pests and diseases. For example growing rice after groundnut in garden land in puddled condition eliminates white grub.

2. 2. 9. Organic manure

- Application of press mud in groundnut @ 12.5 t/ha had a better influence on leaf miner with lower leaflet damage at 38.84 per cent and 2.48 larval numbers per plant during summer 1991. It was 34.93 per cent and 2.72 numbers during kharif, 1991 (Sathiyanandam and Janarthanan, 1995). Rajasekar *et al.* (1995) reported that farm yard manure, *Azospirillum* and *Phosphobacteria* has no significant influence on the control of leaf hopper and fruit borer in bhendi. The incidence of paddy plant and leafhopper was low in *Azospirillum* combined with farmyard manure (Athisamy and Venugopal 1995). Application of organic manure lowered the rice gall midge incidence (5.28%) (Mohankumar *et al.*, 1995).

2. 3. Use of resistant varieties.

- Host plant resistance forms an important component of non-chemical method of pest management. Several resistant varieties of crops have been evolved against major pests, through intensive breeding programmes. Development of varieties with multiple resistances to several pests / diseases is essential.

2. 5. Physical method of pest control

- The following are some examples of the use of physical methods of insect control
- Use of activated clay at one per cent or vegetable oil at one per cent has been found to effectively control damage by *Callosobruchus chinensis* in stored pulses.
- Solar heat treatment of sorghum seeds for 60 seconds using solar drier kills rice weevil and red flour beetle without affecting germination of seeds.
- Biogas fumigation for 5 days period caused mortality of eggs, grubs, adults of pulse beetle *C.chinensis* (Mohan *et al.*, 1987; 1989)
- Drying seeds (below 10% moisture level) prevents insect development.
- Cold storage of fruits and vegetables to kill fruit flies (1-2° C for 12-20 days).

2. 6. Mechanical method of control

2. 6. 1. Mechanical destruction

a. Hand picking of caterpillars

b. Hooking of rhinoceros beetle adult with iron hook

c. Sieving and winnowing for stored product insect control

d. Shaking plants- to dislodge caseworm in rice -to dislodge June beetles from neem trees

2. 6. 2. Mechanical exclusion

a. Wrapping of fruits against pomegranate fruit borer.

b. Banding with grease - against mango mealy bug

c. Trenching - for larvae of red hairy caterpillar

d. Tin barrier - around coconut tree trunk to prevent rat damage

e. Rat proof structure in storage go downs

2. 6. 3. Appliances based on mechanical control method

a. Light trap

b. Yellow sticky traps - for attracting aphids and jassids

c. Bait trap - fish meal trap for sorghum shootfly

d. methyl eugenol trap - for fruit flies

e. Probe trap - for stored product insects

f. Pheromone trap - for various adult insects

g. TNAU automatic insect removal bin - for stored product insects

2. 7. Use of botanicals in pest management

- Grainge and Ahmed (1988) listed about 2400 plant species with pesticidal properties (insecticide, acaricide, nematicide, fungicide etc. which are distributed in 189 plant families).
- Neem oil at 2% and neem seed kernel extract (NSKE) at 5% with liquid soap 0.05% have been proven affective against major pests of rice, sucking pests of cotton and vegetable.
- Neem cake applied at 250 kg/ha at last ploughing before sowing has been found effective against cotton stem weevil and soil insects of many other crops.
- Neem seeds contain more than 100 compounds among which *azadirachtin* has been found to be biologically most active. The biological

effects of neem products are insect growth regulation, feeding deterrent and oviposition deterrent effect.

- Commercial Neem formulations are available in market which contain varying levels of *azadirachtin* (from 0.03% to a maximum of 5%). In India more than 50 firms are manufacturing neem formulations which are available in different brand names.
- A few examples are given below

Sl. No.	Brand name	Azadirachtin content
1.	Nimbecidine	0.03%
2.	Neem guard	0.03%
3.	Bioneem	0.03%
4.	Jaineem	0.03%
5.	Neem gold	0.15%
6.	Fortune-aza	0.15%
7.	Econeem	0.3%
8.	Achook	0.5%
9.	Neem azal TS	1.0%
10.	Neem azal F	5.0%

- In addition to Neem which belongs to Meliaceae, plants belonging to Annonaceae, Asteraceae, Fabaceae, Labiatae, Rutaceae and many other families have been found to possess insecticidal activity. Research in this field will provide valuable information that will help in managing insect pests with plant products.

2. 8. Pheromones in Pest Management

- Pheromones are chemical substances released by insects which attract other individuals of the same species.
- Sex pheromones have been used in pest management in the following ways

a. Monitoring

b. Mating disruption

c. Mass trapping

- These methods can be successfully included in organic method of pest management. Sex pheromones of the following insects are commercially available in market.

Table 9. Commercially available sex pheromones for insects

Sl. No.	Common Name	Scientific name
1.	American bollworm	*Helicoverpa armigera*
2.	Pink bollworm	*Pectinophora gossypiella*
3.	Spotted bollworm	*Earias vitella*
4.	Spiny bollworm	*Earias insulana*
5.	Tobacco cutworm	*Spodoptera litura*
6.	Early shoot borer of sugarcane	*Chilo infuscatellus*
7.	Yellow stem borer of rice	*Scirpophaga incertulas*
8.	Diamond back moth	*Plutella xylostella*
9.	Mango fruit fly	*Bactrocera dorsalis*
10.	Melon fruitfly	*Bactrocera cucurbitae*

- Aggregation pheromones of red palm weevil and *Rhinoceros* beetle of coconut are also available in market. Different types of pheromone traps such as sleeve type trap, delta and sticky traps are also manufactured and sold by different firms. In addition to the above many new pheromones of field and storage pests are being manufactured by commercial firms and will be available to farmers soon.

2. 9. Biological control

- Management of pests and disease causing agents utilizing, parasitoids, predators and microbial agents like viruses, bacteria and fungi is termed as biological control. It is an important component of IPM.
- The three important approaches in biological control are

a. Importation: Importation is also called classical method of biological control where bio-control agents are imported to control a pests of exotic origin.

b. Conservation: This is a method of manipulating the environment to protect the bio-control agents

c. Augmentation: Augmentation aims at mass production of natural enemies / microbial agents and field release. Genetic improvement of bio-control agents to have superior traits also comes under this category.

- The ICAR and State Agricultural Universities play an important role in identifying potential bio-control agents. The commercial bio-control laboratories mass produce the agents and distribute among the farmers. There are at least 20 bio-pesticides production laboratories in Tamil Nadu managed by co-operative and private sectors. The following are the bio-control agents mass produced in Tamil Nadu.

Table 10. Bio-control agents commercially produced in Tamil Nadu

Sl. No.	Biocontrol agents	Pests managed
	I. Parasitoids	
	Egg parasitoids	
1.	*Trichogramma sp.*	Borers, bollworms
2	*Telenomus remus*	*Spodoptera litura*
	Egg larval parasitoid	
3	*Chelonus blackburni*	Cotton bollworms
	Larval parasitoids	
4.	*Bracon brevicornis*	Coconut black headed caterpillar
5.	*Goniozus nephantidis*	Coconut black headed caterpillar
6.	*Elamus nephantidis*	Coconut black headed caterpillar
7.	*Bracon kirkpatrici*	Cotton bollworms
8.	*B.hebetor*	Cotton bollworms
	Pupal parasitoids	
9	*Brachymeria spp.*	Coconut black headed caterpillar
10	*Tetrastychus Israeli*	Coconut black headed caterpillar
11.	*Trichospilus pupivora*	Coconut black headed caterpillar
	II. Predators	
12.	*Chrysoperla carnea* (Green lacewing)	Soft bodied homopteran insects
	Cryptolaemus montrouzieri (Australian lady bird beetle)	Mealy bugs
	III Insect Pathogens	
13.	NPV of *Helicoverpa armigera* (Virus)	*H. armigera*
14.	NPV of *S.litura* (Virus)	*S.litura*
15.	*Bacillus thuringiensis* (Bacteria)	Lepidopteran insects
16.	*Beauveria bassiana* (Fungus)	Many insect pests
	IV. Fungal Antagonists	
17.	*Trichoderma viride*	Root rot and wilt causing fungi (*Rhizoctonia solani, Macrophomina phaseolina, Fusarium sp.)* in pulses, cotton, oilseeds, vegetables
18.	*Trichoderma harzianum*	
19.	*Pseudomonas fluorescence*	Root rot causing fungi in various crops
	V. Weed killers	
20.	*Neochetina bruchi* and *Neochetina eichhornae* (beetles)	Water hyacinth (Aquatic weed)
21.	*Zygogramma bicolorata* (beetle)	Parthenium weed

- Even though many commercial bio-control laboratories are involved in production of these agents, they are hardly sufficient to cover less than one percent of the total cultivated area. Hence there is a vast scope for improvement.

Table 11. Crop wise pest management practices using bio-agents/ botanicals

Sl. No.	Crop	Pest	Bio-agent
1.	Rice	Stem borer	*Trichogramma japonicum* 5 cc/ha/release on 30 and 37 DAT
2.		Leaf folder	*T.chilonis* 5 cc/ha/release on 58, 65 and 72 DAT Neem seed kernel extract 5% spray
3.		Gall midge	*Platygaster oryzae* 1 parasitised gall/ 10 m2
		Earhead bug	Neem seed kernel powder, Notchi leaf powder, Prosopis leaf powder
4.	Sorghum	H. armigera	HaNPV spray at 1.5 x 1012 POB/ha
5.	Pulses	H. armigera	HaNPV spray at 1.5 x 1012 POB/ha NSKE 5% spray *Bacillus thuringiensis kurstaki* 1.5 l/ha
6.	Groundnut	S. litura	SlNPV spray at 1.5 x 1012 POB/ha
7		Red hairy caterpillar	AaNPV spray at 1.5 x 1012 POB/ha
8.	Gingelly	Shoot webber	NSKE 5% spray
9.	Coconut	Rhinoceros beetle	*Metarhizium anisopliae* fungus incorporated in manure pits *Oryctes baculovirus* infected adults may be released Neem seed kernel powder + sand (1:1) in the base of three inner most leaves
10.		Black headed caterpillar	Release of *Goniozus nephantidis* 3000 adults/ ha under the coconut tree Release braconid, bethylid, eulophid and ichneumonid parasitoids from January.
11.		Termites	Neem oil 5% spray upto 2m height of trunk
12		Mealybugs	Neem oil 3% spray on leaves
13.	Cotton	*S. litura*	SlNPV spray at 1.5 x 1012 POB/ha

14.		*H.armigera*	HaNPV spray at 3.0 x 1012 POB/ha at 7 and 12th week after sowing *Trichogramma* spp. egg parasitoid @ 6.25 cc/ha thrice at 15 days interval from 45 DAS *Chelonus blackburnii* (egg larval parasitoid) and *Chrysoperla* (predator) @ 1,00,000 /ha at 6,13 and 14th week after sowing
15.	Sugarcane	*Early shoot borer*	Release 125 gravid female of Sturmiopsis inferens Granulosis virus on 25 and 50 DAP 1.1 x 105 IBS/ml
16.		*Internode borer*	T. chilonis egg parasitoid 2.5 cc/release, 6 releases at fortnightly interval from 4th month
17	Tobacco	S. litura	SlNPV spray at 1.5 x 1012 POB/ha NSKE 5% spray
18.	Citrus	Leafminer	NSKE 5% spray
19.	Grapes	Mealybug	*Cryptolaemus montrouzieri* (beetles) 10 per vine Fish oil insecticidal soap 25g/lit
20.	Sapota	Budworm	NSKE 5% spray
21.	Tomato	S.litura and H. armigera (Fruit borers)	SlNPV and HaNPV at 1.5 x 1012 POB/ha B.t. 2 g/lit T. chilonis 50000/ha/release
22.	Brinjal	Shoot and fruit borer	NSKE 5% spray
		Aphids	*Chrysoperla carnea* Ist instar larva 10,000 /ha
23	Bhendi	Fruitborer	*Trichogramma* 1,00,000 /ha *Chrysoperla carnea* Ist instar larva 10,000 /ha B.t. 2 g/lit
24.	Chillies	S.litura and H. armigera (Fruit borers)	SlNPV and HaNPV at 1.5 x 1012 POB/ha B.t. 2 g/lit *T. chilonis* 50000/ha/release
25.	Cabbage, Cauliflower	Diamond back moth	B.t. 2 g/lit, NSKE 5% *Diadegma semiclausum* (parasitoid) 50,000/ha

3. Biotechnological approaches

Biotechnology has provided new avenues for management of insect pets and it holds great potential to be included in IPM system.

- The low toxicity of proteinase inhibitors and Bt alpha-endotoxin as compared to conventional insecticides would reduce the selection pressure nd may slow down the development of resistance.
- Since all plant parts including growing points would remain covered with toxins, dependence on weather for efficacy of the sprays would be eliminated.
- Since toxins will always be there, so there will be no need of continuous monitoring of pests.
- Transgenic plant would also provide protection to those plant parts which are difficult to be treated with pesticides. Thus, transgenics may prove useful for controlling bollworms and borers which are difficult to control by means of insecticides.
- The cost of application in the form of equipment and labour will be nil or negative.
- The development cost is only fraction of the cost of development of conventional pesticides.
- There would be no problem of contamination in the form of drift and groundwater contamination.
- Insecticidal activity would be restricted to those insects which actually attack the plants. Transgenic plants would be safe to non-target species and human beings.
- Transgenic plants will have inbuilt resistance to various insects replacing some of the current pesticide usage with protection which is intrinsically

biodegradable, thus reducing the use of chemical insecticides and minimizing the problem of environmental pollution.

4. Insecticide status in pest management

- Insecticides application remains one of the effective, quick methods and most widely used pest control tactics. When properly used they provide an efficient, fast, reliable and cost-effective means of pest control. The draw backs or risks in their use include development of resistance, destruction of natural enemies, poisoning of man and animals, environmental pollution and increasing costs. Hence, it is highly needed to switch over to newer insecticide molecules to provide on efficient, fast and reliable means of pest management.

4.1. Criteria for newer insecticide molecules

The newer insecticide molecules should have the following criteria for their environmental safety with effective control.

- Safer to natural enemies
- Low mammalian toxicity
- Effective management with low dose
- Broad spectrum
- No / Low residues
- Phytotonic effect
- Suitable formulation
- Suitable method of application

4.2. Groups of new generation insecticides

The new generation insecticides are grouped into

10. Neonicotinoids / Nitroquanidines
11. Synthetic pyrethroids
12. Insect growth regulators
13. Organic insecticides
14. Organophosphates
15. Carbamates
16. Insecticide combinations

1. Neonicotinoids

The neonicotinoids includes

i) Imidacloprid – Confidor 200 SL, Caucho 600 FS, 70 WS

ii) Acetamiprid – Pride 20 SP

iii) Thiamethoxam – Actara 25 WG, Cruiser 70 WS

2. Insect growth regulators

- Diflubenzuron - Dimilin 25 WP '
- Teflubenzuron - Nomolt 15 SC
- Fluenoxuron - Cascade 10 DC
- Navaluron - Rimon 10 EC

- All these insecticides are non-systemic in their action and are coming Under Benzophenyl urea group of insecticides and when applied, these insecticides are found to be causing inhibition of chitin formation which causes abnormal endodocuticles and abortive moulting. These insecticides are effective chewing insects and defoliators.

3. Carbomates

Indoxacarb - Avaunt 14.5 SC

Thiocarb - Larvin 75 WP

Carbosulfan - Marshal 25 EC

These carbamate insecticides are contact and stomach poison in their action and are targeted against sucking and chewing insects especially in cotton

4. Synthetic pyrethroids

- Lamda cyhalothrin - Karate 5 EC, Kungfoo 2.5 EC
- Beta cyfluthrin - Bulldock 0.25 SC
- These two synthetic pyrethroids are contact and stomach poison in action and effective against sucking and chewing insects. Lamda cyhalothrin is also having phytotonic effect.

5. Organic insecticides

i. Spinosad - Tracer 45 SC, Success 2.5 SC

ii. Abamectin - Vertimec 1.9 EC

iii. Cartap hydrochloride - Caldan 50 SP

i. Spinosad

- It is extracted from actinomycetes Saccharopolyspora spmosa. The insecticide formulation contains two components as spinosyn A+D. It is a contact and stomach poison targeted against Helicoverpa armigera.

ii. Abamectin

- It is extracted from bacteria, Streptomyces avermectilis. This insecticide is having contact and translaminar action and it is used as an Acaricide in ornamentals.

iii. Cartap hydrochloride

- It is extracted from a marin annelid, Zumbriconereis heteropoda,. This insecticide is having systemic contact and stomach poison and causes paralysis of CNS. It is effective against chewing and sucking pests.

6. Organophosphates

i. Profenofos - Curacron 50 EC

ii. Triazophos - Hostathion 40 EC

i. Profenofos

- It is contact and stomach poison insecticide and also having translaminar in action. It is mainly targeted against sucking pests, bollworms and mites in different crops.

ii. Triazophos

- It is an effective acaricide and targeted against sucking and chewing insects. It is contact and stomach poison

5. Future needs

- India's consumption of bio-agents like entomophages, botanical and microbial pesticides, pheromones etc is less than one per cent of the total pesticide consumption compared to 12 per cent globally Hence we must strengthen our usage of bio-agents in the IPM techniques suitable in all major crops.
- Use of pest avoidance tactics, enhancement of biological pest suppression and adoption of other non-chemical methods of pest management would certainly be able to improve our capabilities in solving much of the pest problems.
- About 70 per cent of our people depend on agriculture for their livelihood and more than 80 per cent of them are small and marginal category. Hence, IPM components should be cost effective and environment friendly to suit the situations of the above category. Such a goal can be reached through farmer participatory mode in IPM technology development and transfer.
- There is very high demand for some promising bio-control agent and that practically there is a wide gap between the demand and supply. This is rather a dicey situation, which may need to unhealthy practices. Hence to cater the need of farmers, unemployed farm graduates may be encouraged to start commercial insectaries. Periodical Know-how and do-how training's have to be organized by the ICAR and State Agricultural Universities.
- Survey and surveillance of insect pests have to be carried out at every village level on all crops using pest monitoring devices *viz.*, light traps, pheromone traps baits, fad lures, trap crops, colour and sticky traps etc. forecasting and

forewarning of insect pests have to be strengthened with satellites and computer prediction models.

- More than 500 different crop plant varieties were identified as source of resistance against insect pests. However their usage in the field level is far from satisfactory. Hence this lab to land gap has to be bridged. Plant resistance should be the base of IPM and all other methods have to be pyramided over it.
- The most recent introduction of B.t transgenic plants conferring resistance to certain insect pests like cotton boll worms has expanded the scope of IPM. Such plants where minimum use of insecticides is made help in conserving biological control agents and serve as important IPM tool.
- Without a strong commitment to interdisciplinary research, it is doubtful that Integrated Pest Management will become a reality. Hence all allied fields of Agriculture should join hand in hand to solve pest problems with more involvement is very essential.
- Unfortunately, today, the decision on the pesticide application lies with the dealers, who in their interest advise farmers to use a large number of applications of a variety of chemical pesticides and their mixtures, whether required or not or whether efficacious or not. Prescriptions from Plant protection officials or from Entomologists of the manufactures can form a better base for purchase of plant protection chemical just like a prescription from a doctor for purchase of medicines. This would also help remove the social stigma of adherence to past practices of continuing with hazardous and not so efficacious chemical pesticides. Dealer training and imposition

of qualifications for dealers shall definitely create a positive change towards IPM.

- Each crop/pest and farm level situation is unique and it is not likely that there could be an "Off the shelf" available IPM solution to each crop/pest crisis. There fore, fine tuning based on scientific studies and research becomes imperative. It is definitely a knowledge intensive activity.
- The most important steps to make IPM movement unstoppable and its benefits self-evident are:
- Validation of appropriate non-chemical methods in farmer fields, based on dependable ETL.
- Extensive transfer of Knowledge package "through farmer trainings,
- Large scale availability of high quality non-chemical pest/disease intervention inputs.
- Future needs of IPM greatly depend on research education, training and marketing improvements, and they can be re-oriented as follows.

Important definitions

Allomone

- A chemical substance, produced or acquired by an organism, which, when it contacts an individual of another species in the naturl context, evokes in the receiver a behavioural or physiological reaction adaptively favorable to the emitter; cf. kairomone.

Antifeedant

- A natural or synthetic chemical substance which acts either to inhibit the stimulation of gustatory receptors which normally recognize suitable food, or to stimulate receptors which elicit a negative response to deterrent chemicals.

Biological control

- Biological pests suppression in its narrow, classical sense, usually restricted to the introduction, by man, of parasitoids, predators, and / or pathogenic microorganisms to suppress populations of plant or animal pests; cf. biological insect pest suppression, natural control.

Integrated pest suppression

- An approach to compatible utilization of all available forms of pest suppression, including mechanical, biological, chemical, and natural control, in a systematic fashion, with the primary goal of safe, effective, and economical pest population reduction. It may be directed at a single important pest species by combining a variety of measures against the species, or at a complex of pests, integrating the individual protective measures applied against each, so as not to interfere one with the other.

Microbial pathogen

- Generally, a microorganism which causes disease in its host; more specifically, a term used in preference to microbial "insecticide" to denote a microorganism used by man to suppress insect pest populations.

Parasite

- An animal species which lives on or in a larger animal, the host, feeding upon it, and frequently destroying it. A parasite needs only one or part of one host to reach maturity; cf. parasitoid, predator.

Pheromone

- A pheromone is defined as a chemical or a mixture of chemicals that is released to the exterior by an organism and causes one or more specific reactions in a receiving organism of the same species.

Predator

- An animal which feeds upon other animals (prey) that are usually smaller and weaker than itself, frequently devouring them completely and rapidly. A predator most often is required to seek out and attack more than one prey to reach maturity; cf. parasite, parasitoid.

Resistance

- The relative amount of inherited qualities which allow an organism to influence or reduce the damage done to it by its enemies.

Trap crop

- A small planting of a susceptible and highly attractive host, planted early in the season, or removed in space from the main crop, in order to divert attack and infestation by pets and allow for their easy destruction.

Methods and adopted for controlling pests

The control of insect pests falls under following heads

a. Legislative

- By which the Government prevents the import of infested with insects, which if introduced into this country, would become local pests (e.g. potato tubers with nematodes).

b. Biological method

- The successful control of a pest species by means of another living organism that is encouraged and disseminated by man is called so. It is inexpensive and as long-term control, causes no pollution and poses no risk to human health. Biological agents are available in nature abundantly. Several pathogens including viruses such as nuclear polyhedrosis virus (NPV) and granulosis (GV), bacteria like *Bacillus thuringiensis*, fungi like *Metarhizium, protozoa* like *Schizogregarine* cause diseases in insects to destroy them. This method has been successfully used to control many important pests in a number of economic crops.
- The other biological method of control involves the use of parasitoids and predators. A parasitoid is an organism which completes its life on a single host and ultimately kills it. A predator on the other hand is a free living-

organism and kills the host (prey) immediately and requires more than one prey individuals to complete its life. If the parasitoid attacks the egg stage of the host, it is then called egg parasitoid, (e.g.) *Trichogramma chilonis* on bhendi borer. When they attack at the larval stage of the host, it is then called larval parasitoid, (e.g.) *Apanteles plutella* on diamond back moth caterpillars in cruciferous vegetables. The predatory group of insects capture and consume another insects as their food (e.g.) green lace-wing, *Chrysoperla carnea* whose grubs and the maggots of Syrphid flies dramatically exert control over several aphids in many crops. The adults and grubs of ladybird beetles such as *Coccinella septempunctata*. *Menochilus sexmaculatus*, *Brumoicles suturalis* and *Scymnus nubilus* play important role in the population regulation of several sucking pests and defoliating insects.

c. Cultural methods

- The control of insects through adoption of ordinary farm practices in appropriate time in such a way that the insects are either eliminated or reduced in population is called the cultural method of control. Proper crop rotation or tillage operations may help to keep down the insect population.
- Some early crops are sown in narrow strips around a major crop to serve as a trap for the pests that might be common to both. For instance, sowing of mustard in every twenty fifth row of cabbage crop will help preventing higher incidence of diamond back moth in cabbage and cauliflower and

the preferred mustard plants can be cut and destroyed when the pest appears. This practice is called trap cropping.

d. Mechanical method

- Mechanical control is one by which the insect population is directly hit by mechanical devices or manual operations. Mechanical devices include using fly and maggot traps, setting light and bonfires to attract adult moths and beetles. Manual methods involve hand picking of egg masses, larvae and killing them. Mechanical exclusion consists the use of devices by which insects are physically prevented from reaching the produce (e.g.) wrapping of individual pomegranate fruits with butter paper envelopes to save from the attack of Anar butterfly, *Virachola isocrates*.

e. By use of insecticide

- Insecticide is a substance or mixture of sub¬stances used for killing, repelling or otherwise preventing insects. The insecticide is referred as a 'repellent' if it prevents the pest species in attacking its host, an 'attractant' if the pest species is attracted to source, trapped and an 'antifeedant' if it inhibits feeding on the host. The insecticides are available in any one of the following formuations:

1. Dusts

- The toxicant is diluted by mixing with or by impregnation a suitable finely divided carrier. The carrier may be organic flour clay. The toxicant in a dust formulation ranges from 0.5 to 25% (e.g.) endosulfan 4D, malathion 5D.

2. Granular or Pelleted insecticides

- In a granulation the particle is composed of a base such as an inert material or vegetable carrier impregnated or used with the toxicant which is released from the formu¬lation in its intact form or as it disintegrates giving controlled release particles in the formulation generally possess a size range of 0.25 mm to 2.38 mm diameter. The formulations contain 2 to 10% concentrations of the toxicant (e.g.) carbrofuran 3G, Phorate 10 G.

3. Wettable powders

- It is a powdered formulation which yields a rather stable suspension when diluted with water. The active ingredients such a formulation ranges from 15 to 95% (e.g) BHC 50 WP, sulfur 25 WP.

4. Emulsifiable concentrate

- The formulation contains the toxicant solvent for the toxicant and an emulsifying agent (e.g.) endosulfan, EC, dimethoate 30 EC, fenvalerate 20 EC.

5. Concentrated insecticide liquid

- The toxicant at highly concentrated level is dissolved in non-volatile solvent. An emulsifying, agent is not added here (e.g.) monocrotophos 36 WSC, Phosphamidon 85 WSC.

6. Fumigants

- A chemical compound which is volatile at ordinary temperatures and sufficiently toxic is known as a fumigant (e.g.) Ethylene di bromide, Methyl bromide, Aluminium Phosphide etc.

7. Fungicide

- Fungicide is any substance that is used to kill fungi and their spores. They are also available in dust, wettable powder, emulsiable concentrates or granular formulations.

Plant protection appliances

- The important methods of applying pesticides are dusting and spraying. The dusting operation allows the dust particles when falling free either slowly to settle down due to gravity or drift for long distance due to wind. The appliances that are used for applying dust formulations of pesticides are called dusters. They are either manual or power operated.
- The spray fluid may be solution, an emulsion, or a suspension toxicant. To achieve an effective control of pest, the toxicant is well distributed and to meet this requirement the spray fluid is blown down to fine droplets. The spraying machines may be either hand operated or power operated ones.

Commonly employed manual operated sprayers are (i) knap- sack sprayer (hydraulic or pneumatic), sprayer and pneumatic hand sprayer. Rocker sprayers are useful for tall trees and pneumatic hand sprayers are helpful to spray in gardens. The power operated mist blowers are useful in field cover more area in a limited time. A spray volume of 150 to 200 water is necessary to one hectare of land with power spray with low pressure high volume sprayers but with low press volume sprayers like knapsack sprayers require about 450-500 water to cover one hectare. Insecticides should be applied in the morning or evening hours when the weather is calm or else they will fall on unwanted areas and also may not hit the target. Before application insecticides, it must be ensured that there are no pollinators (like-bees) in the area; for the same reason insecticides should not be applied during blossoms when bees are likely to be at work. After application of insecticides a time lag (7 – 10 days in case of organophosphorus compounds and 20-30 days in case of organochlorine compounds) should be given before consuming the produce. During this period, the insecticides will get degraded and become non-toxic.

Non-insect pests

- Besides the different kinds of insects which damage crops, mites, rats, birds and nematodes cause damage to crop plants.

A. Mites

- Mites possess four pairs of legs as against insects which do have only three pairs of legs. In recent years the mites have become major pests. They cause damage by way of sucking the cellular materials by forming severe deformities. The, chemicals which are used to control the mites are known as 'acaricides'. Sulphur, ethion, dicofol, phosalone are commonly used as acaricides at the rate of 15ml per 10 litres of water.

B. Plant nematodes

- Plant nematodes are small organisms which live soil around the roots of plants. They are about 0.1 to 1.00 mm in length. They are confined to the top 20 to 25 cm of soil, sometimes even to a depth of 3 to.4 m. They are spread from one field to another through percolating water and agronomic practices like ploughing and weeding which involve transport of soil. Most of the symptoms of damage by plant parasitic nematodes are non-specific and often likely be confused with those caused by other pathogens or soil factors like poor drainage, lack of soil nutrition etc. Some of the commonly observed symptoms are:

6. Stunting and wilting
7. Leaf curl
8. Browning or bronzing of leaves
9. Distortion of leaves, stems
10. Brown lesions in roots
11. Knot-like galling of roots

- Control of plant parasitic nematodes is difficult, but nevertheless, necessary for obtaining profitable yields. Crop rotation with a non-host crop or application of large quantities of green leaves or grasses as mulches or summer fallowing and use of resistant varieties will reduce the incidence to some extent. Commonly used nematicides are DD mixture, dibromoethane, dibromo chloropropane, thionazin and aldicarb. In Tamil Nadu, nematode infection is a devastating problem in banana, citrus, potato and in vegetable crops like tomato, chillies and brinjal.

Integrated pest management (IPM)

- IPM is a new system approach which has been necessitated primarily out of the growing concern about the undesirable side effects of large scale use of organic insecticides and often failure of the same to provide for suppression of pests at economic level. Attempts to totally suppress the pests by insecticides may lead to the following problems:
- Development of resistance to chemicals in pest population outbreak of secondary pests resurgence of treated populations unacceptable residues on food and forage products and association legal complications destruction of beneficial insect predators, parasites and pollination hazards to personnel involved in insecticide application, domestic animals and wild life; and
- Expense of pesticides, involving the cost of materials, labour and maintenance of equipments.

- Thus in any IPM programme, the ecological factors are exploited, the control methods are so designed that they are compatible with natural mortality factors in order to optimize control.

Pest Surveillance and Monitoring

- Pest surveillance is the watch kept on a pest for decision-making.

Objectives

- The objectives of the pest and disease surveillance programme in Agricultural and Horticultural crops are to:

    a. Detect species of pest or pathogen present

    b. Assess levels of population / damage / infection

    c. Study the influence of weather and seasonal parameters on pests and diseases.

    d. Know new species of pests and diseases.

    e. Monitor the behaviour of pests under changing cropping pattern / new varieties.

    f. Find out natural enemy population

    g. Watch the behaviour of pests under changing cropping pattern/new varieties

    h. Assess resistance/susceptibility/break-down of resistance in crops to pests and diseases.

    i. Monitor build-up of resistance in pests and pathogens to pesticides

j. Mark endomic areas/pest calendar

k. Launch timely plant protection measures on need-basis,

l. Reduce cost of cultivation

m. Avoid contamination to eco-system, and

n. To forewarn farmers

Methodology for Surveillance

- The surveillance programme encompasses (i) fixed plot survey and (ii) roving survey. The fixed plot and roving surveys involve the *in-situ* assessment of pests and diseases in the standing crop. The supporting methodology includes observations on the activity of pests by setting up light traps, pheromone traps, spore trap, etc. The weather parameters of the respective areas are also recorded to study their influence on the pests and diseases.

Lecture No.6
Insecticides, classification and their mode of action

Introduction

- Insecticides are agents of chemical or biological origin that control insects
- Despite the availability of several ecofriendly technologies for pest management, farmers rely mostly on the chemical pesticides because of their availability, immediate and spectacular effect increased use of these compounds all over the world as well as in India

Classification of pesticides based on target organisms

1. Insecticides eg. endosulfan, malathion
2. Rodenticides eg. Zinc phosphide, warfarin
3. Acaricides eg. dicofol, azinphos methyl
4. Avicides eg. TMTD, anthraquinone
5. Molluscides eg. metaldehyde, trifenmorph
6. Nematicides eg. DD, ethylene dibromide
7. Fungicides eg. Copper oxychloride, mancozeb
8. Bactericides eg. Streptomycin sulphate, aureomycin
9. Herbicides eg. 2,4-D, butachlor

Classification of insecticides

1. Based on chemical nature

A. Inorganic insecticides

eg. Arsenic & Fluorine compounds

B. Organic insecticides

10. Hydrocarbon oils
11. Animal origin eg. Neristoxin
12. Plant origin eg. Nicotine, pyrethrum, rotenone, neem
13. Synthetic organic compounds

   i. Dinitro phenols eg. DNOC

   ii. Organothiocyanates eg. thanite

   iii. Chlorinated hydrocarbons eg. endosulfan

   iv. Organophosphorus compounds eg. phosphamidon

   v. Carbamates eg. carbofuron, aldicarb

   vi. Synthetic pyrethroids eg. cypermethrin

2. Based on mode of entry

- Stomach poison eg. B.t
- Contact poison eg. Chlorinated hydrocarbons
- Fumigant eg. DDVP, Lindane
- Systemic poison eg. Methyl demeton, Dimethoate

3. Based on mode of action

A. General classification

18. Physical poison eg. inert dusts
19. Protoplasmic poison eg. heavy metals like mercury and copper, fluorine and arsenics

20. Respiratory poison eg. hydrogen cyanide, carbon monoxide

21. Nerve poison eg. organophosphates, carbamates

B. Matsumura's classification

22. Physical poison eg. inert dusts.

- Dissolves wax layer & rearrange them – cracking.

2. Protoplasmic poison eg. heavy metals like mercury and copper, fluorine and arsenics

- Denatures protoplasm.

3. Metabolic inhibitors

i. Carbohydrate metabolism inhibitors eg. Sodium flouroacetate

- Inhibits TCA cycle.

ii. Respiratory metabolic inhibitors eg. Rotenoids, arsenicals

- Inhibitors of ET chain
- Inhibitors of oxidative phosphorylation

iii. Amine metabolism inhibitors eg. Formamidines

- Induces accumulation of biogenic amines – octopomine
- Blocks Na+ channel and also K+ current

iv.Mixed function oxidase inhibitors eg. Synergists

v. Insect hormones eg. Juvenile hormone analogues

- Affects synthesis of natural JH

vi. Chitin synthesis inhibitors eg. Diflubenzuron

- Affects deposition of chitin in endocuticle
- Affects other constituents of endocuticle

4. Non metabolic inhibitors (or) neuroactive agents

i. Effect of permeability eg. HCH, DDT

ii. Anticholine esterases eg. OP's, carbamates

iii. Agents for nerve receptors eg. Nicotenoids

5. Hormone mimics eg. methoprene

6. Stomach poison eg. Bt

C. Insecicides mode of action groups

Group	Primary target group	Chemical subgroups
1A	Acetyl choline esterase	Carbamates
1B	inhibitors	Organophosphates
2A	GABA-gated chloride	Cyclodienes
2B	channel antagonists	Polychlorocycloalthanes
2C		Fiproles
3A	Sodium channel modulators	Pyrethroids, pyrethrins
4A	Ach receptor	Chlornicotinyls
4B	agonist/antagonists	Nicotine
4C		Cartap, bensultap
5A	Ach receptor modulators	spinosyns
6A	Chloride channel	Avermectin, emamectin
6B	activators	Milebemycin
7A	Juvenile hormone mimics	Methoprene, hydroprene
7B		Fenoxycarb
7C		pyriproxifen

8A	Unknown or non specific	Methyl bromide
8B	action (fumigants)	Phosphine generating comp.
9A	(selective feeding blockers)	Pymetrozine
9B		Cryolite
10A	(mite growth inhibitors)	Clofentezine, hexythiazox
11A	Microbial disrupters of	*B.t. tenebrionis*
11B	insect midgut membranes	*B.t. israelensis*
11C	(including Bt crops)	*B.t. kurstaki, B.t. aizawi*
11D		*B.t. sphericus*
11E		*B.t. tolworthi*
12A	Inhibitors of	Organotin miticides
12B	oxidativephosphorylation, Disrupters of ATP formation	Diafenthiuron
13A	Uncoupler of oxidative phosphorylation via disruption of H proton gradient	Chlorfenapyr
15A	Chitin biosynthesis inhibitors	Acyl ureas
16A	Ecdysone agonists	Tebufenozide and related
17A	Homopteran chitin biosynthesis inhibitors	Buprofezin
18A	Unknown dipteran specific mode of action	Cyromazine
19A	Octopominergic agonist	Amitraz
20A	Site II electron transport inhibitors	Hydramethylnon
21A	Site I electron transport inhibitors	Rotenone, METI acaricides
22A	Voltage dependent sodium channel blocker	Indoxacarb

Newer insecticide molecules

1. Avermectin insecticides - abamectin, emamectin, ivermectin
2. Macrocyclic lactone insecticides - spinosad
3. Nicotinoid insecticides - imidacloprid, thiamethoxam, thiacloprid, acetamiprid, chlothianidine
4. Oxadiazine insecticides - indoxacarb

5. Thiourea insecticides - diafenthiuron
6. Urea insecticides - flucofuron, sulcofuron
7. Pyrrole insecticides - chlorfenapyr
8. Pyridazinones - pyridaben
9. Quinazolines - fenazaquin
10. Pyrazole insecticides - ethiprol, chlofenofer, fipronil
11. Benzoylureas - teflubenzuron, flufenozuron, diflubenzuron

Miscellaneous insecticide classes

- Methoxyacrylates – Fluacrypyrin
- Naphthoquinones – acequinocyl
- Nereistoxin analogues – thiocyclam, cartap
- Pyridine azomethine – pymetrozine
- Pyrimidanines – pyrimiifen
- Tetronic acids – spiromesifen, spirodiclofen
- Benzenedicarboxamides – flubendiamide

Insecticide formulations

- Formulation involves processing of the technical grade insecticides for better storage, handling, measure, application and efficacy together with safety
- Depending upon the mode of applications, dry and liquid formulations are common forms
- They may also be classified as solid, liquid and gaseous formulations

Classification

1. Solid formulations

- Dust, wettable or water dispersible powder, granules, capsules, baits etc.

2. Liquid formulations

- Solution, emulsifiable concentrate, ultra low volume formulations, suspension etc.

3. Gaseous formulations

- Fumigant, aerosol, foams, smokes, mists and fog.

EC - Emulsifiable concentrate CG - Encapsulated granule CS - Capsule suspension DC - Dispersible concentrate DP - Dispersible powder EG - Émulsifiable granule EO - Emulsion, water in oil EW - Emulsion, oil in water ES - Emulsion for seed treatment FG- Fine granule SC- Suspension concentrate SE- Suspo- emulsion SG- Water soluble granule SL- Soluble concentrate SP- Water soluble powder SS- Water soluble powder for seed treatment SU- Ultra-low volume suspension TB- Tablet	FS - Flowable concentrate for seed treatment G - Granule GC - Macrogranule GL - Emulsifiable gel GP - Flo-dust GW - Water soluble gel OL - Oil miscible liquid OP -Oil dispersible powder WDP- Water dispersible powder WG- Water dispersible granules WP- Wettable powder WS- Water dispersible powder for slurry treatment WSC –Water soluble concentrate

Different formulations

Compatibility of insecticides

- Simultaneous or sequential application of insecticides, fungicides, fertilizers etc in a single cropping season advantageous
- Main reason for combinations of pesticides - saving of time, equipment wear and tear and cost of application
- problems associated with this practice

i. physical incompatibility (agglomeration, phase separation etc.)

ii. chemical incompatibility (degradation of active ingredient, change in pH)

iii. biological incompatibility (reduction in bioefficacy of one by other, phytotoxicity)

Consider the following before combination of pesticides is resorted to

- Do not mix two insecticides, as they will hasten the development of resistance in pests
- Do not mix the incompatible pesticides
- Do not mix the pesticides, as a matter of routine. Apply insecticide-fungicide combination only when both the target insect and plant pathogen are above ETL level.

Tests of compatibility

- Combinations may either prove phytotonic or phytotoxic sometimes
- Physical and chemical tests undertaken for testing of insecticide quality and formulations

9. Acidity and alkalinity test
10. Emulsion stability test
11. Wettability test
12. Sieve test
13. Bulk density test
14. Suspensability test

Compatibility of insecticides Vs. Fungicides

	Benomyl	Carbendazim	COC	Cuman-L	Dithane - M45	Mancozeb	Captan
1. **Chlorinated hydrocarbons**							
Dicofol				C	C		C
Endosulfan		C					
2. Organo phosphates							
Chlorpyriphos		C	C				C
Dichlorvos		C	C	C		C	
Dimethoate	I		I	C	C	C	C
Malathion	C	C		C	C		
Methyl-demeton		C	C				
Monocrotophos		C	C	I	C	C	C
Phosphamidon		C	C	C	C	C	
4. Pyrethroids							
cypermethrin		C	C		C		I

Compatibility of insecticides Vs. Plant nutrients (Fertilizers) and Herbicides

	Borax	**Urea**	**Zinc sulphate**	**Atrazin**	**Alachlor**	**Metachlor**
Chlorfenvinphos		I				
Diazinon		C		I	I	
Endosulfan		C				
Fenitrothion		C				
Methyldemeton		C				
Monocrotophos		C				
Phenthoate		C				

Phorate	C	C		I
Profenofos		C		

Compatibility of insecticides Vs. Biopesticides (Insect Pathogens)

	Bt	Ha NPV	Sl NPV
Chlorpyriphos			
Dimethoate	C		
Endosulfan	C	C	C
Fenitrothion	C		C
Methyldemeton	I		
Monocrotophos	C		
Phorate			
Phosalone	C		
Phosphamidon	C		

Quality control of pesticides

Quality control of pesticides

- The effectiveness of the pesticides in pest control programmes largely depends on the quality which in turn is the function of physico chemical properties of the active ingredients and the characteristics of the formulations
- The establishment, implementation and the monitoring of the standards of the quality of pesticides are very important facets of improved agricultural production
- The Insecticides Act , 1968
- The Insecticides Rules, 1971
- The main objective of the Act is to regulate the import, manufacture, sale, transport, distribution and use of pesticides with a view to prevent risk to human beings and animals and for matters connected therewith.
- Bureau of Indian Standards (BIS)
- Pesticide Industries

- Government (Central and State)

Precautions and directions for drawing samples

- do not take sample in an exposed place.
- See that the tools used for sampling are dry and clean.
- Take necessary precautions regarding toxicity effect of samples being drawn.
- Avoid contamination during and after sampling.
- Containers receiving samples - clean, dry and air tight.
- See that the size of the container receiving samples is such that it is not completely filled by the sample.
- Seal the container with the sample air tight and furnish details regarding sampling, date of manufacture, name of the manufacturer etc.
- Store the sample in a proper place.

Scale of sampling

- All samples of a same batch considered as one lot and samples bearing different batch numbers considered as separate lots.
- Samples from each lot are to be drawn and tested.
- The number of containers to be chosen for sampling depends on the size of the lot.

Physical tests

A. Dust and wettable powder formulations

20. Sieving Test for particle size requirement
21. Test for bulk density
22. Sieve test after accelerated storage
23. Compensability test
24. Wettability test

B. Emulsion concentrate or emulsifiable concentrate

25. Emulsion stability test
26. Cold test, flash point test and heat stability test

C. Granules

27. Attrition test
28. Water runoff test, wet test for encapsulation and liquid holding capacity

Chemical tests

29. Test for acidity/ alkalinity
30. Active ingredient content

Disposal of pesticides

- All unused pesticides and containers must be disposed off carefully
- Improper disposal of pesticide wastes and pesticides containers can result in incidents of animal poisoning or environmental contamination

Pesticide wastes may range as follows

- Accidental spillage
- Left over from excess spray mixtures
- Unsold pesticide materials
- Damaged containers
- Pesticides which lost their expiry dates
- Wrong application

Disposal techniques

Disposal of spilled pesticides

- Don't wash with much of water
- Sprinkle moist sand or saw dust
- Remove the contaminated soil and burry
- Wash the contaminated floor with lime or 10% sodium bicarbonate

Disposal – Burial under soil

- Burial site must be carefully chosen
- The area should be marked out and identified such that leakage of buried pesticide will not contaminate water bodies.
- Should be buried 50 cm below
- Lime may be mixed to enhance degradation process

Disposal of containers

- Misuse of containers should be avoided
- Empty and clean the containers before disposal

- Drain the pesticide in a vertical position for 30 seconds
- Rinse with water thrice
- Make the container unusable by puncturing and deforming
- Should be buried
- Paper and fibre container should be burnt in open air
- Herbicide containers should not be burnt in the vicinity of crops
- When burning don't respire the smoke
- Glass containers should be broken and buried

Pesticide disposal technology

- The diversity in chemical properties of pesticides and their formulated products and the quantity and composition of pesticide wastes complicate the disposal technology
- No single treatment system can be universally applied

I. Chemical detoxification and disposal methods

59. Acid or base hydrolysis, oxidation, reduction or irradiation
60. Other methods such as fixation, wet scrubbing, Chlorinolysis, neutralisation, precipitation, ion exchange and solvent extraction for treating industrial pesticide production plant effluents and other industrial wastes.

II. Physical detoxification and disposal methods

1. Incineration

- This is the best method of detoxification and disposal of non-metallic toxicants.

2. Ocean incineration

- In this the incinerator is taken into the sea in a ship and hazardous chemicals are combusted.

3. Deep well injection and ground burial and use of chemically modified peat are other physical disposal methods

III. Biological detoxification and disposal methods

63. Soil incorporation
64. Land fills
65. Activated sludge system
66. Enzymatic treatment.

Biorational insecticide

- Biorational pesticide
- "Any type of insecticide active against pest populations, but relatively innocuous to non-target organisms, and, therefore, non-disruptive to biological control" (Stansly *et al.*1996).
- An insecticide can be "innocuous" by having low or no direct toxicity, or by having systemic or by moving rapidly into the leaf through the leaf surface, or by having short field residual, thereby minimizing exposure of natural enemies to the insecticide.

- an insecticide can be innocuous to one natural enemy or even some life stages of one natural enemy but can be toxic to another natural enemy or other life stages
- The biorational nature of pesticides depends upon the time, pest and crop upon which they are used
- It needs good safety on non-target pest

Chemical Action	Common Name	Target Pest
Systemics (nicotinoids)	Imidacloprid Thiamethoxam Acetamiprid	Whiteflies, aphids Whiteflies, aphids Whiteflies, aphids
Insect Growth Regulators	Pyriproxyfen Buprofezin Tebufenozide Methoxyfenozide Novaluron	Whiteflies, aphids Whiteflies Leps. Leps. Whiteflies, Leps.
Miscellaneous	Pymetrozine Spinosad Indoxacarb Emamectin benzoate Chlorantraniliprole	Aphids, whiteflies Leps., leafminers Leps. Leps., leafminers Leps., leafminers

Pesticide 2007

S.No.	Chemical name	Trade name	Dose (*a.i.* ha-1)	Crop	Pest
1.	Flubendiamide 480 SC	Fame	24g	cabbage	Diamond back moth
2.	Flubendiamide 480 SC		48g	Tomato	*Helicoverpa armigera*
3.	Flubendiamide 480 SC		60g	Chillies	Fruitborer
4.	Flubendiamide 480 SC		48g	Redgram	*Maruca testulalis, Excelastis atomosa Helicoverpa armigera*
5.	Flubendiamide 480 SC		48g	cotton	bollworms
6.	Flubendiamide 480 SC		24g	rice	Leaf folder

7.	Fipronil 80 WG		50g	Rice	Stem borer and leaf folder
8.	Fipronil 5SC	Regent	50g	Rice	Stem borer and leaf folder
9.	Fipronil 80 WG		50g	Grapes	Thrips
10.	Fipronil 80 WG		50g	Chillies	Thrips
11.	Imidacloprid 200 SL	Confidar Tatamida	50g	Grapes	Grapevine flea beetle
12.	Imidacloprid 200 SL		25g	Cucumber	Sucking insects
13.	Imidacloprid 200 SL		50g	Tobacco	Sucking pests
14.	Imidacloprid 17.8 SL		15g	okra	Sucking pests
15.	Imidacloprid 17.8 SL		25g	okra	Sucking pests
16.	Imidacloprid 17.8 SL		50g	Cotton	Sucking pests
17.	Imidacloprid 70 WG	Admire	24.5g	Cucumber	Aphids, leaf hoppers
18.	Triazophos 20EC	Hostothion	600g	cotton	Bollworms
19.	Triazophos 40EC		200g	Chillies	Sucking pests
20.	Spirotetramat 150 OD		60g	Chillies	Sucking pests
21.	Spirotetramat 150 OD		75g	Cotton	Sucking pests
22.	Emamectin benzoate 5 SG	Proclaim	11g	Cotton & Bhendi	*Helicoverpa armigera*
23.	Emamectin benzoate 5 EC	-	15g	Bhendi	Fruit borer
24.	Emamectin benzoate 5 EC	-	15g	cotton	Bollworms
25.	Emamectin benzoate 1.9 EC		20g	Bhendi	Fruit borer
26.	Emamectin benzoate 1.9 EC		20g	cotton	Bollworms
27.	Thiamethoxam 25 WG		25g	cotton	Sucking pests
28.	Thiamethoxam 25 WG	Actara	25g	rice	GLH & BPH
29.	Indoxacarb 14.5 SC	Isacarb, Avaunt	75g	Cotton	Bollworms
30.	Indoxacarb 14.5 SC		25g	Cabbage	Diamond back moth
31.	Indoxacarb (KN 128)15 EC		40g	cabbage	Diamond back moth
32.	Indoxacarb (KN 128)15 EC		75g	Cotton	Bollworms
33.	Spinosad 2.5 SC	Success	18.75g	Cabbage	Diamond back moth
34.	Spinosad 45 SC	Tracer	75g	Chillies	Fruit borers
35.	Bifenthrin 10 EC	Talstar	50g	Rice	Leaf folder
36.	Spiromesifen 240 SC	Oberon	120g	Okra	Red spidermite
37.	Spiromesifen 240 SC	Oberon	96g	Tea	Tetranychid mite
38.	Buprofezin 25 SC		200g	cotton	Sucking pests
39.	Buprofezin 25 SC		200g	rice	GLH & BPH

40.	Buprofezin 25 SC	Applaud 25 SC	325g	Grapes	Mealybugs
41.	Ethiprole 10 SC		50g	Rice	BPH, WBPH
42.	Thiacloprid 24 SC	Alanto	50g	Rice	BPH, WBPH
43.	Propargite 570 EC	Omite	570g	Okra	Red spider mite
44.	Fenazaquin 10 EC	Magister	100g	Okra	Red spider mite
45.	Fenpyroximate 5 SC	Senda, Mitigate	30g	chillies	mite
46.	Chlorpenapyr 10 SC	Intrepid	100g	Cabbage	Diamond back moth
47.	Diafenthiuron 50 WP		0.16g	Cardamom	Shoot and capsule borer, thrips
48.	Diafenthiuron 50 WP	Pegasus	0.1g	Cardamom	thrips
49.	Acetamiprid 20 SP	Pride	50g	Cotton	Sucking pests
50.	Abamectin 1.9 EC	Abamectin	22.5g	Cotton	Boll worms
51.	Chlorantraniliprole 20 SC	Coragen	40 g	chillies	Fruit borers
52.	Chlorantraniliprole 20 SC	Coragen	40 g	tomato	Fruit borers
53	Chlorantraniliprole 20 SC	Coragen	40 g	Red gram	Pod borer complex
54.	Chlorantraniliprole 20 SC	Coragen	10 g	Cabbage	Diamond back moth
55	Lambdacyhalothrin 10%WP	Icon	62.5g/1000sq.ft	Household	Mosquito
56	Lambdacyhalothrin 5 CS	Karate Zeon	25 g	Brinjal, okra ,tomato	Borers

New molecule of pesticide and their dosage against key pests

S.No.	Chemical name	Trade name	Dose a.i. ha^{-1})	CROP	PEST
1.	Flubendiamide 480 SC	Fame	24g	cabbage	Diamond back
2.	Flubendiamide 480 SC		48g	Tomato	*Helicoverpa era*
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10.	Fipronil 80 WG		50g	Chillies	Thrips
11.	Imidacloprid 200 SL	Confidar ıida	50g	Grapes	Grapevine flea
12.	Imidacloprid 200 SL		25g	Cucumber	Sucking insects
13.	Imidacloprid 200 SL		50g	Tobacco	Sucking pests
14.	Imidacloprid 17.8 SL		15g	okra	Sucking pests
15.	Imidacloprid 17.8 SL		25g	okra	Sucking pests
16.	Imidacloprid 17.8 SL		50g	Cotton	Sucking pests
17.	Imidacloprid 70 WG	Admire	24.5g	Cucumber	Aphids, leaf s
18.	Triazophos 20EC	Hostothion	600g	cotton	Bollworms
19.	Triazophos 40EC		200g	Chillies	Sucking pests
20.	Spirotetramat 150 OD		60g	Chillies	Sucking pests
21.	Spirotetramat 150 OD		75g	Cotton	Sucking pests
22.	Emamectin benzoate 5 SG	Proclaim	11g	Cotton &	*Helicoverpa ra*
23.	Emamectin benzoate 5 EC	-	15g	Bhendi	Fruit borer
24.	Emamectin benzoate 5 EC	-	15g	cotton	Bollworms
25.	Emamectin benzoate 1.9 EC		20g	Bhendi	Fruit borer
26.	Emamectin benzoate 1.9 EC		20g	cotton	Bollworms
27.	Thiamethoxam 25 WG		25g	cotton	Sucking pests
28.	Thiamethoxam 25 WG	Actara	25g	rice	GLH & BPH
29.	Indoxacarb 14.5 SC	Isacarb, Avaunt	75g	Cotton	Bollworms
30.	Indoxacarb 14.5 SC		25g	Cabbage	Diamond back moth
31.	Indoxacarb (KN 128)15 EC		40g	cabbage	Diamond back moth
32.	Indoxacarb (KN 128)15 EC		75g	Cotton	Bollworms
33.	Spinosad 2.5 SC	Success	18.75g	Cabbage	Diamond back moth
34.	Spinosad 45 SC	Tracer	75g	Chillies	Fruit borers
35.	Bifenthrin 10 EC	Talstar	50g	Rice	Leaf folder
36.	Spiromesifen 240 SC	Oberon	120g	Okra	Red spidermite
37.	Spiromesifen 240 SC	Oberon	96g	Tea	Tetranychid mite
38.	Buprofezin 25 SC		200g	cotton	Sucking pests
39.	Buprofezin 25 SC		200g	rice	GLH & BPH
40.	Buprofezin 25 SC	Applaud 25 SC	325g	Grapes	Mealybugs
41.	Ethiprole 10 SC		50g	Rice	BPH, WBPH
42.	Thiacloprid 24 SC	Alanto	50g	Rice	BPH, WBPH

43.	Propargite 570 EC	Omite	570g	Okra	Red spider mite
44.	Fenazaquin 10 EC	Magister	100g	Okra	Red spider mite
45.	Fenpyroximate 5 SC	Senda, Mitigate	30g	chillies	mite
46.	Chlorpenapyr 10 SC	Intrepid	100g	Cabbage	Diamond back moth
47.	Diafenthiuron 50 WP		0.16g	Cardamom	Shoot and capsule borer, thrips
48.	Diafenthiuron 50 WP	Pegasus	0.1g	Cardamom	thrips
49.	Acetamiprid 20 SP	Pride	50g	Cotton	Sucking pests
50.	Abamectin 1.9 EC	Abamectin	22.5g	Cotton	Boll worms
51.	Chlorantraniliprole 20 SC	Coragen	40 g	chillies	Fruit borers
52.	Chlorantraniliprole 20 SC	Coragen	40 g	tomato	Fruit borers
53	Chlorantraniliprole 20 SC	Coragen	40 g	Red gram	Pod borer complex
54.	Chlorantraniliprole 20 SC	Coragen	10 g	Cabbage	Diamond back moth
55	Lambdacyhalothrin 10%WP	Icon	62.5g/1000sq.ft	Household	Mosquito
56	Lambdacyhalothrin 5 CS	Karate Zeon	25 g	Brinjal, okra ,tomato	Borers

Lecture No.7
Methodology for Surveillance

Definition-Pest Surveillance

- **Pest surveillance** is the watch kept on a pest for decision-making.

• Objectives

The objectives of the pest and disease surveillance programme in Agricultural and Horticultural crops are to:

a. Detect species of pest or pathogen present

b. Assess levels of population / damage / infection

c. Study the influence of weather and seasonal parameters on pests and diseases.

d. Know new species of pests and diseases.

e. Monitor the behaviour of pests under changing cropping pattern / new varieties.

f. Find out natural enemy population

g. Watch the behaviour of pests under changing cropping pattern/new varieties

h. Assess resistance/susceptibility/break-down of resistance in crops to pests and diseases.

i. Monitor build-up of resistance in pests and pathogens to pesticides

j. Mark endomic areas/pest calendar

k. Launch timely plant protection measures on need-basis,

l. Reduce cost of cultivation

m. Avoid contamination to eco-system, and

n. To forewarn farmers

Methodology for Surveillance

- The surveillance programme encompasses (i) fixed plot survey and (ii) roving survey. The fixed plot and roving surveys involve the in situ assessment of pests and diseases in the standing crop. The supporting methodology includes observations on the activity of pests by setting up light traps, pheromone traps, spore traps, etc. The weather parameters of the respective areas are also recorded to study their influence on the pests and diseases. The observations on the pests and diseases cover their alternate cultivated host crops and weed host plants.

A. Fixed Plot Survey

- Two fields of about 1 acre in size are selected in two different villages in the jurisdiction of each Agricultural Officers. Five micro plots each of the size of one square metre area are fixed in each field. These micro plots are laid one each in four quarters of the field and one in the middle. The micro plots should be fixed about 10 metres away from the bunds. The observations for most of the pests are confined to five micro plots in each field.

B.Roving Survey

- The roving survey is conducted every week at the rate of two fields in each of the four villages in the jurisdiction of each Agricultural Officers (T&V). In each field, observations are recorded from the south west corner by a diagonal walk.

Surveillance programme - three kinds

- The reports involved in the surveillance programme are of three kinds.

White card report or Normal report

- This is a weekly report in which the pest and disease situations are reported regularly.

Yellow card

- This is a special reporting system wherever pest or disease is noticed at 50% of the economic threshold level but still not attained ETL status. The information is immediately passed on for alerting the Joint Director of Agriculture (T&V), his subject matter specialists, and the scientists.

Red card

- This reporting system is adopted when a pest or a disease has reached the critical economic threshold level where immediate action programme has to be launched for controlling the pest or disease.

Survey

- Regular survey activity is necessary for successful surveillance programmes. Surveys may be qualitative or quantitative.
- Qualitative survey aims at pest detection, employed with newly introduced pests and often precedes quantitative survey.
- Quantitative survey attempts to define numerically the abundance of an insect population in time and space; useful for future population detection and assessment of damage potential.

Sampling

- Sampling requires that we take a representative part of the total population and base our estimate on that part. Sampling technique is the method used to collect information for a single sample.
- Sampling programme describes when sampling is to begin, location of samples, number of samples and how often samples should be taken.
- Common sampling techniques are In situ counts, knock down, netting, trapping, extraction from soil, indirect technique.

Definitions

Decision making

- Decision making is the key stone in insect pest management programmes; it indicates the course of action to be taken in any pest situation.

Economic Damage: is the amount of injury, which justifies the cost of artificial control measures.

Gain Threshold: is the tem used to express the beginning point of economic damage.

$$\text{Gain Threshold} = \frac{\text{Management cost (Rs. /acre)}}{\text{Market value of the product (Rs. /kg)}} = \text{kg/acre}$$

Economic Injury Level (EIL): is defined as the lowest number of insects that will cause economic damage or the minimum number of insect that would reduce yield equal to gain threshold.

Economic Threshold (ET):

- Indicate the number of insects (density or intensity) / damage when management action should be taken to prevent population/ damage reaching EIL.

Market value/crop value: is one of the most variable factors and accounts for much of the change in EILs. The relationship between EIL and market value is inverse.

Management Costs: The cost of managing a pest population must be estimated before profitability of an action can be assessed.

Life table

- Life table is a condensed tabulation of certain vital statistics of insect population, which provides a format for recording, and accounting for all population change is the life cycle of a species. So the construction of life table is an important component in the understanding of the population dynamics of a species. But it takes considerable time and manpower to obtain realistic results. If carried out correctly life table remain the most important analytical technique available for identifying key mortality components in an insect pest's life cycle.

- Age specific life tables are more commonly used in entomology than time-specific life tables. The former are based on the fate of a real cohort throughout a generation, while the latter are based on the fate of an imaginary cohort. Age specific life table provides a means of identifying the potential role of parasitoids and predators in the regulation of pest population. The data required to construct a life table for key factor analysis are a series of successive samples taken from each life stage of a generation. The first step in constructing a life table is to obtain an estimate of the potential natality (Number of individual entering post-ovarial stage). This is calculated from an estimate of the mean fecundity per female, which is multiplied by the number of female of reproductive age. Mortality refers to the total mortality obtained in a population.

Utility of life tables

1. **Calculation of replacement rate:** A valid life table can be determining whether a population is growing, declining, or remaining stable.
2. **Simulation:** Once a valid life table is constructed for on insect population, it may be used to stimulate the out come of management decisions.

3. **Determination of key factors:** Key factor analysis has proved to be a valuable aid in identifying the environmental factors most closely related to intergenerational population trend.

Limitation

- Life table analysis is only as valid as the accuracy of the sampling techniques used to obtain initial data.

Lecture No.8

- ## Biological control in pest management

Introduction

- Use of natural enemies to suppress pest species. The Natural enemies are Predators, Parasitoids and Pathogens. Classical biological control is cottony cushion scale Icerya purchase in 1889 with *Roaolia cardinalis* beetle (Miracle of Entomology). The steps involved in biological control are

2. Conservation and encouragement of indigenous natural enemies.
3. Importation of exotic natural enemies.
4. Augmentation (mass rearing and release).

- Qualities of an effective natural enemy: 1) Good host searching capacity. 2) Host specificity. 3) Wider adaptability 4) High dispersal ability 5) Amenability to culturing. 6) Ability to withstand competition. 7) Ability to outnumber the pest. 8) High survival capacity.

- **Parasitoids**

Parasitoids

Parasite

- An animal species, which lives on or in a larger animal, the host, feeding upon it, and frequently destroying it. A parasite needs only one or part of host to reach maturity.

Parasitoid

- An insect parasite of an arthropod; parasitic only in its immature stages, destroying its host in the process of its development, and free living as an adult.

Types of parasitoids

1. Based on the developmental site in the host

a. Ectoparasitoid

- An insect parasite which develops externally on its arthropod host.
- (eg). *Bracon brevicornis* on coconut black headed caterpillars.

b. Endoparasitoid

- An insect parasitoid which develops within the body of its arthropod host.
- (eg) *Eriborius trochanteratus* on coconut black headed caterpillar.

2. Based on host specificity

a. Monophagous parasitoid

- Highly host specific attacking a single host species. E.g. *Parasierola nephantidis* (Goniozus) (Bethylidoe) on *Opisina arenosella* (coconut black headed caterpillars).

b. Oligophagous parasitoid (Stenophagous): Attacking a group of related host species.

c. Polyphagous parasitoid: Attack a wide variety of host species. (eg) *Trichogramma Spp*. (Trichogrammatidae) on eggs of
many Lepidopteran species.

3. Based on the host

a. Primary parasitoid: A parasitoid parasitizing a pest. It is beneficial (eg) *Trichogramma sp.*

b. Seconday parasitoids: A parasitoid attacking another parasitoid. It is harmful (eg.) *Opisina arenosella* (pest) *Bracon brevicornis* (Primary parasitoid) – *Pleurotropis sp.* (secondary parasitoid).

c. Tertiary parasitoid: A parasitoid attacking secondary parasitoid. It is beneficial. (eg) *Trichospilus coerulescens*

- All parasitoids whose hosts are parasitoids are called as hyperparasitoids (Parasitoids of Parasitoids).

4. Based on the number of parasitoids developing from a single host insect

a.Solitary parasitoid:

- One progeny alone is capable of completing its development in or on its host (eg) *Eriborus trochanteratus.*

b. Gregarious parasitoid:

- Several progeny are capable of completing its development in or on a single host. *(eg) Bracon breviconis.*
- A further extension of gregaiousness is Polyembryony in which several individuals develop from a single egg. (eg) Platygaster.

5. Based on the stage of host insect attacked

Order: Hymenoptera (90% of parasitoid coming under this order)

I.Egg parasitoid

a. *Trichogramma chilonis*: Trichogrammatidae – Eggs of sugarcane internode borer, cotton bollworm, rice leaf folder.

b. *T. japonicum*: Trichogrammatidae – Eggs of rice stem borer

c. *Telenomus rowani* : Scelonidae – Eggs or rice stem borer

d. *T.remus* : Scelonidae – Eggs of tobacco caterpillar

II. Egg-Larval parasitoid

a. *Chelonus blackburni*: Braconidae – Eggs of cotton spotted bollworm.

III. Larval parasitoid

a. *Bracon hebetor*: Braconidae – Larvae of coconut black headed caterpillar

b. *B.brevicornis* :Braconidae – Larvae of coconut black headed caterpillar

c. *Compoletis chloridae*: Ichneumonidae – Larvae of H. armigera

d. *Cotesia plutella* :Braconidae – Larvae of diamondback moth

e. *Eriborus trochanteratus*: Ichneumonidae – Larvae of coconut black headed caterpillar

f. *Goniozus nephantidis* : Bethylidae – Larvae of coconut black headed caterpillar

g. *Platygaster oryzae*: Platygasteridae – Larvae of rice gall midge.

IV. Larval – Pupal parasitoid

a. *Isotima javensis*: Ichneumonidae – Pre – pupal parasite of top shoot borer of sugarcane.

V.Pupal parasitoid

a. *Brachymeria nephantidis*; Chalcidae – Pupae of coconut black headed caterpillar.

b. *Tetrastichus israeli*: Eulophidae – Pupae of coconut black headed caterpillar.

c. *Trichospilus pupivora*: Eulophidae – Pupae of coconut black headed caterpillar.

d. *Xanthopimpla punctata* : Ichneumonidae

VI. Nymphal and adult parasitoid

a. *Aphelinus mali* : Aphelinidae – Aphids

b. *Encarsia formosa*: Aphelinidae – Cotton whitefly

Order: Diptera (10% of parasitoid coming under this order)

I. Larval parasitoid

a. *Sturmiospsis inferens:* Tachinidae: Larvae of sugarcane early shoot borer.

b. S*paggossia bassiana*: Tachinide: Larvae of coconut black headed caterpillar.

II. Larval – pupal parasitoid

a.*Eucelatoria bryani*: Tachinidae : Larvae of H.armigera

Types of Parasitism

- Parasitism is a relationship between two species in which one, the parasite, obtains its nutritional requirements from the body material of the other, the host.
- **Simple parasitism:** There is a single attack of the parasitoid on the host irrespective of the number of eggs laid. (eg) *Parasierola nephantidis* on *Opisina arenosella*.
- **Super parasitism:** Many individuals of the same species of the parasitoid attack a single host, (eg) *Trichospilus pupivora* on *Opisina arenosella*.
- **Multiparasitism:** Parasitism by different species of parasitoids on the same host at a time. (eg) *Eriborus trochanteratus, Bracon brevicornis* and *Parasierola nephantidis* attacking *Opisina arenosella*.

- **Hyperparasitism:** Parasitoids attacking another parasitoids. (eg) *Pleurotropis sp*. (Hyperparasitoid) on *Bracon brevicornis* (Primary parasitoid)
- **Cleptoparasitism:** Attack by a parasitoid on a host previously parasitized by another parasitoid. (eg) *Eurytoma pini* on Pine shoot moth
- **Autoparasitism (Adelphoparasitims):** A special type or parasitism in which the female develops as a primary parasitoid, but the male is a secondary parasitoid through females of its own species. (eg) *Encarsia formosa* a parasitoid of white fly.

Adaptations in parasitioids

- Egg is laid on the host plant of the host by the parasitoid. Egg of the parasitoid is ingested into the body system of the host. (eg) Tochinid fly.
- Parasitic larva finds its host when it moves in search of food. (eg) Tachinid maggot.
- Eggs are laid on the outer surface of the host. The parasitic grubs remain outside and feed on the host. (eg) Bethlid on *Opisina*.
- Eggs may be laid outside. The hatching grubs bore the body wall of the host and feed inside the host.
- Eggs are laid and development occurs inside the host.
- Adult parasites are highly efficient in locating the host.
- They posses sense organs to locate the hosts.
- Ovipositor is suitably developed for proper egg placement.
- Polyembryony – several individuals develop from a single egg. Because of this, the larger host is thoroughly exploited.

- Phoresy – One organism is utilized by another for transport. (eg) A chalcid parasitoid attaches itself to ant and gets transported to ants nest for parasitizing the ant grubs.

Ideal qualities of a parasitoid

- High host searching capacity – This is one of the primary requisite particularly in a situation of low host density.
- Having a narrowly limited host range – so that when the pest population is reduced low densities, the parasite is able to maintain itself on alternate hosts. Alternate hosts may accommodate the parasite population during seasons when pest may accommodate the parasite population during seasons when pest is not available or when the pest is controlled by chemical insecticides. However, the available host range should not be so large that the parasite population host range should not be so large that the parasite population dissipates itself upon economically harmless species.
- Having a life cycle considerably shorter than that of the pest when the pest population consists of overlapping generations and having a life cycle synchronized with that of the pest when the pest population is composed of a single development stage at any time.
- Potential rate of increase (high fecundity) to keep the pest population under check.
- Able to survive in all habitats occupied by the pest i.e. the natural enemy should have adaptability to a board range of climatic variations.
- Able to be cultured easily in the laboratory
- Able to quickly reduce the pest population

- Absence of superparasitism and multiparasitism.

Parasitoids of agricultural importance

- *Trichogramma sp.* – egg parasitoid of sugarcane intermode borer.
- *Chelonus balckburni* – egg larval parasitoid of potato tuber moth
- *Bracon brevicornis* – Larva parasitoid of coconut blackheaded caterpillar (BHC)
- *Parasierola nephantidis* – Larva parasitoid of coconut BHC
- *Eriborus trochanteratus* – Larva parasitoid of coconut BHC
- *Eucelatoria bryani* – Larval parasitoid of American bolloworm *Helicoverpa armigera*
- *Sturmiopsis inference* – Larval parasitoid of sugarcane shoot borer
- *Eucarcelia illota* – Larval pupal parasitoid of *H.armigera*
- *Trichospilus pupivora* – Pupal parasitoid of coconut BHC
- *Tetrastichus israeli* – Pupal parasitoid of coconut BHC

Mass culturing of parasitoids

- It includes the mass culturing of the host insects and the parasitoids. Eggs and larvae of rice moth, *Corcyra cephalonica* are widely used on hosts for many parasitoids. Mass production techniques of importance parasitoids and their host insects are given below.

Lecture No.9
Pesticide Application Methods

Pesticide application methods

- The desired effect of pesticide can be obtained only if it is applied by an appropriate method in appropriate time. The method of application depends on nature of pesticide, formulation, pests to be managed, site of application, availability of water etc.

1. Dusting

- Dusting in carried out in the morning hours and during very light air stream. It can be done manually or by using dusters. Some times dust can be applied in soil for the control of soil insects. During is cheaper and suited for dry land crop pest control.

2. Spraying

- Spraying is normally carried out by mixing EC (or) WP formulations in water. There are three types of spraying.

3. Granular application

- Highly toxic pesticides are handled safely in the form of granules. Granules can be applied directly on the soil or in the plant parts.
- The methods of application are

a) Broadcasting: Granules are mixed with equal quantity of sand and broadcasted directly on the soil or in thin film of standing water. (eg) Carbofuran 3%G applied @ 1.45kg/8 cent rice nursery in a thin film of water and impound water for 3 days.

b) In furrow application: Granules are applied at the time of sowing in furrows applied @ 3 g per meter row for the control of sorghum shootfly.

c) Side dressing: After the establishment of the plants, the granules are applied a little away from the plant (10-15 cm) in a furrow.

d) Spot application: Granules are applied @ 5 cm away and 5 cm deep on the sides of plant. This reduces the quantity of insecticide required.

e) Ring application: Granules are applied in a ring form around the trees.

f) Root zone application: Granules are encapsulated and placed in the root zone of the plant. (eg) by mixing it with equal quantity of sand in the central whorl of crops like sorghum, maize, sugarcane to control internal borers.

h) Pralinage: The surface of banana sucker intended for planting is trimmed. The sucker is dipped in wet clay slurry and carbofuran 3G is sprinkled (20-40 g/sucker) to control burrowing nematode.

4. Seed pelleting/seed dressing

- The insecticide mixed with seed before sowing (eg.) sorghum seeds are treated with chlorpyriphos 4ml/kg in 20 ml of water and shade dried to control shootfly. The carbofuran 50 SP and imdacloprid is directly used as dry seed dressing insecticide against cotton sucking pests.

5. Seedling root dip

- It is followed to control early stage pests (eg) in rice to control sucking pests and stem borer in early transplanted crop, a shallow pit lined with polythene sheet is prepared in the field. To this 0.5 kg urea in 2.5 litre of water and 100 ml chlorpyriphos in 2.5 litre of water prepared separately are poured. The solution is made upto 50 1 with water and the roots of seedlings in boundless are dipped for 20 min before transplanting.

6. Sett treatment

- Treat the sugarcane setts in 0.05% malathion for 15 minutes to protect them from scales. Treat the sugarcane setts in 0.05% Imidacloprid 70 WS @ 175 g/ha or 7 g/l dipped for 15 minutes to protect them from termites.

7. Trunk/stem injection

- This method is used for the control of coconut pests like black headed caterpillar, mite etc. Drill a downward slanting hole of 1.25 cm diameter to a depth of 5 cm at a light of about 1.5m above ground level and inject 5 ml of monocrotophos 36 WSC into the stem and plug the hole with cement (or) clay mixed with a fungicide. Pseudo stem injection of banana, an injecting gun or hypodermic syringe is used for the control of banana aphid, vector of bunchy top disease.

8. Padding

- Stem borers of mango, silk cotton and cashew can be controlled by this method. Bark of infested tree (5x5 cm) is removed on three sides leaving bottom as a flap. Small quantity of absorbent cotton is placed in the exposed area and 5-10 ml of

Monocrotophos 36 WSP is added using an ink filler. Close the flap and cover with clay mixed with fungicide.

9. Swabbing

- Coffee white borer is controlled by swabbing the trunk and branches with lindane 1 per cent suspension.

10. Root feeding

- Trunk injection in coconut results in wounding of trees and root feeding is an alternate and safe chemical method to control black headed caterpillar, eriophyid mite, red palm weevil. Monocrotophos 10 ml and equal quantity of water are taken in a polythene bag and cut the end (slant cut at 45) of a growing root tip (dull white root) is placed inside the insecticide solution and the bag is tied with root. The insecticide absorbed by root, enter the plant system and control the insect.

11. Soil drenching

- Chemical is diluted with water and the solution is used to drench the soil to control certain subterranean pests. (eg) Chlorpyriphos / dimethoate used against cutworms, soilmealy bug.

12. Capsul placement

- The systemic poison could be applied in capsules to get toxic effect for a long period. (eg) In banana to control bunchy top vector (aphid) the insecticide is filled in gelatin capsules and placed in the crown region.

13. Baiting

- The toxicant is mixed with a bait material so as to attract the insects towards the toxicant. A) Spodoptera. A bait prepared with 0.5 kg molasses (jiggery), 0.5 kg carbaryl 50WP and 5 kg of rice bran with required water (3 litres) is made into small pellets and dropped in the field in the evening hours. B) Rats: Zinc phosphide is mixed of 1:49 ratio with food like popped rice or maize or cholam or coconut pieces (or) warfarin can be mixed at 1:19 ratio with food. Ready to use cake formulation (Bromodiolone) is also available. C) Coconut rhinoceros beetle: Castar rotten cake 5 kg is mixed with insecticide.

14. Fumigation

- Fumigants are available in solid and liquid forms. They can be applied in the following way. Soil: To control the nematode in soil, the liquid fumigants are injected by using injecting gun. Storage: Liquid fumigants like Ethylene dibromide (EDB), Methyl bromide (MB), carbon tetrachloride etc. and solid fumigant like Aluminium phosphide are recommended in godowns to control stored product pest. Trunk: Aluminium phosphide ½ to 1 tablet is inserted into the affected portion of coconut tree and plugged with cement or mud for the control of red palm weevil.

I. Preparation of spray solution

1) Quantity of insecticide required. The requirement of quantity of commercial formulation of the insecticide can be calculated by the formula.

Volume of spray fluid x Strength of the spray solution desired (%)

= ————————————————————————————————

Strength of commercial formulation (%)

2. Strenth of the finished spray solution: To calculate the strength of a finished spray solution when a known quantity of chemical is added to known quantity of water, the following formula may be adopted.

Quantity of the insecticide used x Strength of the insecticide (%)

= ————————————————————————————————

Quantity of finished spray solution required

3. In case of granules

Recommended dose a.i./ha x 100

Quantity of chemical needed = ———————————————————————— x Area

% a.i.of insecticide

Points to be considered in spray fluid preparation spraying

- Use good quality water to prepare spray fluid
- Prepare spray fluid in clean drum or plastic buckets
- For mixing pesticide, use long handled stir
- Always prepare spray fluid just before use
- Spraying should be done under ideal weather conditions
- The walking speed of the operator should be uniform to ensure even coverage of spray chemicals in the targt area.

Botanicals

- Among the plant derivatives, neem oil 0.5 to 3 per cent and neem seed kernel extract 5 per cent with teepol 0.05 per cent are quite effective against major pest of fruits crops, vegetables etc. Neem oil (NO): to get a per cent solution first mix 30 ml of neem oil with 5 ml of sticking agent teepol until white emulsion is formed. Then add one litre of water and mix thoroughly for use of spray fluid. Neem seed kernel extract (NSKE): For the preparation of 5 per cent NSKE, take 50 gm of powered seed kernel and soak it the in small quantity of water, over night. Filter through muslin cloth and make up the volume to one litre. Add one ml of teepol per litre before spraying high volume sprayer. Neem leaf powder: Powder shade dried neem leaves and use as such to word off stored product pests. Neem products are applied as high volume sprays during early morning or late evening hours for better efficacy with low degradation. The following neem based pesticide formulations have been registered provisionally under the Insecticides Act, 1968 for the control of insect pests of okra, red gram, cotton, Bengal gram, brinjal, cabbage, potato, tomato, tobacco, rice, groundnut, fruit trees, etc.

Formulation	Trade name
Neem triterpene emulsion (Kernel extract ontaining 0.03% azadirachtin)	Margocide CK 20 EC
Neem oil emulsion containing azadirachtin).03%	Margocide OK 20 EC Nimbecidine
Neem oil based WSP containing azadirachtin).03%	Achook
Azadirachtin technical concentrate 10% w/w 0.15%)	Neemgold
Neem oil 93% EC containing 0.03% w/w zadirachtin	RD-9 Repelin 93 EC

Other plant products

Chrysanthemum

- Pyrethrum based formulations are obtained from flowers of chrysanthemum. Two formulations like Pyrethrum 0.2% D and Pyrethrum 1% EC are registered for use against the pests of vegetables.

Tobacco

- Waste tobacco extract, nicotine 40% solution and nicotine sulphate 10% WDP registered for research purpose. Notchi leaf extract 10% mahua oil 3%, pinnai oil 3% pungam oil 3% etc. are used in pest management. Vegetable edible oils are also used as seed dressing material (1:100) to avoid the egg laying by pulse beetles in black gram, peas, lab-lab, green gram.

II. Safe handling of pesticides

1. Storage of pesticide

a. Storehouse should be away from populated areas, wells, domestic water storage, tanks.

b. All pesticides should be stored in their original labeled containers in tightly sealed condition.

c. Store away from the reach of children, away from flames and keep them under lock and key.

2. Personal protective equipment: Protective clothing that cover arms, legs, nose and head to protect the skin.

a. Gloves and boots to protect the skin.

b. Helmets, goggles and facemask to protect hair, eyes and nose.

c. Respiration to avoid breathing dusts, mists and vapour.

3. Safety in application of pesticides

- Safe handling of pesticides (Fig.) involves proper selection and careful handling during mixing and application.

a) Pesticide selection

- Selection of a pesticide depend on the type of pest, damage, losses caused, cost etc.

Safety before application: i) Read the label and leaflet carefully. ii) Calculate the required quantity of pesticide. iii) Wear protective clothing and equipment before handling. iv) Avoid spillage and prepare spray fluid in well ventilated area. v) Stand in the direction of the wind on back when mixing pesticides. vi) Don't eat, drink or smoke during mixing. vii) Dispose off the containers immediately after use.

b) Safety during application

i) Wear protective clothing and equipment. ii) Spray should be done in windward direction. iii) Apply correct coverage. iv) Do not blow, suck or apply mouth to any spray nozzle. v) Check the spray equipment before use for any leakage.

c) Safety after application: i) Empty the spray tank completely after spraying. ii) Avoid the draining the contaminated solution in ponds, well or on the grass where cattle graze. iii) Clean the spray equipment immediately after use. iv) Decontaminate protective clothing and foot wear. v) Wash the hands thoroughly with soap water, preferably have a bath. vi) Dispose off the containers by putting into a pit. vii) Sprayed field must be marked and unauthorized entry should be prevented. First aid: In case of suspected poisoning, call on the physician immediately. Before calling on a doctor, first aid treatments can be done by any person. Swallowed poison: 1) during vomiting, head should be faced downwards. 2) Stomach content should be removed within 4h of poisoning. 3) To give a soothing effect, give either egg mixed with water, gelatin, butter, cream, milk, smashed potato. 4) In case of nicotine poisoning, give coffee or strong tea.

Skin contamination: 1) contaminated clothes should be removed. 2) Thoroughly wash with soap and water.

Inhaled poison: 1) Person should be moved to a ventilated place after loosing the tight cloths. 2) Avoid applying frequent pressure on the chest.

Lecture No.10

Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Mango and Sapota

- **MANGO**
- **I.Inflorescence feeders**

1.Mango hoppers- *Idioscopus niveosparsus* Leth, *I.clypealis* Leth and *Amritodes atkinsoni* Leth.

(Cicadellidae : Hemiptera)

Damage

- Both nymphs and adults suck the sap from tender shoots and inflorescence resulting in withering and shedding of flower buds and flowers leads to wilting and drying of shoots and leaves.
- The flower stalks and leaves of infested trees become sticky due to the deposition of honey-dew secreted by the hoppers that encourages the growth of black sooty mould on foliage and other plant parts.
- The peak activity is confined during blossom and the loss ranges from 25 to 60 %. During the off - season, the hoppers congregate on newly developed shoots and suck the sap, results in malformation the leaves feeding on them.
- As a consequence, leaves become malformed and undersized.
- The hoppers take shelter in cracks and crevices on the barks during non-flowering season.

Bionomics

- Of these three species, *A. atkinsoni* is the largest one occurring right through the year and other two species have been observed to be mostly present during the blooming of the tree.
- The largest *A. atkinsoni* has two spots on scutellum while the smalll. clypealis has two spots on scutellum and dark spot on the vertex, while the least sized 1 . niveosparsus has three spots on scutellum.
- The adult hopper is light greenish-brown with black and yellow markings, wedge shaped with broad head measures 3-4 mm in length.
- It inserts the eggs singly into the plant tissues of young leaves, shoots, flower stalks and unopened flowers.
- A female lays about 200 eggs.
- The eggs hatch in 4-7 days.
- The nymph with red eyes appeared while yellowish green to greenish brown during the 5 instar occupying 8-13 days.
- The total life cycle from egg to adult takes 2-3 weeks for completion.

Management

- Grow less susceptible varieties *viz*., Banganapalli, Chinnarasam and Alphonsa.

- Avoid close planting, as the incidence is very severe in overcrowded and neglected orchards.
- Spray two rounds, of acephate 75 SP at 1 g /litre or phoasalone 35 EC at 1.5 ml / litre or carbaryl 50 WP at 42 g / litre of water, first round at the time of new flesh panicle emergence and 2nd at two weeks after the first spray.
- Spray wettable sulphur at 2 g / litre of water after spraying carbaryl to avoid mite resurgence
- Collect and destroy affected inflorescence or sticky inflorescence to minimize population build-up.

2. Aphid-*Toxopetra odinae* Vdg. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from tender shoots and inflorescence resulting drying up of the same plant parts and development of sooty mould.

Management

- Spray dimethoate 30 EC 1.77ml or methyldemeton 25 EC 1 ml / litre water

3. Flower webber-*Eublemma versicolor* (Noctuidae: Lepidoptera)

Damage

- The caterpillar webs together the flower buds and inflorescence.

- It remains inside the web and feeds on the floral parts and also tunnels into the flower stalks.

Bionomics

- The moth is purplish grey with an oblique line on the wings.
- It lays eggs singly on the pedicels and sepals of flower buds.
- The incubation period is 3-4 days.
- The full grown larva is smooth, greenish yellow with light brown head and a pro - thoracic shield measuring 20 mm in length.
- The larval period is 18-20 days.
- It pupates inside the inflorescence and emerges as adult in 8-9 days.
- The life cycle is completed in 29-33 days.

Management

- Remove and destroy affected flowers and tender shoots.
- Spray dimethoate 30 EC 0.06% or methyl demeton 25 EC 0.05% or Dimethoate 0.03 % .

4.Hairy caterpillar *Eurproctis fraterna* M. *Porthesia scintillans* Wlk. (Lymantridae: Lepidoptera)

Damage

- The caterpillar webs the inflorescence and feed on them causing shedding of flower buds and flowers.

Bionomics

- The adult moth of *E. fraterna* is yellowish with pale transverse lines on the fore wings.
- The larva is reddish brown with reddish head surrounded by white hairs and long tufts of hair all over the body and a long preanal tuft.
- The adult of *P. scintillans* is yellowish with spots on the edges offore wings.
- The larva is yellow colored with brown head, a yellow stripe with a central red line on the body and tufts of black hairs dorsally on the first three abdominal segments.

5. Loopers *Thalassodes quadraria* Guen. (Geometridae : Lepidoptera)

Damage

- The larvae web together the inflorescence and tunnel into the flower stalk.

Bionomics

- The adult moth is greenish in colour.
- The larva possessing the colour of new shoot and assuming a typical pose on•twing in often mistaken for a leaf petiole.

6. Looper- *Chloroclystis sp*. (Geometridae: Lepidoptera)

Damage

- The larva enters in the flower buds and damages the ovaries of newly opened flowers

Bionomics

- The adult moth is small and delicate with greyish wings bearing wavy lines.

7. Flower gall midge-*Procystiphora mangiferaae* Felt. (Cecidomyiidae: Diptera)

Damage

- The maggot feeds on the internal content of the buds which become conical in shape, turn brown and drop.
- The infestation results in flower dropping and malformation of flowers.

Bionomics

- The adult fly is light orange in colour.
- It lays eggs inside the flower buds.
- The maggot feeds on stalks of stamen, anthers, and ovary.
- It pupates inside the bud itself.
- The life cycle is completed in 12-24 days.

8. Flower gall midge-*Erosomyia indica* Felt. (Cecidomyiidae: Diptera)

Damage

- The maggot infests the flower buds, inflorescence stalk and developing fruits.
- The inflorescence becomes stunted and malformed.
- The infested bud does not open.

Bionomics

- The adult is yellowish in colour.
- It lays the eggs on inflorescence peduncle or at the base of developing fruit.
- The maggot is yellowish and it pupates in the soil.

9.Flower gall midge-*Dasyneura amaramanjarae* Grov.(Cecidomyiidae :Diptera)

Damage

- The maggot feeds on the ovary and the nectaries of growing bud which fail to produce fruits.
- Several larvae are found in single flower.

Bionomics

- The adult flies insert the eggs into un opened flower buds.
- A female fly lays about 40-50 eggs.
- The incubation period is 30-36 hours.
- The larva becomes full fed after three moults and drop down to the soil to undergo diapause.

- The maggot hibernate in soil thus the carry over of the pest to the next year is accomplished.
- When the favourable condition set in they pupate and emerge as adults.

II. Borers

1.Stemborer-*Batocera rufomaculata* Dejean. (Cerambycidae: Lepidoptera)

Damage

- The grubs feed by tunneling through the bark of branches and main stem.
- The damage may also show itself by the shedding of leaves and drying of terminal shoots in early stage of attack.
- When the damage occurs at the main stem, the whole tree succumbs.

Bionomics

- The adult is a large longicorn beetle about 5 cm long and 1.6 cm broad and yellowish brown in colour.
- It has two pink dots and lateral spines on thorax.
- It lays eggs singly on the bark, or cracks and crevices on the tree trunk or branches hatch in about 1-2 weeks.
- The grub is stout with well-defined segmentation and yellow in colour.
- The grub makes *zig - zag* burrow beneath the bark.
- The grub feeds on the internal tissues and become full fed in about six months.
- It pupates inside the tunnel itself. The pupal period is. 19-36 days.

Management

- Remove and destroy the dead trees and affected branches from the garden.
- Swab trunk with carbaryl 20 g/1.
- Use light trap 1 / ha to attract adult moths or beetles.
- Locate bore holes, spike out grubs using a needle or iron wire.
- Exclude the alternative host, silk cotton from mango orchards.
- Grow less susceptible varieties *viz.*, Neelam, Humayudin, and Panchavarnam.
- Swab coal tar + Kerosene (1 :2) on the basal part of the trunk up to 3 feet high after scraping the loose bark to prevent the female from egg laying.
- Spike out the grub if the bore holes are located, and add insecticide emulsion (monocrotophos 0.1 % at 20 ml / hole) a fumigant tablets (3 g Aluminium phosphide) or petrol and seal the holes with the mud.
- Follow padding with monocrotophos 36 WSC 10 ml per tree soaked in absorbent cotton when the trees are not in bearing stage.
- Apply carbofurean 3 - 5 g per hole and plug with mud after removing the grub by using needle.
- Apply carbofuran granules in the soil at 75 g / tree basin.

2.Bark caterpillar-*Indarbela tetraonis* Moore and *L.quadrinotata* Wlk. (Metarbelidae : Lepidoptera)

Damage

- The larva chews out the bark resulting *zig-zag* galleries and silken webbed masses comprising of chewed materials and excreta.

Bionomics

- Adult moth is pale brown with fore wings having brown spots and streaks and white hind wings.
- The larva is 40-45 mm long, stout and dirty brown in colour.

3. Shoot borer *Clumetia transversa* Walk. (Noctuidae: Lepidoptera)

Damage

- The caterpillar bores into the tender shoots from top to downwards make a characteristic tunnel to a depth of 5-6 inches.
- The damage resulted in stunting of whole seedling with individual twigs showing a peculiar terminal bunchy appearance.

Bionomics

- The adult moth is greyish with dark grey wing having wavy designs.
- The eggs are laid singly and they hatch in 2-3 days.
- The larva is dark pink with dark brown pro - thoracic shield.
- It pupates in soil on the damaged shoot.

4. Fruit borer-*Hyalospila leuconeurella* Rogonot. (Phycitidae: Lepidoptera)

Damage

- The larva borers into the developing fruits and tunnel into the pulp.

6. Fruit fly - *Bactrocera (= Dacus) dorsalis* Hend. (Tephritidae : Diptera)

Damage

- The maggot destroy and convert the pulp into a bad smelling, discoloured semi liquid mass unfit for human consumption.
- The infestation results in fruit drop and start rotting from inside.
- On complete rotting of the fruits, the damaged fruit develop yellow spots with black centers through which liquid oozes out on pressing.

Bionomics

- The adult fly is brown or dark brown with hyaline wings and yellow legs.
- The female fly lays eggs in clusters of 2-15 just beneath the skin of the ripening fruits. A single female lays up to 200 eggs during oviposition period of one month.
- The egg period is 22-23 days.
- The maggot feeds on pulp and become full grown in about 7 days.
- It pupates 3-7 inches below the soil.

Management

1. Plough the interspaces to expose the pupae during the off - season.
2. Collect and destroy the fallen fruits.
3. Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/ 1 litre of water + 1 ml of Malathion solution.
4. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the adult flies.
5. Conserve parasitoids like *Optius compensates* and *Spalangia philippinensis*.
6. Use bait spray combining molasses or jaggery 10g/1 and one of the insecticides, fenthion 100 EC 1 ml/1, malathion 50 EC 2 ml/1, dimethoate 30 EC 1 ml/1,

carbaryl 50 WP 4g/1, two rounds at fortnightly intervals before ripening of the fruits.

6. Mango nut weevil - *Sternochetus mangiferae* Fab. (Curculionidae: Coleoptera)

Damage

- The grub tunnel in a zig - zag manner through the pulp endocarp and the seed coat and they finally reach the cotyledons.
- As the fruit develops the tunnel get closed.
- The grub feeds on the cotyledons and destroy them.
- The adults who emerge from the pupae also feed on the developing seed and this may hasten the maturity of infested fruits.

Bionomics

- The adult weevil is stoutly built, 6 mm long, dark brown in colour.
- It lays eggs singly on the marble sized fruits by scooping out the surface tissue and cover over with a transparent secretion.
- The ovipositon puncture heals leaving minute spot. On a single fruit up to 15 eggs may be laid in a day.
- The egg period is 7 days.
- The newly hatched out grub is creamy, yellow apodous tunnel the fruit pulp and enter into cotyledons.
- The larval period is 20-30 days. It undergoes five larval instars and pupate inside the nut along the concave side.
- The pupal period is 7 days. The total life cycle occupies 40-50 days.
- The adult often remain inside the nut until they are thrown away after consumption of the pulp.
- The weevil hides in crevices of the tree trunk as they have longevity of 10 months.

Management

- Follow prophylactic measures in Neelum and Bangalora varieties as these varieties are susceptible.
- Collect and destroy the fallen fruits, which contain 85 % of the weevil

- Spray emamectin benzoate 1 ml / litre during marble stage and second spray at 15 days after the first spray.
- Take up insecticides spray directing towards the base of the trunks during the non-flowering season.
- Tieing red ant colonies in mango orchards help to reduce the damage of nut weevil remarkably.

III. Leaf feeders

1. Shoot webber- *Orthaga exvinacea* Hmps. (Pyraustidae: Lepidoptera)

Damage

- The larva webs together the leaves and feed on them.
- The infested leaves wither and dry up. In case of severe attack, a tree shows many webbed nests of leaves presenting on the whole a sickly appearance.

2. Leaf caterpillar-*Bombotelia jocosatrix* Guen. (Noctuidae: Lepidoptera)

Damage

- The larva feeds on tender leaves causing defoliation.

Bionomics

- The adult moth has dark brown fore wing.

3. Leaf caterpillar-*Euthalia garuda* M. (Nymphalidae: Lepidoptera)

Damage

- The caterpillar feeds on leaves.

Bionomics

- The adult butterfly is brownish black with white spots on wings. The caterpillar has the colour of lead and is not easily detected on it

4. Slug caterpillar-*Parasa lepida* Cramer. (Cochlididae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves gregariously in the beginning, subsequently they disperse.
- It causes severe defoliation.

Bionomics

- The adult moth is stout with wing expanse of 4.0 cm and having green wings fringed with brown patches.
- The eggs are laid in batches of 10-15 on the under surface of leaves.
- The eggs are ovals flat scale- like in shape.
- The fecundity is on an average 167 eggs / female.
- The egg period is 7 days.
- The caterpillar is fleshy, slug-like with yellowish green body bearing a greenish blue stripe dorsally and yellowish green stripes laterally.
- The larval period is 5-6 weeks undergoes seven instars.
- It pupates in a hard shield - like greyish cocoon on the tree trunks for 4-5 weeks.

Management

- Set up light traps to monitor and kill the adult moths.
- Spray the crown with carbaryl 0.1 % (or) dichlorovos 0.02 % or malathion 0.05 % solution.
- In severe cases, root feeding of monocrotophos as explained earlier under leaf eating caterpillar may be taken up with safety precautions.
- Collect all the stages of pests *viz.*, eggs on tree trunks, leaves, larvae during migration stage, pupae in soil and leaf sheath and adult moth during emergence and destruction.
- Organise mass collection campaign involving farmers, school children and college students.
- Spray dichlorovos @ 2 ml / litre using specially designed tractor mounted tall tree sprayer.
- Dust methyl parathion or Dimethoate 0.03 % / tree using power operated bellowed crane duster to reach tall trees.
- Encourage the predatory birds to pick up the larval stages.

5. Leaf miner- *Acrocercops syngramma* Meyr. (Gracillaridae : Lepidoptera)

Damage

- The caterpillar mines into the leaves producing blister like patches on them.

Bionomics

- The adult moth is silvery grey moth with fringes of hairs on the wing margin.
- The larva is reddish brown in colour.

6.Shoot borer - *Platypeplus (= Argyroploce) aprobola* Meyr. (Eucosmidae: Lepidoptera)

Damage

- The larva webs together the leaves, buds and flowers and bore into shoots.

7. Leaf midges - *Amradiplosis amraemyia* Grover., *A. brunneigallicola* Rao and *A.echinogalliperda* Mani. (Cecidomyiidae: Diptera)

Damage

- The maggot forms different shapes and sizes of galls on leaves.

Bionomics

- The adult is tiny mosquito like fly and the maggot is yellowish in colour.

Management

- Spray diniethoate1.7ml or methyl demeton 2 ml / litre of water.

8. Leaf mining weevil *Rhychaenus mangiferae* Marshl.(Curculionidae : Coleoptera)

Damage

- The grub mines into the tender leaves while the adult weevil scrapes the leaf surface. In severe cases leaves crumble and dry up.

Bionomics

- The adult weevil is brown with enlarged hind femur. It lays eggs singly within minute holes bitten on the lower side of tender leaves.
- The egg period is 2-3 days.
- The grub mines the leaves and pupates in an oval chamber within the mine.
- The larval and pupal periods are 5.5 and 3.33 days respectively.
- The total life cycle takes about 12 days for oviposition.

9. Leaf twisting weevil- *Apoderus tranquebaricus* F. (Curculionidae: Coleoptera)

Damage

- The adult weevil has the habit of cutting and twisting the mango leaves into shapely thimble like rolls which remain attached to the parent leaves.
- The grub feeds on the leaf tissue within the leaf roll.

Bionomics

- The adult weevil is medium sized, reddish brown with a long snout. Eggs are laid in each leaf roll.
- The grub pupates within the leaf roll.

Management

- Spray insecticides like monocrotophos at 1.25 ml or Dimethoate 0.03 % / litre of water to check the spread of infestation.

10. Leaf cutting weevil - *Deporaus (= Eugnamptus) marginatus* Pasc. (Curculionidae: Coleoptera)

Damage

- The adult beetles cut down the leaf at the base and cause holes on the tender leaves.

Bionomics

- The adult weevil is small, black and brown with a long snout.
- The female excavate the cavities by the snout and lays eggs singly on the under surface of tender leaves.
- The grub mines the fallen leaf feeding on the mesophyll.
- It pupates in small oval chamber.

11. Red ant-*Oecophylla smaragdina* Fab. (Formicidae : Isoptera)

Damage

- The worker ants stitch together the terminal leaves with silk thread in the form of nests which remain green.

- The ant distributes the aphids, mealy bug and scales on different parts of the tree thus helping to spread their infestation.
- It gives annoyance to person who climbs up the trees.

Bionomics

- A colony of red ant has one queen, a number of soldiers, and two kinds of workers.
- Egg, larva, pupae are housed separately.
- The eggs are covered with mucilage.
- The egg period is 4-8 days. There are three larval instars.
- The pupa is stored in any where and has duration of 5-7 days.
- The ant is carnivorus feeding on flies, moths, beetles, and caterpillars.

Management

- Manage red ants if harvesting is found very difficult by using neem oil 30 ml /liter. Do not eradicate or control red ants.

IV. Sap feeders

1. Whitefly- *Aleurocanthus mangiferae* Q & B. (Aleyrodidae: Hemiplera)

Damage

- Both nymphs and adults suck the sap from the under surface of leaves causing yellowing of leaves in patches.

Management

- Remove the weeds like Clerodendron infortunatum and grass by ploughing during June-July.

2. Scale - *Chionaspis vitis* Green. (Diaspididae: Hemiptera)

Damage

- Both nymphs and adults desap the leaves causing yellowing

3. Mealy bug-*Drosicha mangiferae* Green. (Pseudococcidae: Hemiptera)

Damage

- It infests the leaves and inflorescence.

Management

- Remove alternative weed hosts like *clerodendran* by ploughing during June - July.
- Spray chloropyriphos 20 EC 2.5 ml / litre or monocrotophos 36 WSC 1.5 ml / litre of water.
- Rake up soil to destroy ovisacs and dust carbaryl 15 D or lindane 1.3 D around tree basin.

4. Leaf psyllid - *Microceropsylla brevicornis* D.L. Crawford. (Psyllidae : Hemiptera)

Damage

- The nymph feeds on tender stems, leaf stalks and leaf veins.
- The infested leaves drop and dry up.
- The sooty mould growth is occurred on leaves due to honey dew secretion of the bug.

Bionomics

- The adult bug is greenish yellow in colour.
- It inserts egg singly on leaf tissues.
- The incubation period is 8-9 days.
- It has five nymphal instars completed in 19-24 days.

V. Non - insect pests

1.Red spider mite- *Oligonychus mangiferae* Rash & Sap. (Tetranychidae : Acarina)

Damage

- It infests the lower leaf surface.

2. Eriophyid mite -*Aceria mangiferae* Sayed. (Eriophyidae : Acarina)

Damage

- It infests the internal and axillary buds resulting in stoppage of their growth and development of close lateral buds.
- The infestation results in the crowded bud formation becoming and malformed.

SAPOTA

I. Borers

1. Leaf webber or chickoo moth - *Nephopteryx eugrapllylla* Rag. (Pyraustidae: Lepidoptera)

Damage

- The caterpillar webs together the leaves scrape the chlorophyll and reduced to net work of veins.
- It also bores inside the buds, flowers and some time tender fruits become withered and shed.
- Presence of clusters of dried leaves hanging from webbed shoots and appearance of dark brown patches on leaves and cluster of dead leaves are the typical symptoms of attack.

Bionomics

- The adult moth is greyish with fore wings having brown or black spots and hind wing semi hyaline.
- The female lays pale yellow, oval shaped eggs in-groups of 2 or 3 or singly on leaves and buds of young shoots.
- The fecundity is 374 eggs per female.
- The egg period is 2-11 days.
- The larva is pinkish in colour with three dorso lateral brown stripes on each side.
- It pupates in leaf web itself for 8-9 days.
- The total life cycle is completed in 26 - 92 days.
- There are 7-9 overlapping generation per year.
- The maximum activity of pest is seen during June-July.

Management

- Plant less susceptible PKM 1 sapota variety.
- Collect and destroy webbed leaves, shoots and buds along with larvae.
- Use light trap @ 1/ha to monitor activity.
- Spray two rounds of carbary 10.1% or *Bacillus thuringiensis* 0.1% or NSKE 5% along with sticking agent or phosalone 0.05% or malathion 0.1% in alternation at 20 days interval from new shoot formation to harvest of fruits.

2. Bud worm - *Anarsia epotias* Meyr. (Gelechiidae: Lepidoptera)

Damage

- The caterpillar bores into the flower buds by webbing the: floral buds and flowers together. The infested floral parts shed.

Bionomics

- The adult moth is grey coloured with black patch on wings.
- The Larva is small, slender, pinkish brown in colour with black head and yellowish brown thoracic shield.

Management

- Spray phosalone 35 BC 2 ml / litre or Dimethoate 0.03 % / litre

3. Fruit fly - *Bactrocera dorsalis* Bend. *B. zonatus* Saund.,B. *tau* and B. *correctus* Beezzi. (Tephritidae : Diptera)

Damage

- The maggot destroy and convert the pulp into a bad smelling, discoloured semi liquid mass unfit for human consumption.
- The infestation results in fruit drop and start rotting from inside.
- On complete rotting of the fruits, the damaged fruit develop yellow spots with black centers through which liquid oozes out on pressing.

Bionomics

- The adult fly is brown or dark brown with hyaline wings and yellow legs.
- The female fly lays eggs in clusters of 2-15 just beneath the skin of the ripening fruits.
- A single female lays up to 200 eggs during oviposition period of one month.
- The egg period is 22-23 days.

- The maggot feeds on pulp and become full grown in about 7 days.
- It pupates 3-7 inches below the soil.

Management

- Plough the interspaces to expose the pupae during the off - season.
- Collect and destroy the fallen fruits.
- Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/ 1 litre of water + 1 ml of Malathion solution. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the adult flies.
- Conserve parasitoids like *Optius compensates* and S*palangia philippinensis*.
- Use bait spray combining molasses or jaggery 10g/1 and one of the insecticides, fenthion 100 EC 1 ml/1, malathion 50 EC 2 ml/1, dimethoate 30 EC 1 ml/1, carbaryl 50 WP 4g/1, two rounds at fortnightly intervals before ripening of the fruits.

4. Sapota Seed borer - Trymalitis margaritas

Biology

- The mating of male and female moths was observed during evening hours between 7.00 to 11.00 p.m. and the period of coitus lasted for 8 to 13 minutes.
- The pre-oviposition, oviposition and post-oviposition period lasted for 1.50 to 2.1, 1.0 to 2.0 and 1.0 to 2.2 days, respectively.

- The fecundity was ranged from 29 to 255 with an average 161.8±77.236 eggs per female.
- The incubation period varied from 10.35 to 12.25 days with an average of 11.16 ± 0.715.
- The average percentage of eggs hatched was found to be 92.
- The total period required for completion of larval development ranged from 10.75 to 13.75 days with an average of 12.33 ± 0.832 days.
- The first instar larvae were very minute, white in colour with pinkish tinge, without distinctly segmented and hairless body.
- The average length and breadth of first instar larva was 1.761 ± 0.038 and 0.692 ± 0.012 mm, respectively.
- Fully developed larvae was pinkish in colour and it measured about 12.467 ±0.022 mm in length and 2.673 ± 0.013 mm in breadth.
- The full grown larva stopped feeding come out of the seed and started folding the leaf with the help of series of silken threads to form a cocoon.
- The pre-pupal period varied from 17 to 33 minutes.

- The pupa was small, dark brown in colour and obtect.
- The pupal period ranged from 10.0 to 15.0 days with an average of 13.15 ± 1.663 days.
- The pupa measured from 7.61 to 10.10 mm in length and 2.6 to 3.6 mm in breadth.
- The adult moths were small in size, having whitish forewings with grayish spots on it and fringed with hairs at the margins of the wings.
- The hind wings were cream coloured with thick hairs at the margins.
- The adult measured 7.1 to 12.0 mm in length, 2.1 to 2.6 mm in breadth.
- The adult male lived for 3.25 to 6.0 days, while female moths lived for 4.0 to 7.0 days.
- Total life cycle from egg laying to emergence of adults varied from 34.10 to 45.0 days with an average of 38.5 ± 3.117 days.

Management

- Sapota seed borer is an invasive pest that might have been accidentally introduced in India from Sri Lanka a decade back.
- The seed borer attacks immature fruits and it is difficult to distinguish between infested and uninfested fruits prior to the emergence of larvae.
- Tiny holes
- Fruits with tiny exit holes are the only indication of seed borer infestation. During the tunnelling process, the larva drags out the excreta from the seed to the pulp.
- Majority of the larvae emerge from the seeds after feeding on the cotyledons completely and prior to ripening of the fruit.
- Small black ants inhabit such damaged fruits. The larva on exiting from the fruit cuts a leaf and folds it over to make a fine shell-like structure within which it pupates.
- The adult is a small delicate greyish white moth with bell shaped wings and resembles bird droppings.
- The seed borer incidence depends on the variety and availability of susceptible stage of fruits (marble-lime size fruits).
- There is no variety that is completely resistant to the seed borer infestation.
- After main fruiting season, the pre-seasonal stray fruits serve as source of survival during off season.
- Thus, Sanitation is to be maintained for eliminating the sources of seed borer infestation.
- Collection and destruction of the off season stray mature fruits after main harvest till November will bring down the pest incidence.
- Erecting light traps in the field during cropping season will attract adult moths and will minimize the incidence.
- Effective management of seed borer relies primarily on the stage of spray intervention.
- The time of application is crucial in the management of seed borer.

Spraying

- First spray intervention should be made when the fruits are of small lime size and thereafter the sprayings should be repeated at fortnightly intervals during main fruiting season.
- Alternating the sprays of Deltamethrin 2.8 EC at 1 ml/l and Bt at 1 ml/ at fortnightly interval will bring down the seed borer infestation.

II. Leaf feeders

1.Hairy caterpillar *Metanastria hyrtaca* Cram. (Lasiocampidae : Lepidoptera)

Damage

- The hairy caterpillar feeds on leaves causing defoliation.

Bionomics

- The adult is stout grayish brown moth exhibiting sexual dimorphism.
- Male moth has pectinate antenna and chocolate brown patch in the middle of fore wings.
- Female moth is bigger in size with longer and broader wings having wavy transverse bands.
- The larva is nocturnal, cylindrical grayish brown, stout and hairy.

Management

- Kill the aggregating larvae on the bark using a torch of fire or with a bucketful of cowdung slurry during the day time in households.
- Spray fish oil rosin soap to kill the larva because of asphyxiation.
- Expose burning torches against hairy caterpillars which are on trunks.
- Spray chlorpyriphos 20 EC 0.04% or Dimethoate 0.03 % or malathion 50 EC 0.1% or phosalone 35 EC 0.07% or carbaryl 50 WP 0.1%.

2. Leaf twisting weevil - *Apoderus tranquebaricus* Fa b. (Curculionidae : Coleoptera)

Damage

- The adult weevil has the habit of cutting and twisting the mango leaves into shapely thimble like rolls which remain attached to the parent leaves.
- The grub feeds on the leaf tissue within the leaf roll.

Bionomics

- The adult weevil is medium sized, reddish brown with a long snout.
- Eggs are laid in each leaf roll.
- The grub pupates within the leaf roll.

Management

- Spray insecticides like monocrotophos at 1.25 ml or endosulfan 2.0 ml / litre of water to check the spread of infestation.

3. Leaf miner - *Acrocercops syngramma* Meyr.(Gracillaridae: Lepidoptera)

Damage

- The caterpillar mines into the leaves producing blister like patches on them.

Bionomics

- The adult moth is silvery grey moth with fringes of hairs on the wing margin.
- The larva is reddish brown in colour.

III. Sap feeders

1.Whitefly - *Trialeurodes ricini* Misra. (Aleyrodidae : Hemiptera)

Damage

- Water soaked spots on the leaves which become yellow and dried.
- Colonies of whitefly on the under surface of leaves.

Bionomics

- The adults are pale yellow with white wings covered with waxy powder.
- It lays eggs in clusters on the under surface of leaves. Nymphal stage undergoes four instars.
- The life cycle is completed in 19-20 days during July-September.

2. Striped mealy bug - *Ferrisia virgata* Ckll. (Psedococcidae: Hemiptera)

Damage

- Yellowing of leaves in older plants.
- Under surface of leaves and terminal shoots covered with white mealy mass.

Bionomics

- The female mealy bug lays 185-409 eggs during an oviposition period of 20-29 days.
- The egg period is 3-4 hours.
- The nymph undergoes 4 instars.
- The nymphal period is 26-47 days.
- Adult female lives for 36-53 days and male for 1 - 3 days.

3. Green Scale - *Coccus viridis*

Introduction

- The green scale, *Coccus viridis* (Green), an insect pest of citrus and other plants, is found out-of-doors and in greenhouses in Florida.
- This pest was first found in Florida near Davie.
- This insect is also referred to as the coffee green scale.

Adults

- The adult female is shiny pale green with a conspicuous black, irregular U-shaped internal marking that is dorsally visible to the naked eye.
- Two sub-marginal black eye spots are also present and can be seen with a hand lens.
- The outline shape may be described as elongate-oval and moderately convex.
- Adult scales are 2.5 to 3.25 mm. Dead scales are light brown or buff color and the black internal marking is lost.

Nymphs

- Nymphs, or immature green scales are oval, flat and yellowish green in color, and have six short legs.
- There are three nymphal stages before becoming an adult, each stage being larger and more convex than the previous stage.

Eggs

- Eggs are whitish green and elongate-oval and are laid singly and hatch beneath the female where they are protected.
- Eggs hatch from a few minutes to several hours after being laid.

Life History and Habits

- Green scale is parthenogenetic and oviparous.
- Some adults were observed by Fredrick to complete egg deposition in eight days, and others deposited eggs over a 42-day period.
- In south Florida, the length of time that passed from the egg to egg-depositing maturity during the late summer months was from 50 to 70 days. Eggs hatch into crawlers that wander around the plant or disperse to other hosts.
- Once a suitable leaf or green shoot is found the nymphs settle and begin to feed.
- They usually remain in this same spot unless their position becomes unfavorable.
- The mature female does not move.
- Green scale appears in a rather definite pattern on citrus leaves.
- The undersurface of the leaf is preferred, and adult scales may be found in a line along both sides of the midrib and lateral leaf veins.
- Often they attack the young shoots, then one can usually see only a mass of scales.

Host Plants

- The green scale has a wide host range consisting of vegetable, fruit and ornamental crops.
- The preferred host for green scale in Florida is groundsel bush, Baccharis halimifolia L., a non-cultivated plant. Preferred cultivated hosts are gardenia and ixora.
- The Division of Plant Industry has recorded green scale on 174 hosts in Florida since 1942.

Economic Importance

- This tropical soft scale may occur on cultivated hosts in commercial nurseries, resulting in a quarantine of the infested plants until the scale is under control.
- Usually infestations are accompanied by sooty mold, a black fungus growth, which develops on honeydew excreted by the scale.
- Accumulations of sooty mold cause the infested plant to be unsightly.
- When large populations are present yellowing, defoliation, reduction in fruit set and loss in plant vigor are caused.
- This pest is especially damaging to young trees in the first two years after transplanting.

Management

Chemical control

- Direct insecticidal sprays to lower leaf surfaces and new growth to give thorough coverage.

Biological control

- Several entomogenous fungi were observed associated with green scale on citrus, and some apparently played an important role in the natural limitations of the scale on citrus during certain seasons of the year.
- In Florida, these fungi include: the white-fringed fungus, *Verticilium* (*Cephalosporium*) *lecanii* (*Zimmerman*); *Aschersonia cubensis* (*Cuban aschersonia*); the pink scale fungus, *Nectria diploa*; and a grayish blue fungus
- The white-fringed fungus is the most common and apparently causes the highest percentage of mortality.
- All attempts to artificially spread or inoculate the fungus to healthy green scale were unsuccessful.
- The green scale is often associated with ants. Controlling ant populations help to reduce levels of this pest.
- Ants protect the green scales from lady beetles and other predators.
- In turn, the ants feed on the sweet honeydew excreted by the scales.
- Without the ants the green scale is more vulnerable to predation by beetles.

Cultural Control

- Scales are usually brought into greenhouse situations with the introduction of infested plant material.
- All plant material going into the greenhouse should be thoroughly inspected for scales and other insects before being introduced.

4. Mealy bugs - *Planococcus citri* (Pseudococcidae: Homoptera)

5. Aphids -*Toxoptera aurantii* (Aphididae : Homoptera)

Hosts

- This aphid has over 120 hosts that include *camellia*, cocoa, coffee, *Ficus*, *Hibiscus*, *Ixora*, kamani, lime, macadamia, mango, mock orange, *Pittosporum*, pomelo and Vanda orchid.

Damage

- Aphids feed by sucking sap from their hosts. This often causes the plants to become deformed, the leaves curled and shriveled and, in some cases, galls are formed on the leaves.
- In most cases the black citrus aphid is a minor pest of coffee wherever it is found.
- This pest congregates on the tender young shoots, flower buds and the undersides of young leaves.
- They are not known to feed on the older and tougher plant tissues On coffee it causes some leaf distortion and malformation of growth of leaves and tips of shoots.
- It is often more a serious pest in nurseries.

- Like other soft bodied insects such as leafhoppers, mealybugs and scales, aphids produce honeydew.
- This sweet and watery excrement is fed on by bees, wasps, ants and other insects.
- The honeydew serves as a medium on which a sooty fungus, called sooty mold, grows.
- Sooty mold blackens the leaf, decreases photosynthesis activity, decreases vigor and causes disfigurement of the host.
- When the sooty mold occurs on fruit, it often becomes unmarketable or of a lower grade as the fungus is difficult to wash off.
- Aphids vector many plant diseases which cause substantially greater losses than caused by direct feeding injury.
- This is often the most damaging feature of an aphid infestation.
- The black citrus aphid is a vector of virus diseases of *Coffea liberica*, *Coffea arabica* var. *bullata* (blister spot) and *Coffea excelsa* (ringspot). Fortunately, aphid vectored viruses of coffee have not been reported in Hawaii.
- On Citrus it is a vector of Citrus *tristeza* virus, citrus infectious mottling virus and little leaf and lemon-ribbing virus of lemon.
- Presently, Citrus tritesa virus is the only known citrus virus that occurs in Hawaii.

Biology

- The development of this aphid is temperature dependent. At 77°F a generation (nymph to adult) may take as little as 6 days.
- In cooler temperatures (below 59°F), a generation may take as long as 20 days.
- Higher temperatures also reduce development rate, at 86û F populations of this aphid will sharply decline.
- Generations are continuous throughout the year in Hawaii.

Eggs

- Eggs are not produced by this species.
- Females give birth to living young.
- Infested young shoots

Nymphs

- There are four nymphal stages of this aphid.
- The first stage is approximately 1/36 inch in length and the last about 1/17 inch.
- They are without wings and brownish in color.

Adults

- Only females are found.
- They are oval, shiny black, brownish-black or reddish brown in color, either with or without wings, measuring 1/25 to 1/12 inch in body length and having short black-and-white banded antennae.

- Winged individuals tend to have darker abdomens and be slightly thinner.
- The incidence of winged individuals is dependent on the population density and leaf age.
- Reproduction is partheneogenic or non sexual.
- Females start reproducing soon after becoming adults.
- They produce 5 to 7 live young per day, up to a total of about 50 young per female.

Behavior

- Newly born nymphs are found grouped together since mothers do not move about while birthing.
- This is the only aphid with an audible stridulation or high piercing sound caused by the aphid rubbing two parts of it body together much like crickets.
- Large colonies will produce this scrapping sound when they are disturbed.

Management

Non-Chemical Control

- Several natural enemies of the black citrus aphid keep this pest under control.
- Sometimes to the extent that insecticides are usually unnecessary.
- Predators in Hawaii include *Allograpta obliqua* Say, *Chrysopa basalis, Chrysopa microphya* McLachlan, *Coccinella inaequalis* Fabricius,

Coelophora inaequalis, *Platyomus lividigaster* Mulsant and *Scymnodes lividgaster*.

- The parasites in Hawaii include *Aphelinus semiflavus* Howard and *Lysiphlebus testaceipes* (Cresson).
- There are many other predators and parasites to this pest throughout the world.
- This pest is also controlled by the entomogenous fungus *Acrostalagmus albus*.

Chemical control

- If chemical control becomes necessary either insecticidal oil, or a synthetic aphidicide (insecticide) may be used.
- Chemical control should only be applied at the first signs of damage during periods of flush growth.
- Flush growth (young red leaves) on coffee should be completely moistened after application of chemicals.

Lecture No.11

- **Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Citrus**

I. Borers

1. Lime or Orange tree borer - *Cheledonium cinctum* Guer and *C.alcamene* Thoms. (Cerambycidae: Coleoptera)

Damage

- The grub bores into stem and feeds on the internal tissues, which resulted in drying of terminal shoots in early stages, followed by wilting of thicker branches and main stem.

Bionomics

- The adult is dull metallic green to dark violet with a yellow band across the middle of the elytra and in 2.5-3cm long.
- It lays eggs at an angle of twigs or thorns and covers by a resinous fluid secretion.
- A single female can lay up to 30-50 eggs.
- The incubation period is 11-72 days.
- The grub is creamy white with flat head.
- It pupates in the tunnel for about three weeks.
- The life cycle is completed in one year.
- The adult beetle emerges during April and May and remains within the pupal chamber for a long time.

Management

- Prune the infested branches containing grubs.
- Plug the fresh holes with cotton soaked in monocrotophos solution mixed at 5 ml / 20 ml of water.
- Follow the padding with monocrotophos 2.5 ml +2.5 inl of water.
- Check multiplication of borers by keeping orchard clean and drench soil around tree with chlorpyriphos 20 EC 5 ml /1.
- Prune and destroy damaged branches containing grubs before they enter trunk.
- Swab trunks with carbaryl 50 WP at 20 g/1 to avoid egg laying.
- Collect and kill eggs and grubs from barks and bore holes.
- Inject 10 ml of monocrotophos 36 WSC or kerosene, petrol, carbon disulphide or chloroform plus creosote (2:10) in live bore holes and plug with wet clay.

- Spray monocrotophos or dimethoate 0.03 % /1 in case on infestation on leaves by adult beetles.
- Alternate hosts in the nearby vicinity like jamun, guava, litchi, pomegranate, neem, or kapok should also be treated.
- Encourage activity of natural enemies, *Syrphus spp*. and *Coccinella septumpunctata*

2. Orange trunk borer - *Anoplophora versteegi* Ritsema. (Lamiidae: Coleoptera)

Damage

- The grub tunnels into the trunk and feeds on the internal content of the trunk resulting the death of the tree.
- The adult beetle feeds on the leaf tissue along the mid rib, keeping the margins intact.

Bionomics

- The female beetle lays eggs singly in cracks on bark up to 2 feet height from the ground.
- A single female lays about 33-85 eggs.
- The grub feeds on sap wood making horizontal galleries before it enter into centre of the trunk.
- The larval period is 267-290 days. It pupates inside the gallery for 33-43 days.

Management

- Hand picks the adults by shaking the trees and kills them.
- Paint the base of the tree trunk with persistent insecticides.

3. Bark caterpillar - *Indarbela tetraonis* Moore. (Metarbelidae: Lepideptera)

Damage

- The grub bores into the bark and sap wood making zig-zag galleries filled with silken webbed masses comprising chewed up materials and excreta.
- In severe infestation the flow of sap is interfered.
- The growth of the plant is arrested and fruit formation capacity is drastically reduced.

Bionomics

- The adult moth is pale brown with rufous head and thorax.
- The female lays eggs in masses of 15-25 under loose bark of the trees.
- A single female lays about 2000 eggs in her life span.
- The egg period is 8-10 days.
- The newly hatched larva is dirty brown while the full grown caterpillars have pale brown bodies with dark brown head measuring 50-60 mm in length.
- The larval period is 9-11 months.

- It pupates inside the tunnel for 3-4 weeks.
- The adult moth emerges during summer.

II. Leaf feeders

1.Citrus leaf miner - *Phyllocnistis citrella* Stainton. Lepidoptera)

Damage

- The larva mines into the tender leaves and form zig - zag galleries which feeds on the epidermal cells leaving behind the remaining leaf tissues quite intact.
- The infested leaves turn pale, gets distorted, and dry.
- The mining of larval may lead to secondary infection by fungi and bacteria causing citrus canker.

Bionomics

- The adult moth is tiny, silvery white with 4.2 mm wing expanse with fringed wings.
- It lays eggs singly on the leaves and twigs.
- The fecundity is 36-76 eggs per female.
- The egg period is 2-10 days.
- The larva enters the leaf tissues and feed inside the galleries.
- The larval period last for 5-10 days.
- It pupates in a leaf curl at the leaf margin within a silken cocoon.
- The pupal period is 6-12 days.

Management

- Grow less susceptible variety like PKM 1.
- Collect and destroy damaged leaves along with larvae.
- Spray dichlorvos 76 WSC 1 ml/1 or dimethoate 30 EC 1 ml/ 1 or fenthion 100 EC 1 ml / 1 or monocrotophos 36 WSC 1.5 ml/1 or imidacloprid 200 SL 0.5 ml/ 1 or NSKE 5% or neem oil 3% after new flush formation.
- Encourage activity of parasitoids, *Tetrastichus phyllocnistoides*, *Elasmus sp*, and *Bracon phyllocnistoides*.

2. Citrus butterfly -*Papilio demoleus* Linn and *P. polytes* (Papilionidae : Lepidoptera)

Damage

- The young larvae found on the upper surface of leaves and feed on the leaf lamina from margin to mid rib.
- The grown up caterpillar feeds even on matured leaves and cause severe defoliation to the entire plant.

3. Leaf roller- *Psorostichia (= Tonica) zizyphi* Staint. (Oecophoridae: Lepidoptera)

Damage

- The larva webs together and folds the leaves.
- It feeds from within the leaf roll on the epidermis of leaves.
- The infestation resulted in rolling and crinkling of leaves.

Bionomics

- The adult moth is small brown.
- The female moth lays eggs singly or in group along the mid ribs of leaves.
- A female can lays up to 404 eggs in her life span.
- The egg, larval and pupal period are 3-5, 9-11 and 5-10 days respectively.
- It pupates in leaf folds.
- The total life cycle of the pest is completed in 20-31 days.

Management

- Collect and destroy damaged leaf folds along with larvae and pupae.
- Encourage activity of *Brachymeria euploeae* and *Apanteles sp*.
- Spray carbaryl 10.1% or dimethoate 0.03 % or NSKE 5%.

4. Blue butterfly- *Tarucus indica* Fab and *Chilades laius* Cramer. (Lycaenidae Lepidoptera)

Damage

- The larva feeds on leaves and causes defoliation.

III. Sap feeders

1. Fruit sucking moths - *Eudocima (= Othreis) conjuncta* Cramer. *E. fullonica Cramer*., *E. materna Linn* and *E. ancilla Cramer*. (Noctuidae: Lepidoptera)

Damage

- The adult moth pierces the fruits for sucking the juice and make characteristic pin-hole damage in citrus and other fruits.
- The feeding site is easily infected with fungi and bacteria causing rotting and dropping of fruits.

Bionomics

- The adult moth of E. conjuncta is faint orange brown having marginal dark bands mixed with white spots on hind wings. E. materna has three black spots on the fore wings. O. ancilla has white bands in the middle fore wing. E. fullonica has tripod black mark in the forewing and curved marking in hind wing.
- The moth is nocturnal in habit.
- It lays eggs on wild plants and weeds in and around the citrus orchard.
- The egg period is about 2 weeks.
- The larvae is stout, typical semi looper, has a dorsal hump on the last segment of the body.
- The larva passes five instars and completes its larval stage in 4 weeks.
- It pupates for 2 weeks in the dried leaves or in the soil.

Management

- Remove and destroy the alternative weed host plants especially Tinospora cardifolia, Cocculus pendulus in the vicinity of the orchard.
- Bait with fermented molasses at 100 g + malathion 50 EC @ 10 ml / litre of water.
- Bag the fruit with polythene bags punctured at the bottom individually fruits in small-scale area.
- Create smoke on one side of the field and allow it individual fruits in small¬ scale area.
- Set up light traps or food lures to attract and kill the moths.
- Cover the entire field / orchard with nylon net and spray with contact insecticide.
- Collect and dispose off damaged fallen fruits to prevent further attraction of adults.
- Cover fruits with polythene bags (300 gauge) punctured at the bottom.
- Apply smoke to prevent moth attck.
- Use light traps or food lure (pieces of fruits) to attract moths.

2. Aphids -*Toxoptera citricidus* Kirkaldy and *T. aurantii* Boyen. (Aphididae Hemipetera)

Damage

- Both nymphs and adults suck the sap from the leaves resulting stunting, curling of leaves and falling of flower buds and developing fruits.
- The infested leaf attracts sooty mould due to honeydew secretion of the insect.

Bionomics

- The adult fly is dark orange with smoky wings and fore wings having four whitish areas of the irregular shape.
- The female fly lays yellowish brown, oval eggs arranged in spiral on broad leaves.
- The egg period is 7-14 days.
- The nymphal period is 38-60 days with four nymphal instars.
- It pupates on leaf surface.
- The pupal period last for 100-131 days. There are two generations in a year.

Management

- Spray monocrotophos 36 WSC at 1.5 ml/litre of water.

3. Whitefly - *Dialeurodes citri* Ashmead. (Aleyrodidae : Hemiptera) Black fly *Aleurocanthus woglami*

Damage

- The nymphs and adults desap the leaves and young shoots.
- The nymphs excrete honey dew in large quantities which attracts the black fungus causing sooty mould development on the leaf surface.
- The infested plants are stunned, and produce few blossoms.

Bionomics

- The adult is small measuring 1.02 -1.52 mm in length.

- The female lays oval, pale yellowish eggs singly on the lower surface of the young leaves.
- It lays up to 200 eggs in her life span. The eggs hatch in 10-20 days.
- The larva crawls about for a few hours and then inserts its proboscis into the succulent portion of the twigs.
- It pupates on the surface of leaves.
- The nymphal period is 25-71 days.
- The pupal period last for 114-159 days.
- There are two generations in a year.

Management

- Collect and destroy damaged leaves, flowers and fruits along with life stages.
- Spray methyl demeton 25 EC 2 ml/1 or monocrotophos 36 WSC 1ml/1.
- Use yellow sticky traps at 15/ha.
- Spray quinolphos 25 EC at 2 mil litre of water or monocrotophos 36 WSC 2.5 mil litre of water.

4. Citrus mealy bug - *Pseudococcus filamentosus* Cockerell. (Pseudococcidae : Hemiptera)

Damage

- Both nymphs and adults suck the cell sap causing wilting and drying of young seedlings.

- The infested plants develop sooty moulds on the surface of leaves due to honeydew excreted by the insect.

Bionomics

- The female lays eggs in masses of 300 on the plant surface.
- The eggs are hatched in 10-20 days.
- The nymphs crawl out and feed on under surface of leaves.
- A white waxy covering develops on their bodies.
- The nymphs become full grown in 6-8 weeks.
- The male nymphs spin cotton like cocoons and pupate within it.
- All the stages of development occur at the same time.

Management

- Debark the branches and- apply methyl parathion paste.
- Use sticky trap on the shoot bearing the fruits at a length of 5 cm.
- Use dichlorovos (0.2 %) in combination with fish oil rosin soap (25 g I litre) as spray or dipping fruits for two minutes.
- Apply aldicarb lOG 50 g I tree around the base at the time of pruning.
- Release the coccinellid predator *Cryptolaemus montrouzieri* @ 10 beetles/tree.
- Release an exotic parasitoid *Leptomastrix dactylopii* 5000-7000 I ha.

- Put a band of diazinon 5 g around the tree trunk leaving 30 cm from the main stem.
- Follow ant control methods such as destruction of ant holes, red ant nests and skirting of citrus trees after harvest.
- Use sticky traps on fruit-bearing shoots at a length of cm
- Collect damaged leaves, twigs and stems along with mealy bug colonies and destroy.
- Single soil application of aldicarb 10 G at 50 g/ tree around base during pruning.
- Spray methyl parathion 0.1% emulsion, dimethoate 150 ml plus kerosene oil 250ml in 100 1 of water or carbaryl 0.05% plus oil 1% or malathion 0.1% or monocrotophos 0.1%.

5. Citrus red scale - *Aonidiella aurantii* Maskell. (Diaspididae: Hemiptera)

Damage

- It settles in large numbers on stem, branches, leaves and fruits and suck the cell sap.
- The infested plants become stunted, loose the vigour and gradually dry up.

Bionomics

- The female scale produces young one (crawlers) which moves for a short period, settle and cover with a white waxy secretion.
- It reaches sexual maturity in 10-15 weeks.

- There are several generations in a year.

6.Cottony cushion scale - *Icerya purchasi* Maskell. (Margarodidae : Hemiptera)

Damage

- Both nymphs and adults infest the twigs and leaves.
- The infested twigs are killed and leaves turned pale and dropped prematurely.
- The development of sooty mould on the infested leaves is typical symptom.

Bionomics

- It reproduces parthenogenetically as the males are rare.
- The female scale lays up to 700 eggs in the ovisac held behind the body.
- The newly hatched out nymphs feeds on leaves and twigs.
- It becomes adult after moulting for three times.
- The life cycle is completed in 46-240 days.

Management

- Collect damaged twigs and stems along with soft and hard scales and destroy.
- Spray methyl parathion 0.03% emulsion or dimethoate + kerosene oil at 150 ml + 250 ml respectively in 100 1 of water or carbaryl 0.05% + oil 1% or malathion 0.1% or monocrotophos 1 ml/ 1 or fenthion 100 EC 1 ml/l.
- Spray fish oil rosin soap 25 g/1 or neem oil 3% or dimethoate 0.03 % /1.

- Encourage natural enemies, *Aphelinus sp*., and predators, *Chilocorus nigritus*, *Scymnus sp*. and *Rodolia cardinalis*.
- Enforce ban by law, transport of wattle from the Nilgiris and kodaikanal to elsewhere.

7. Citrus psylla - *Diaphorina citri* Kuwayama. (Psyllidae : Hemiptera)

Damage

- The nymphs are found congregated on young half open leaves and desap the same.
- The infestation resulted in arresting the growth of the plants.
- Since the insect inject the toxins along with saliva, the leaves and flower buds wilt and die gradually.
- It also acts as vector of citrus virus causing citrus decline disease.

Bionomics

- The adult is brown with its head lighter brown and pointed measuring 3 mm in length.
- A female lays 500 almond shaped orange coloured and stalked eggs on tender leaves and shoots.
- The incubation period is 10-20 days in winter, 4-6 days in summer.
- The nymphs are flat orange yellow in colour and louse like creature.
- The nymphal period is 10-11 days. The females live longer than males.
- There are 8-9 over lapping generation in a year.

Management

- Prune the affected trees and dried shoots periodically prevent the multiplications of psyllids.
- Conserve the natural enemies by avoiding broad-spectrum insecticides.
- Spray neem seed kernel extract 5 % or neem oil 1 % or monocrotophos 36 WSC at 1 ml or quinalphos at 1 ml with 0.5ml teepol / litre of water.
- Spray dimethoate 1675 ml or malathion 1250 ml / ha during February ¬March, May-June and July-August.
- Encourage activities of natural enemies such as *Syrphids* and *Chrysopids*.

IV. Non - insect pests

1. Citrus mite - *Panonychus citri* Mc Gregor. (Tetranychidae: Acarina)

Damage

- Both nymphs and adult suck the sap from leaves, tender fruits and green bark.
- In case of severe infestation there is complete defoliation of plants.
- The infested fruits turn yellow and remain undeveloped.

Bionomics

- It lays about 50 eggs each arranged singly along large veins on the lower surface of leaves.

- The eggs are round, minute and orange in colour which are embedded in the leaf tissues.
- The egg period is 7 days.
- The freshly hatched out nymphs desap the leaves for 304 days. It is full grown in 4-5 days, moult and transform into adult mite.
- The total life cycle is completed in 17-20 days.

2. Mite - *Phyllocoptes oleivorus* Ashmead. (Eriophyiidae: Acarina)

Damage

- Both nymphs and adults desap the leaves from the under surface of leaves and fruit surface.
- The infestation causes bronzing of leaves and silvery, scaly discoloration on lemon fruits and rusty to black discolorations on the other citrus fruits.

Management

- Spray fenazaquinone 2 ml / litre or wettable sulphur 50 WP 2 g / litre of water.

Lecture No.12

- **Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Banana**

I. Borers

1. Rhizome weevil - *Cosmopolites sordidus* Germ. (Curculionidae: Coleoptera)

Damage

- The grub bore into the sucker and tunnel into the rhizome resulting death of the unopened leaves at the heart of the plant is called "pipe" and withering of outer leaves. A result of severe attack, the plants show pre - mature withering.
- Scarcity of leaves and production of under sized fruits.
- The corm of infested plants has extensive tunnels plugged with excreta.
- High incidence of pest occurs during April - October.

Management

- Trap adult weevil with pseudo stem chopped into pieces
- Uproot and destroy the infested rhizome from the field.
- Use pest free suckers for planting.
- Apply carbofuran 3 G 10 gram per plant at the time of planting.
- Trap adult weevils with corm chopped into small pieces and kept near infested clump at 65/ha (Banana corm split trap) or use cosmolure traps at 5/ha.
- By paring and pralinage method, apply carbofuran 3 G 40g or phorate 10 G 20g; or apply lindane 1.3 D 20 g or carbaryl 10-20 g/ sucker before planting.
- Dip suckers in monocrotophos 0.05% and plant 24 h later.

2. Pseudostem borer - *Odoiporus longicollis* (Curculionidae: Coleoptera)

Damage

- The first instar larvae feed on the tissues around the air chamber of the leaf sheath.

- The second instar larva bores into the inner sheaths of the pseudostem and moves across in a horizontal or slight oblique direction.
- The third and fourth instar larvae feed voraciously and riddle the pseudo stem cutting a thin hole on the out surface of the pseudostem for better aeration.
- The infested part of pseudostem decomposes as a result of which plants become very weak and break easily in wind.
- Exudation of plant sap from leaf sheath, yellowing and withering of leaves, immature ripening of fruits, destroying of flower primordia, decaying of leaf sheath and corm and finally falling of whole plant are the symptoms of damage.
- The severity of pest notices in ratoon crop compre to first year crop

Bionomics

- The adult weevil is reddish brown and black measuring 1.3 cm long. It thrusts the eggs within the air chamber of leaf sheath through oviposition slit made by rostrum at the rate of one egg per air chamber.
- Eggs are laid in the area of the pseudostem about 1 - 1.5 metres above the ground level.
- The incubation period is 3-5 days in summer and 5-8 days winter.
- The grubs are apodous and have duration of 26.2 days in summer and 68.1 days in winter with five larval instars.
- It pupates in the tunnel towards the periphery.

- The pupal period last for 20-24 days in summer and 37- 44 days in winter. Adult feeds on tissue of leaf sheath from its inner surface and also on decaying tissues.
- Infective for up to 13 days after feeding on infected material.

Management

- Adopt good husbandry practices such as weeding, manuring and mulching which improve weevil tolerance.
- Remove dried leaves periodically and keep the field clean.
- Prune the side suckers every month.
- Use healthy and pest free suckers to check the pest incidence.
- Spray monocrotophos 36WSC at 1 ml / litre of water.
- Do not dump infested materials into manure pit.
- Uproot infested trees, chop into pieces and burn.
- Spray methyl parathion 50 EC 2 ml/1 or monocrotophos 36 WSC 1 ml/1 on trunk. Alternatively, dilute 50 ml of monocrotophos 36 WSC with 350 ml of water and inject 4 ml (2ml at 45 cm from ground level, another 2 ml 150 cm from ground level) using banana injector' or long needle in the pseudostem at monthly intervals from 5th to 8th month. Do not follow stem injection after 8 months of growth.

3. Fruit fly - *Bactrocera dorsalis* Hendel. (Tephritidae : Diptera)

Damage

- The maggot destroy and convert the pulp into a bad smelling, discoloured semi liquid mass unfit for human consumption.
- The infestation results in fruit drop and start rotting from inside.
- On complete rotting of the fruits, the damaged fruit develop yellow spots with black centers through which liquid oozes out on pressing.

Bionomics

- The adult fly is brown or dark brown with hyaline wings and yellow legs.
- The female fly lays eggs in clusters of 2-15 just beneath the skin of the ripening fruits.
- A single female lays up to 200 eggs during oviposition period of one month.
- The egg period is 22-23 days.
- The maggot feeds on pulp and become full grown in about 7 days.
- It pupates 3-7 inches below the soil.

Management

1. Plough the interspaces to expose the pupae during the off - season.
2. Collect and destroy the fallen fruits.
3. Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/ 1 litre of water + 1 ml of Malathion solution. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the adult flies.
4. Conserve parasitoids like *Optius compensates* and *Spalangia philippinensis*.
5. Use bait spray combining molasses or jiggery 10g/1 and one of the insecticides, fenthion 100 EC 1 ml/1, malathion 50 EC 2 ml/1, dimethoate 30 EC 1 ml/1, carbaryl 50 WP 4g/1, two rounds at fortnightly intervals before ripening of the fruits.

II. Sap feeders

1.Banana aphid - *Pentalonia nigronervosa* Coq. (Aphididae: Hemiptera)

Damage

- There is no direct damage caused by this pest but it acts as a vector for the notorious virus disease bunchy top disease of banana.
- The disease is characterised by the initial appearance of green streaks on the secondary veins on the ventral side of lamina.
- The affected leaves become brittle and petioles completely elongated.
- The leaves become small and eventually the crown of plants becomes composed of stunted leaves, which present bunchy top appearance.

Bionomics

- The adult viviparous insects are of two forms, winged and wingless.
- The alate viviparous female has reddish to dark- brown body measuring on an average of 1.45 mm in length. In the apterous viviparous female the body is reddish to dark brown measuring on an average 1.55 mm in length.
- The male insects are not observed. The female reproduces parthenogenetically.
- The female gives birth to young ones from the second day, of its emergence.
- A female brings forth 32-50 young ones. The nymph has 4 instars conferring a period of 8-9 days.
- The aphids occur on banana plant in colonies.

- They shelter at the base of the pseudostem, top region of the pseudostem and leaf axils.
- The population is high from early September to late January with two peaks in between one during September-October and the other during December-January.
- Moderate temperature and high humidity favours the increase in aphid population.
- Infective aphid can transmit the virus to healthy plant in 1.5-2 hours of feeding.
- The minimum acquisition feeding time for nymph is 16 hours.
- The aphid remains infective for up to 13 days after feeding on infected material.

Management

- Spray methyl demeton 2 ml / litre or monocrotophos 1 ml / litre or dimethoate 1.70 ml / litre of water,
- Direct the spray towards the crown and pseudostem base up to ground level at 21 days interval at least thrice.
- Avoid injection of monocrotophos after flowering.
- Destroy diseased plants with rhizome.
- Inject 5 ml of 2, 4-D herbicide (125 mg/1) into pseudostem using injecting gun for effective killing of diseased plants.

- Spray methyl demeton 25 EC 500 ml or monocrotophos 36 WSC 250 ml/ha or dimethoate 30 EC 500 ml/ha to control aphids. Direct spray towards crown and pseudostem base at 21 days interval at least thrice.
- Follow pseudostem injection with monocrotophos 36 WSC after diluting 1 ml in 4 ml of water at 45 days interval. Use banana injector devised by TNAU or lumbar puncture needle. Avoid injecting monocrotophos after flowering.
- Encourage activity of predators, *Scymnus*, *Chilomenes sexmaculata*, *Chrysoperla carnea* and other *coccinellids*; and entomopathogen, *Beauveria bassiana*.

2. Tingid bug - *Stephanitis typicus* Dist. (Tingidae: Hemiptera)

Damage

- The lacewing feeds in the sap of leaves causing the discoloration of the leaves.

Management

- Collect and destroy damaged leaves, flowers and fruits along with life stages.
- Spray methyl demeton 25 EC 2 ml/1 or monocrotophos 36 WSC 1ml/1.
- Use yellow sticky traps at 15/ha.

3. Scale - *Aspidiotus destructor* Sign. (Diaspididae: Hemiptera)

Damage

- Both nymphs and adults desap the leaves causing yellowing of leaves in patches

4. Spittle bug - *Phymatostetha deschampsi* Linn. (Cercopidae: Hemiptera)

Damage

- The nymphs and adults suck the juice from the leaves causing yellowing of leaves.

5. Leaf thrips - *Helionothrips kadaliphilus* Ram & Marg. (Thripidae : Thysanoptera)

Damage

- It infests the lower surface of the leaves causing blighted appearance and yellowing.
- In severe cases of infestation the leaf dries.

Management of lacewing bug and thrips

- Spray methyl demeton 20 EC 2 ml / litre or monocrotophos 36 WSC 1.25ml ml/ litre of water

6. Flower thrips - *Thrips florum* Schmutz. (Thripidae: Thysanoptera)

Damage

- Both nymphs and adults desap the fruits and flowers resulting corky scab on fruits and flowers.

7. Fruit rust thrips - *Chaetanaphothrips signipennis* Bag. (Thripidae: Thysanoptera)

Damage

- Both nymphs and adults lacerate and suck the sap from the leaves and fruits.
- The infestation resulted in yellowing of leaves and rusty growth over the fruit.

Management

- Collect and destroy damaged leaves, fruits and flowers.
- Spray methyl demeton 25 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 or monocrotophos 36 WSC 1.25 ml/1.

II. Leaf feeders

1. Woolly bear - *Pericallia ricini* Fab. (Arctiidae: Lepidoptera)

Damage

- The caterpillars feed on the leaves voraciously and cause severe defoliation

2. Tobacco caterpillar - *Spodoptera litura* Fab. (Noctuidae: Lepidoptera)

Damage

- The larva feeds on the leaves causing defoliation during night hours.

3. Bag worm - *Kophenae cuprea* Moore. (Psychidae: Lepidoptera)

Damage

- The larva scrapes the chlorophyll and later it riddles with irregular holes on the leaves.

Bionomics

- The adult moth is brownish in colour.
- The larva is also brownish covered with conical bag.

4. Leaf beetle - *Nodostoma subcastatum* Jacoby. (Eumolpidae : Coleoptera)

Damage

- The adult beetle bite small holes on leaves.

III. Non - insect pest

1. Burrowing nematode - *Radapholus similis*

Damage

- The nematode in banana cause black-head toppling disease.
- At the bearing stage toppling of trees is an obvious symptom of attack due to root rot.
- The feeding of nematodes causes discoluration of cortex.
- The wounding cause's discolouration as a result reddish brown cortical lesions develop.
- Both roots and corm of the plants are attacked and the necrosis decrease the root system to a few short stubs, reduction in the leaf size, yellowing of leaves and reduction in bunch weight.

- The trees succumb to winds and yield loss up to 39 per cent has been recorded due to nematodes.

Management

- Remove the nematode affected plants along with corm from the field and burn it.
- Pre -treat the suckers (Paring and pralinage) with carbofuran 3 G after removing the discoloured portions.
- The suckers and dipped in the clay slurry and 40 g of carbofuran granules are sprinkled over the surface and planted.
- Dip the suckers in 0.05 % solution (1.5 ml / litre of water) of monocrotophos 36 WSC at the time of planting.
- Apply carbofuran granules @ 10-20 gm/ plant around the pseudostem two months after planting.

Lecture No.13

Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Guava

I. Sap feeders

1. Tea mosquito bug - *Helopeltis antonii* Sign. (Miridae: Hemiptea)

Damage

- The nymphs and adults feed on the young leaves, buds and tender shoots the tissues around the feeding punctures die and dry up due to toxic action of saliva injected.
- It results the water soaked lesions followed by brownish spots at the feeding site.
- Resin exudes from the feeding puncture. Blossom or inflorescence blight and die back symptoms appear.
- The terminal shoots are also dried. Shedding of flowers and nut also takes place.

Bionomics

- The adult is a reddish brown bug with red thorax and black and white abdomen.
- The eggs are inserted into the epidermis of tender shoots, axis of inflorescence, the buds and midribs.
- The eggs are sausage shaped, 2 mm long, slightly covered with a pair of breathing filaments which project out its operculum.
- The egg period is 5 to 7 days.

- Nymphal period is 15 days.
- The reddish brown and ant like nymphs undergoes five instars.
- The life cycle is completed in 22 days.
- This pest attacks guava, cocoa, pepper, cinchona, tamarind, mango, neem, cotton and avocado.

Management

- Remove dead wood and criss cross branches in cashew plantations atleast once in two to three years will help in effective spraying of insecticides against the pest.
- Collect and destroy damaged fruits.
- Use light trap at 1/ha to monitor the activity of moths.
- Ensure clean cultivation as weed plants serve as alternate hosts.
- Spray hostothioan at 2 ml / litre or carbaryl 50 WP 2 g /litre or malathion 50 EC at 1ml/litre or neem oil 3 % spraying should be done in early morning or late evenings, at least four times at 21 days interval during fruiting season.

2. Aphids -*Aphis gossypii* Glover. (Aphididae: Hemiptera)

Damage

- It is a potential pest on cotton infesting tender shoots and under surface of the leaves.
- They occur in large numbers suck the sap and cause stunted growth, gradual drying and result in death of the plants.

- Development of black sooty mould due to the excretion of honey dew giving the plant a dark appearance. Being a polyphagous pest, it is recoreded in brinjal, bhendi, chillies,guava and gingelly. Curling and crinkling of leaves are typical symptoms.

Bionomics

- Yellowish or greenish brown nymphs found on the under surface of leaves.
- They are often attended by ants for the sweet honey dew secretion.
- Winged forms may be seen under crowded conditions.

Management

- Spray monocrotophos 36 WSC at 1.5ml / litre or dimethoate 30 EC at 1.7 ml / litre of water.

3. Guava scale -*Chloropulvinaria psidii* Mask. (Coccidae: Hemiptera)

Damage

- Both nymphs and adults of scales are found in large numbers of the under surface of leaves, tender twigs and shoots causing yellowing and distortion of leaves.

Bionomics

- The adult is shield shaped, oval, yellowish green measuring 3 mm in length.

- The female lays eggs in a ovisac beneath the body.
- The first instar crawlers move and start feeding on the tender portion of the plants

4. Whitefly - *Aleurotuberculatus psidii* Singh. (Aleyrodidae: Hemiptera)

Damage

- Both nymphs and adults infest the under surface of the leaves causing yellowing symptoms.

Damage

- Both nymphs and adults infest the under surface of the leaves causing yellowing symptoms.

5.Spiraling whitefly - *Aleurodicus dispersus* Russell. (Aleyrodidae : Hemiptera)

- The spiralling whitefly *Aleurodicus dispersus* Russell poses threat to many agricultural and horticultural crops both in the glasshouse and field conditions in India.
- *Aleurodicus dispersus*, native to Caribbean islands and Central America, is reported to occur in North America, South America, Asia, Africa, Australia and several Pacific islands.
- In India, it was first recorded in 1993 at Thiruvananthapuram, Kerala on tapioca.

Biology

- Eggs are laid in a typical spiral pattern from which the whitefly derives its common name. Female whitefly lays yellowish white eggs, which hatch in 7 days and 4-6 days and 5-8 days. Fecundity ranges from 51.8 to 64.06 eggs/ female. There are four nymphal instars, which are greenish, white and oval. The duration of first, second, third fourth instar lasts for 2.15-6.50, 2.7-5.00, 2.9- 5.96 days and 6.5- 8.1 days. Fourth instar nymphs are covered with heavy wax material. The total nymphal period normally lasts for 12 to 14 days and pupal period lasts for 2 to 3 days. Development from egg to adult occupies 18 to 23 days and 22.5-29.66 days. Adults are larger with dark reddish brown eyes and fore wings with characteristic dark spots. Adults live for 13 to 22 days.

6. Mealybug - *Maconellicoccus hirsutus* Green. (Pseudococcidae : Hemiptera)

Damage

- Mealy bugs found on leaves, shoots, nodes, bunch and loose bark of grapevine.
- Infestations of the growing point with mealy bug results in malformation of leaves and shoot tips.
- The greatest damage is done to the fruit bunches.
- Honey dew secreted by mealy bug nymphs and adults, support the growth of sooty mould on leaves, shoots and branches, sooty and sticky bunches harbouring mealy bugs and their white cottony wax masses tend to be inferior in the market value as table grapes.

- Raisin cannot be prepared from such bunches.
- The quality of the wine is affected. In case of severe infestation in the nursery, young vines are often killed.
- The yield loss by mealy bug alone is ranging from 50-100 % in the field.

Bionomics

- The adult females are pinkish and sparsely covered with white wax.
- Each female deposits from 350-500 eggs in a loose cottony terminal ovisac during a week's time.
- The eggs are orange in colour. The egg period is 5-10 days.
- The crawlers are also orange in colour.
- The females have three, while males have four nymphal instars. A generation is usually completed in a month but extended in winter months.

Management

- Debark the vines and swab with methyl parathion to minimize the population.
- Apply sticky substances *viz.*, tack-trap or bird tangle foot on the shoot bearing the fruit bunch at a length of 5 cm to keep the bunches free from infestation.
- Release exotic predator *Cryptolaemus montrouzieri* Muls. in grape vine garden @ 1000-1500 beetles per acre (a single predator consumes 900-1500 mealy bug eggs or 300 nymphs in its development)

- Combine the release of predator and spraying of insecticides dichlorovos (0.20 %) or chlorpyriphos (0.05 %) since they are non toxic to Cryptolaemus.
- Apply granular insecticide aldicarb @ 50 g per vine or phorate 10G @20 gm per vine around the base of the plant.
- Avoid the spraying of insecticides *viz*., malathion, carbaryl, diazinon, dimethoate, monocrotophos, methyl demeton, phasalone, quinolphos, fenitrothion, methyl parathion since they are highly toxic to the predator.

7. Mealybug - *Ferrisia virgata* (Pseudococcidae : Hemiptera)

- **See under tomato**

8. Thrips - *Selenothrips rubrocinctus* Giard. (Thripidae: Thysanoptera)

Damage

- It infests the leaves causing yellowing.

II. Leaf feeders

1. Hairy caterpillar - *Euproctis subnotata* Walker. (Lymantriidae : Lepidoptera)

Damage

- The caterpillar feeds on leaves and floral parts.

2.Leaf roller - *Eucosma rhothia* Meyr. (Eucosmidae : Lepidoptera)

Damage

- The caterpillar rolls the leaves and feeds within the roll.

III. **Borers**

1. Bark eating caterpillar - *Indarbela tetraollis* Moore. (Metarbelidae: Lepidoptera)

Damage

- The larva feeds on the bark under silken galleries which serve as shelter and it also bores into the stem and branches and killing them eventually.

2. Castor capsule borer - *Dichocrocis (=Conogethes) punctiferalis* Guen. (Pyraustidae: Lepidoptera)

Damage

- The larva borers into the central core of the pseudostems resulting in the death of the central spindle causing charactersic "dead heart" symptom.
- In the case of capsules, the caterpillars bore into the immature capsules and feed on the seeds rendering them empty. The caterpillars occasionally tunnel into the panicle also.
- A characteristic indication for the presence of the larvae is the oozing out of excreted frass materials at the mouth of the bore hole, which are very conspicuous on the stem or pods.

Bionomics

- The adult is a medium sized brownish yellow coloured moth with a number of dark spots on the wings.

- It lays eggs on the top leaf axils of young pseudostem.
- The larva bore into the tender parts of the panicle, flower buds and immature capsules only, the later stage larva bore into the stem.
- The full grown larva is measuring 15-25 mm long and it pupates within the larval tunnel inside the pseudostems.
- The life cycle is completed within 25-40 days.

Management

- Collect and destroy the affected plant parts.
- Destroy the alternate host plants from the vicinity of the plantation
- Spray phosalone 3 ml/litre or Dimethoate 0.03 % /lit or quinolphos 4 ml/litre or fenthion 1.25ml / litre of water

3. Fruit borer -*Duedorix isocrates* Fab. (Lycaenidae : Lepidoptera)

Damage

- The larva bores inside the developing fruits and feeds on the pulp and seeds.
- The infested fruits are infected by fungi and bacteria causing fruit rot disease.
- The damaged fruits ultimately fall off and give an offensive odour.
- It causes 40-90 per cent damage to the fruits.

4. Fruit fly - *Bactrocera (= Dacus) diversus* Coq. (Tephritidae : Diptera)

Damage

- The maggot bores into the fruits and feeds on soft pulp.
- The infested fruits show small cavities with dark greenish punctures and when cut open, the wriggling maggots are seen inside.
- It infestation causes rotting and dropping of fruits.

Bionomics

- The adult fly is smoky brown with greenish black thorax having yellow marking.
- It is active throughout the year except severe cooler months.
- It lays the eggs on the soft skin offruits. The egg period is 1-4 days during July.
- The maggot is pale cream in colour, cylindrical in shape measuring 5-8 mm in length.
- The larval stage lasts for 4-5 days. It pupates in soil.
- The pupal period extends from 7 days in August to 13 days in November.
- The adult stage over winters in cooler months.

Management

- Collect and destroy fallen and infested fruits by dumping in a pit and cover with a thick layer of soil or apply lindane 1.3 D over them.
- Plough interspace to expose pupae.
- Encourage parasitoids *Opius compensates* and *Spalangia philippinensis*.
- Use methyl eugenol lure trap (25/ha) to monitor and kill adults or prepare methyl eugenol and malathion 50 EC mixture at 1:1 ratio and use 10 ml mixture / trap.
- Use polythene bag fish meal trap with 5 g of wet fish meal + 1 ml dichlorvos soaked in cotton at 50 traps/ha. Renew fish meal and dichlorvos soaked cotton once in 20 and 7 days respectively.
- Use bait spray combining molasses or jaggery 10g/ 1 and one of the insecticides, fenthion 100 EC 1 ml/, malathion 50 EC 2 ml/1, dimethoate 30 EC 1 ml/1, carbaryl 50 WP 4 g /1, two rounds at fortnight interval before ripening of the fruits.
- Spray hostothion 2ml /litre or malathion at 1 ml/1 four times at 15 days interval.
- Rake the soil around the tree during the pest incidence and apply lindane dust 1.3 % at 25 kg /ha.

IV. Non - insect pests

1. Scarlet mite -*Brevipalpus phoenicis* Geijskes. (Tenuipalpidae : Acarina)

Damage

- Both nymphs and adults suck the cell sap from fruits which resulted in browning of nodal regions, appearance of brown patches on calyx and surface of fruits.
- In severe infestation, it covers the entire surface of fruits leading to splitting of fruits.

Management

- Collect and destroy damaged plant parts.
- Spray wettable sulphur 2 g/ 1 or proporgite 1 ml/litre

Lecture No.14

- **Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Aonla and Jack**

AONLA

I. Leaf feeders

1. Leaf roller - *Caloptilia acidula* (Meyr.) (Gracillaridae: Lepidoptera)

Damage

- Slender greenish caterpillar rolls up apical extremity of leaves and lives within the fold.
- Folded portion is skeletonized and dried up.

Bionomics

- Larvae pupate within leaf fold and pupal period is for 8 to 10 days.
- Larva is cylindrical and yellow with thin scattered hairs.
- Adult is a small brownish moth.

II. Sap feeders

1. Whitefly - *Trialeurodes rara* Singh (Aleyrodidae:Hemiptera)

- Nymphs and adults suck sap by remaining from undersurface of leaves, affected leaves,which show yellowing and turns to brown incolour.
- Whitefly colonies are present on ventral side and they are yellowish in colour.

2. Aphid - *Setaphis bougainvillea* T. (Aphididae: Hemiptera)

Damage

- Both adults and young ones congregate on under surface of leaves and continuously suck the sap and results in yellowing.
- Yellowing of leaves is the symptom of damage caused by colonies of nymphs and adults found on under surface of the leaves.

3. Bug- *Scutelleria nobilis* Fab. (Scutelleridae: Hemiptera)

- Adult is a blue metallic green bug.
- It sucks sap from the leaves and twigs and causes yellowing of leaves.

4. Fruit piercing moth -*Othreis fullonia* and *O.maternal* (Noctuidae; Lepidoptera)

Damage

- Adult moth sucks sap from fruits by making puncture and there is secondary infection and affected fruits rotting and falls down.

Management

- Remove and destroy the weed plants like *Tinospora* and *Cocculus*.
- Remove and destroy damaged fruits.
- Smoke orchards during evening hours to get rid off adults.
- Use light traps at 1 / ha.
- Use poison bait (malathion 0.05% plus fermented molasses or crude sugar and fruit juice to attract and kill adults).

III. Borers

1. Fruit borers - *Deudorix isocrates* (Lycaenidae: Lepidoptera),

Achace janata (Noctuidae: Lepidoptera)

Damage

- Larvae feed on leaves and bore into developing fruits.
- They feed on hard green seeds and damage whole fruit.

IPM

- Collect and destroy damaged fruits.
- Spray monocrotophos 1.25 ml/l.

2. Bark caterpillar - *Indarbela tetraonis* (Metarbelidae; Lepidoptera)

Damage

- It makes tunnels in main trunk and branches. Larvae construct loose irregular webbing of silken thread along with excretory pellets, pieces of bark and frass.
- Infestation results in deterioration of vitality of tree and reduction of yield.

Management

- Keep the orchards clean
- Collect loose and damaged barks and destroy them.
- Kill larvae by inserting thin iron spike or wire into the hole.
- Spot application of 10 ml of monocrotophos or fenthion or methyl parathion / 1 of water.

1. Apical twig gall maker - *Betousa stylophora*

- The pest causes gall formation on stem and shoot.

- The larva of this moth tunnels in the apical portion of the shoot and infested portion bulges into a gall. When the larva is active, reddish gum-like secretion extrudes through a hole at one end.
- Fresh galls are generally formed during the season between June and August. The full size galls measure from 2.3 to 2.5 cm in length and 1 to 1.5 cm in width.
- This pest attack may result in stunted growth of the trees, affecting flowering and fruiting pattern.
- In the initial stage of the infestation, terminal shoots swell in size very soon and full size galls can be seen in the month of September - October.y discouraging the overcrowding of branches, pruning the galls and destroying it along with the pest after harvest is one of the ways of managing the pest attack.
- In the regular case of occurrence, any systemic pesticide may be sprayed in the beginning of the season and will be repeated for every 15 days, if needed.

2. Aphid - *C. emblica*

Damege

- Aphid, *C. emblica* in colonies was found sucking the cell sap from leaflets, tender shoots and green fruits.
- It also secreted large quantity of honey dew which favoured the development of shooty mold affecting vitality of the trees and also quality of the fruits.

Control measure

- The lady bird beetles (*Coccinellids*) were observed predating on this aphid.

5. Mealy bug

Damage twig

- The nymphs were found sucking the cell sap from tender shoots or twigs,
- The infestation was at a very low level.

Control measure

- Generalized predators *viz*., spiders and mantid were observed feeding on this pest on aonla trees.

4. Leaf eating hairy caterpillar - *S. celtis*

Damage

- The pest was found defoliating the leaflets and young twigs.

Biological control

- It was also parasitized by two hymenopterans *viz*., *Cotesia* (*Apanteles*) *sp*. and *Charops sp*.

6. Foliage defoliating weevil - *M. discolor*

JACK

I. **Borers**

1. Shoot and fruit borer - *Margaronia caesalis* Wlk.(Pyraustidae : Lepidoptera)

Damage

- The larva bore into tender shoots, flower buds and developing fruits.
- As a result of attack, wilting of affected shoot, buds dries up and drop down while the fruit start rotting.
- The fallen fruits due to borer damage also serve as a source of the pathogen entry

Bionomics

- The adult moth is brown with grey elliptical patterns on the wings.
- It lays eggs on tender shoot and flower buds.
- The caterpillar is pink with black wart and bright hairs.
- It pupates inside the tunnel.
- The pupae are reddish brown.
- The total life cycle is about 4-5 weeks

Management

- Remove and destroy the affected shoots, flower buds and fruits in the initial stage of the attack.
- Cover the fruits with perforated alkathene bags of convenient size.
- Spray monocrotophos 36 WSC 2ml/ litre or carbaryl 50 WP 0.1 %,4gms
- Spray copper oxychloride at 0.25 % to check if there is fruit rot incidence

2. Bark borer - *lndarbela tetroanis* Moore. (Metarbelidae: Lepidoptera)

Damage

- The larva nibble the trunk or main stem and bore into the same making a short tunnel downwards.
- The excreta and fine chewed wooden particles are thrown out over the holes on trunk and main branches in web masses

3. Stem borer Bark borer - *Batocera rufomaculata* Dejean. (Cerambycidae: Coleoptera)

Damage

- The grubs feed by tunneling through the bark of branches and main stem.
- The damage may also show itself by the shedding of leaves and drying of terminal shoots in early stage of attack.
- When the damage occurs at the main stem, the whole tree succumbs.

Bionomics

- The adult is a large longicorn beetle about 5 cm long and 1.6 cm broad and yellowish brown in colour.
- It has two pink dots and lateral spines on thorax. It lays eggs singly on the bark, or cracks and crevices on the tree trunk or branches hatch in about 1-2 weeks.
- The grub is stout with well-defined segmentation and yellow in colour.
- The grub makes *zig - zag* burrow beneath the bark.

- The grub feeds on the internal tissues and become full fed in about six months.
- It pupates inside the tunnel itself.
- The pupal period is. 19-36 days.

Management

- Remove and destroy the dead trees and affected branches from the garden.
- Swab trunk with carbaryl 20 g/1.
- Use light trap 1 / ha to attract adult moths or beetles.
- Locate bore holes, spike out grubs using a needle or iron wire.
- Exclude the alternative host, silk cotton from mango orchards.
- Grow less susceptible varieties *viz.*, Neelam, Humayudin, and Panchavarnam.
- Swab coal tar + Kerosene (1 :2) on the basal part of the trunk up to 3 feet high after scraping the loose bark to prevent the female from egg laying.
- Spike out the grub if the bore holes are located, and add insecticide emulsion (monocrotophos 0.1 % at 20 ml / hole) a fumigant tablets (3 g aluminium phosphide) or petrol and seal the holes with the mud.
- Follow padding with monocrotophos 36 WSC 10 ml per tree soaked in absorbent cotton when the trees are not in bearing stage.
- Apply carbofurean 3 - 5 g per hole and plug with mud after removing the grub by using needle.
- Apply carbofuran granules in the soil at 75 g / tree basin.

4. Bud weevil - *Ochyromera atrocarpi* M. (Curculionidae : Coleoptera)

Damage

- The grubs bore into tender buds and fruits.
- The infested buds and flowers fall to ground.
- The adult weevil feeds on leaves causing defoliation.

II. Leaf feeders

1. Leaf caterpillar - *Glyphodes bivitralis* Sign. (Pyraustidae : Lepidoptera)

Damage

- The caterpillar feeds on leaves cause defoliation.

2. Leaf webber - *Perina nuda* Fab. (Lymantriidae: Lepidoptera)

Damage

- The caterpillars infest the leaves cause defoliation.

Bionomics

- The adult moth is dimorphic; female with brownish white wings; male with half brownish and half wings.
- The female lays eggs in clusters or rows on the leaves.
- The eggs are pink in colour, cylindrical, round and 0.7 mm long.
- The larval period is 16-20 days. The pupal period last for 5-9 days.
- The total life cycle is completed in 27-39 days.

Management

- Hand pick and destruct the larva in the initial stage of attack.
- Spray monocrotophos 36 WSC 1.5 1.25mllitre or chloropyriphos 20 EC 2.5 ml / litre of water.

III. Sap feeders

1. Lace wing bug - *Stephanitis chariesis* D&M. (Tingidae : Hemiptera)

Damage

- Both nymphs and adults suck the sap from under surface leaves causing yellowing symptom.

2. Spittle bug - *Cosmoscarta relata* D. and *Clovia lineaticollis* M.(Cercopidae : Hemiptera)

Damage

- The nymphs cover the branches with its frothy secretion causing yellowing and drying of terminal shoots.

Management

- Spray methyl parathion 50 EC 2 ml/1ml / litre.
- Dust methyl parathion 2 % or quinalphos 1.5 % at 5 kg per medium sized tree.

3. Aphid - *Greenidia atrocarpi* Westw. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults desap the leaves causing yellowing symptom.

4. Citrus aphid - *Toxoptera aurantii* Boyen. (Aphididae : Hemiptera)

Damage

- Both nymphs and adults suck the sap from leaves causing yellowing of the leaves.

5. Thrips - *Pseudodendrotllrips divivasana* R.K and M. (Thripidae: Thysanoptera)

Damage

- It infests the leaves causing whitish patch on leaves and these patches coalise and turns to yellowing.

6. Mealy bug - *Nipaecoccus viridis* mask Mask. (Pseudococcidae: Hemiptera)

Damage

- Both nymphs and adults desap the tender leaves and shoots.

Bionomics

- The adult female is dark casteneous covered with sticky cretaceous white ovi-sac.
- It lay eggs in ovisacs; which are rounded, cylindrical, and chestnut in colour.
- A single female lays about 200-400 eggs.
- The egg period is 7-10 days.

7. Pink waxy scale - *Ceroplastes rubens* Mask. (Coccidae: Hemiptera)

Damage

- It covers the shoot and fruit in stalk suck sap and excretes honeydew, which develop the sooty mould later.

Lecture No.15

- **Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Grapevine**

I. Sap feeders

1. Leafhopper - *Erythroneura sp* (Cicadellidae: Hemiptera)

Damage

- Both nymphs and adults suck the sap resulting in tiny white spots on the foliage.
- In case of severe infestation, leaves turn yellow, brown and in severe case fall from the vines.

Bionomics

- The leafhopper deposited the eggs on the leaf tissues.
- The eggs are hatched in 14 days. The nymphs are pale in colour and wingless.
- It feeds on the lower surface of leaves and become adults after molting five times.
- The nymphal period is 3-5 weeks. This pest completes 2-3 generations in the season.

2. Grapevine thrips - *Rhipiphorothrips cruentatus* Hood. (Heliothripidae: Thysanotptera)

Damage

- Both nymphs and adults lacerate/scrape the epidermis of leaves and suck the sap due to laceration silvery patches.
- Infest the under surface of leaves and suck the cell sap.

- The infestation resulted in development of silvery white scorchy patches on the leaves.
- The attacked vine either does not bear fruits or the fruit drop off prematurely.
- It lays bean shaped eggs on the under surface of leaves.
- The fecundity of the hopper is 50 eggs per female.
- The eggs period is 3-8 days.
- The nymphs are small yellowish brown in colour.
- The nymphal period last for 9-20 days.
- The pupal period is 2-5 days.
- On emergence of adults both sexual and parthenogenetic reproduction takes place simultaneously.

3. Thrips - *Scirtothrips dorsalis* Hood. (Thripidae: Thysanotptera)

Damage

- Both nymphs and adults infest the tender leaves causing curling and crinkling of leaves. The crop growth stunted and bronzed, the infested buds and flowers become brittle and drops.

Bionomics

- The insect reproduces asexually as well as parthenogenetically. The female thrips inserts the eggs into the veins of leaves. It lays about 40-50 eggs. The nymphs on hatching crawl on to the tender shoot for feeding. It pupates in sheltered places such as leaf axils, leaf curls and base of flowers and fruits. Egg period is 5 days and larval period is 7-8 days. Pre-pupal period is 18-24 hours and pupal period is 48-56 hours. The total life cycle is completed within 10-15 days.

Management

- Inter-crop with agathi Sesbania grandiflora to provide shade which regulates the thrips population.
- Apply carbofuran granules at 200 g /cent area in the nursery.

- Root dip the chilli seedlings in monocrotophos 0.05 % solution for 20 minutes before transplanting gives protection up to 28 days.
- Apply dust formulation of insecticides early in the morning at 25 kg/ha.
- Spray dimethoate 30 EC 2 ml/ litre or formothion 2 ml/ litre thrice at fortnightly intervals.

4. Whitefly - *Aleurocanthus spiniferus* Singh. (Aleyrodidae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from the under surface of leaves causing yellowing symptom.

5. Mealy bug - *Ferrisia virgata* Ckll. (Pseudococcidae: Hemiptera)

- This is the striped mealybug, *Ferrisia virgata* (Cockerell). Notice the very long waxy filaments around the body, the long tails and the presence of two stripes on the body. This species does produce an egg mass or ovisac.
- Fringe heavy & wedge-shaped
- 2 dark stripes on the back
- Body fluid light color
- No ovisac produced
- Anal filaments present and about one-half the length of the body

6. Mealy bug - *Maconellicoccus hirsutus* Green. (Pseudococcidae: Hemiptera)

Damage

- Mealy bugs found on leaves, shoots, nodes, bunch and loose bark of grapevine.

- Infestations of the growing point with mealy bug results in malformation of leaves and shoot tips.
- The greatest damage is done to the fruit bunches. Honey dew secreted by mealy bug nymphs and adults, support the growth of sooty mould on leaves, shoots and branches, sooty and sticky bunches harbouring mealy bugs and their white cottony wax masses tend to be inferior in the market value as table grapes.
- Raisin cannot be prepared from such bunches.
- The quality of the wine is affected.
- In case of severe infestation in the nursery, young vines are often killed.
- The yield loss by mealy bug alone is ranging from 50-100 % in the field.

Bionomics

- The adult females are pinkish and sparsely covered with white wax.
- Each female deposits from 350-500 eggs in a loose cottony terminal ovisac during a week's time.
- The eggs are orange in colour. The egg period is 5-10 days.
- The crawlers are also orange in colour.
- The females have three, while males have four nymphal instars.
- A generation is usually completed in a month but extended in winter months.

Management

- Debark the vines and swab with methyl parathion to minimize the population.
- Apply sticky substances *viz.*, tack-trap or bird tangle foot on the shoot bearing the fruit bunch at a length of 5 cm to keep the bunches free from infestation.
- Release exotic predator *Cryptolaemus montrouzieri* Muls. in grape vine garden @ 1000-1500 beetles per acre (a single predator consumes 900-1500 mealy bug eggs or 300 nymphs in its development)
- Combine the release of predator and spraying of insecticides dichlorovos (0.20 %) or chlorpyriphos (0.05 %) since they are non toxic to Cryptolaemus.
- Apply granular insecticide aldicarb @ 50 g per vine or phorate 10G @20 gm per vine around the base of the plant.

- Avoid the spraying of insecticides *viz*., malathion, carbaryl, diazinon, dimethoate, monocrotophos, methyl demeton, phasalone, quinolphos, fenitrothion, methyl parathion since they are highly toxic to the predator.

7. Hard scale - *Aspidiotus cycloniae* Comst. (Diaspididae: Hemiptera)

Damage

- It infests the grapevine.

8. Coreid bug - *Anoplocnemis phasiana* F. (Coreidae: Hemiptera)

Damage

- Both nymphs and adults feed on tender shoots results in withering and drying up of leaves.

9. Fruit sucking moth - *Othreis fulloniea* Cramer., *O. materna* Linn., and *O. aneilla* Cramer. (Noctuidae: Lepidoptera)

Damage

- The adult moth pierces the fruits for sucking the juice and make characteristic pin-hole damage in fruits.
- The feeding site is easily infected with fungi and bacteria causing rotting and dropping of fruits.

Bionomics

- The adult moth of *E. conjuncta* is faint orange brown having marginal dark bands mixed with white spots on hind wings. *E. materna* has three black spots on the fore wings. *O. ancilla* has white bands in the middle fore wing. *E. fullonica* has tripod black mark in the forewing and curved marking in hind wing.

- The moth is nocturnal in habit.
- It lays eggs on wild plants and weeds in and around the orchard.
- The egg period is about 2 weeks. The larvae is stout, typical semi looper, has a dorsal hump on the last segment of the body.
- The larva passes five instars and completes its larval stage in 4 weeks.
- It pupates for 2 weeks in the dried leaves or in the soil.

Management

- Remove and destroy the alternative weed host plants especially *Tinospora cardifolia*, *Cocculus pendulus* in the vicinity of the orchard.
- Bait with fermented molasses at 100 g + malathion 50 EC @ 10 ml / litre of water.
- Bag the fruit with polythene bags punctured at the bottom individually fruits in small-scale area.
- Create smoke on one side of the field and allow it individual fruits in small¬ scale area.
- Set up light traps or food lures to attract and kill the moths.
- Cover the entire field / orchard with nylon net and spray with contact insecticide.
- Collect and dispose off damaged fallen fruits to prevent further attraction of adults.
- Cover fruits with polythene bags (300 gauge) punctured at the bottom.

- Apply smoke to prevent moth attack.
- Use light traps or food lure (pieces of fruits) to attract moths.

10. Castor semilooper - *Achaea janata* Linn. (Noctuidae : Lepidoptera)

Damage

- The adult moths suck the juice from the fruits causing rotting and dropping of fruits.

II. Leaf feeders

1. Flea beetle - *Scleodonta strigicollis* Mots. (Eumolpidae: Coleoptera)

Damage

- The adult flea beetles bite small holes on tender leaves.
- The grub feeds on roots.

Bionomics

- The adult is shining beetle with a metalic bronze colour and black patches on elytra measuring 4.5mm long.
- The female lays eggs beneath the bark in groups of20-40.
- The fecundity is 220 -569 eggs per female.
- The eggs are hatched in 4-8 days.
- The larval period lasts 34-45 days.
- It pupates in an earthern cell.
- The pupal period is 7-11 days.
- The total life cycle is completed in 52 days.
- The adult hibernates in March and from May onwards they start feeding on tender shoot and leaves.

Management

- Remove the loose bark at the time of pruning and spray phosalone 35 EC 2 ml I litre of water after pruning.

2. Leaf roller - *Sylepta lunalis* Gn. (Pyraustidae: Lepidoptera)

Damage

- The caterpillar rolls up the leaves causing defoliation.

3. Sphinx moth - *Hippotion celerio* L. (Sphingidae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves voraciously and causes severe defoliation

4. Leaf miner - *Phyllocnistis toparcha* Meyr. (Gracillariidae: Lepidoptera)

Damage

- The caterpillar mines into the leaves.

5. Leaf eating caterpillar - *Spodoptera litura* Fab. (Noctuidae: Lepidoptera)

Damage

- Young caterpillars of both the insects bore into the tomato fruits while they mature. The *Helicoverpa* larva remains partly out on the fruit hole while eating, where as the *Spodoptera* caterpillar can be seen remaining wholly inside the fruit. The bore holes are generally plugged with excreta.

Bionomics

- *H.armigera* – The adult moths are marked with characteristic 'V' shaped speck on the light brownish fore wing and a smoky dark border on the hind wing. It lays spherical yellow colour eggs singly on tender parts of plants. It has very high fecundity which may go up to 3000 eggs/female. They hatch 4-8 days and the caterpillars may start feeding on young foliage and later move to the young tomato fruits. There is a remarkable change of colour as the caterpillar passes from one instar to another. It pupates in an earthern cocoon in soil. Pupal period is 10-25 days.

- *S.litura* – The adult moths are stout with grayish brown alternated with white markings on the fore wing while the hind wings are radiantly white with a brown border. The eggs are laid in masses and covered with brown hairs on the surface of the affected leaves. The young caterpillars are voracious and may start feeding on young foliage and finally they migrate to young fruits. Laval period is 2-3 weeks. Pupation takes place in an earthern cocoon in soil.

Management

- Collect and destroy the infested fruits from the field.
- Collect the egg masses of S.litura and destroy them.
- Collect and destroy the larvae of the H.armigera and S.litura.
- Set up light traps to attract and kill the moths of both pests.
- Set up pheromone traps @ 12 / hectare to attract the male moths H.armigera and S.litura.
- Release an egg parasitoid *Trichogramma chilonis* for 6 times @ 50,000 / hectare / week, first release coinciding with flowering time and based on ETL of 4-6 moths / six pheromone traps.

- Spray NPV of H.armigera at 450 LE per hectare + cotton seed kernel powder 300 g/hectare thrice. Each application should be followed by Trichogramma releases.
- Spray NPV of *S.litura* at 250 LE per hectare in the evening hours.
- Prepare poison bait (Rice bran 12 kg/Jaggery 2.5 kg + carbaryl 50 WP 1.25 kg and water 7.5 litres / hectare) and keep the bait in the evening hours to attract the cater pillars of S.litura.
- Grow simultaneously 40 days old America tall marigold and 25 days old tomato seedlings at 1.16 rows.
- Spray endosulfan 35 EC 2 ml / litre or carbaryl 50 WP 2 g/litre or *Bacillus thuringiensis* @ 2 g. / litre or quinolphos 2.5 ml / litre of water.

III. Borers

1. Stem girdler - *Sthenias grisator* Fab. (Cerambycidae: Coleoptera)

Damage

- The grub bores into the bark and tunnels into the dry wood.
- The infestation resulted in wilting of branches and then the entire vine.
- The beetles have the habit of ringing the vines resulting in drying up of the regions beyond the cut.

Bionomics

- The adult beetle is greyish brown with white and brown irregular marking resembling the bark colour, elytra have an elliptical greyish median spot and an eye shaped patch measuring 24 mm long.

- The eggs are thrust in between barks and sapwood in clusters of 2-4 eggs by female beetle, which cuts branches slits under the bark of girdled branch.
- The egg period is 8 days.
- The hatched out grub feed inside the stem and completes its larval stage by 7-8 months.
- The total life cycle occupies more than a year.

Management

- Cut and burn the infested branches below the girdling point.
- Hand picks the beetles and destroys them which may help in migrating this longing horn beetle.
- Swab the trunk with carbaryl 50 WP 4 g / litre of water.

2. Grape vine beetle - *Sinoxylon anale* Lesne. (Bostrychidae: Coleoptera)

Damage

- The grubs and adults cause damage to the grape vine.
- The adult beetle makes circular hole and extending to the center of the stem.
- It constructs longitudinal galleries and forms a number of exist.
- The attacked plant gradually dry and dies away.

Bionomics

- The adult beetle is sturdy, walks slowly and flies rarely.
- The female lays eggs in the tunnels.
- The grub is thickly slightly curved and yellowish white in colour.
- The chewed out materials are thrown out of the holes.

Management

- Remove loose bark, prune and destroy the infested parts to prevent the infestation by the beetle.
- Spray carbaryl 50 WP at 2 kg / ha to the dormant woody portion of the vines.

Lecture No.16

- **Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Ber & Pomegranate**

BER

I. **Borers**

1. Fruit borer - *Meridarchis scyrodes* Meyr. (Carposinidae: Lepidoptera)

Damage

- The caterpillar borers into the fruits feeding on the pulp and accumulating fecal frass within.

Bionomics

- The adult moth is small, dark brown, in colour while the larva is reddish brown in colour.

Management

3. Collect and destroy damaged fruits.
4. Spray malathion 2 ml/1 or dimethoate 1.5 ml /1 at the time of fruit set, two rounds at 15 days interval.

2. Fruit fly - *Carpomyia vesuviana* Costa. (Tephritidae: Diptera)

Damage

- The maggots bore into the pulp forming reddish brown galleries.
- The infested fruits rot and turn dark brown and smell offensively.

Bionomics

- The adult fly is small, black spotted with banded wings.
- It lays creamy white and spindle shaped eggs in cavities made on the fruits by ovipositor.
- Fecundity of the insect is 22 eggs / female.
- The incubation period is 2-3 days.
- The maggots feed on the flesh of the fruit and fully grown in 7-10 days.
- The maggot comes out of fruit by making 1-2 holes in the skin.
- It pupates in soil for 14-30 days.

Management

- Remove and destruct the infested fruits from the ber orchard.
- Incorporate lindane 1.3 % or chlorphyriphos 0.4 % dust 40 kg / hectare to the soil under the tree or near the trees to reduce the fruit fly incidence.
- Cultivate fruit fly resistant varieties such as Safeda Illaichi, Chinese, Sanaur-1, Tikadi and Umran.
- Collect and destroy fallen and infested fruits by dumping in a pit and covering with a thick layer of soil or incorporate lindane 1.3 D 30 g/tree.
- Plough interspaces to expose pupae.
- Encourage parasitoids *Opius compensates* and *Spalangia philippinensis*.

- Use methyl eugenol lure trap (25/ha) to monitor and kill adults of fruit flies or prepare methyl engenol and malathion 50 EC mixture at 1:1 ratio and take 10 ml mixture/trap.
- Use polythene bags fish meal trap with 5 g of wet fish meal + one ml dichlorvos soaked in cotton at 50 traps / ha. Fish meal and dichlorvos soaked cotton should be renewed once in 20 and 7 d respectively.
- Use bait spray combining molasses or jaggery 10 g/ 1 and one of the insecticides, fenthion 100 EC 1 ml/1, malathion 50 EC 2 ml/1, dimethoate 30 EC 1 ml/1, carbaryl 50 WP 4g/1, two rounds at fortnight interval before ripening of the fruits.
- Spray malathion 50 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 or dichlorvos 0.1% at the time of flower formation and fruit set.

II. Leaf feeders

1. Hairy caterpillar - *Thiacidas postica* Walker. (Noctuidae: Lepidoptera)

Damage

- The hairy caterpillar feeds on leaves causing defoliation.

Bionomics

- The adult moth is greyish brown with black double lines on wings. The female moth lays eggs on the lower surface of leaves in batches. A single female can lay up to 318-708 eggs. The incubation period is 5-13 days. The larva is grey brown hairy caterpillar. The larval period is 16-55 days. It pupates in a cocoon for 7-39 days.

Management

- Hand pick egg masses and caterpillars and destroy.
- Use light trap at 1/ha to attract adults.
- Spray lambda cyhalothrin 5 % EC 0.5 ml/1 or malathion 50 EC 2 ml/1 or carbaryl 50WP 2 g/1.

2. Leaf webber - *Psorosticha zizyphi* S. (Oecophoridae: Lepidoptera)

Damage

- The larva webs together leaves causing defoliation.

3. Leaf butterfly - *Tarucus theophrastus* Fab. (Lycaenidae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves.

Bionomics

- The adult butterfly is blue in colour.
- The caterpillar is small, fleshy green, EP: 3-5; LP; 15 and PP: 5-7 days.

4. Tussoc caterpillar - *Dasychira mendosa* Hb. (Lymantriidae : Lepidoptera)

Damage

- The caterpillar feeds leaves causing defoliation.

5. Grey weevil - *Myllocerus transmarinus* Hbst. (Curculionidae : Coleoptera)

Damage

- The adult weevil scrapes and feed on the leaves.

III. Sap feeders

1. Spittle bug - *Machaerota plantiae* (Cercopidae : Hemiptera)

Damage

- The nymphs infest the leaves and feed on them.

2. Mealy bug - *Drosicha mangiferae* Green and *Drosichiella tamarindus* Green.(Margarodidae: Hemiptera)

Damage

- Both nymphs and adults feeds on foliage causing yellowing symptom.

3. Lac insect - *Kerria* (=*Laccifer*) *lacca* Kerr. (Tachardidae : Hemiptera)

Damage

- Both nymphs and adults desap the twigs.

Management

- Collect and burn affected branches after pruning
- Spray methyl demeton 25 EC 1 ml/1.

4. Scale insect - *Aspidiotus orientalis* (Diaspididae : Hemiptera)

Management

- Prune all the infested materials, collect and burn them.
- Spray methyl demeton 25 EC at 2 ml / litre of water.

IV. Non - insect pest

1. Mite - *Phytoptipalpus transitans* (Tenuipalpidae : Acarina)

Damage

- It infests the foliage.

2. Red spider mite - *Eutetranychus banksi* Me Greg. (Tetranychidae : Acarina)

Damage

- It infests the leaves causing scarification of leaves.

POMEGRANATE

I. Sap feeders

1. Thrips - *Rhipiphorothrips cruentatus* Hood. (Thripidae: Thysanoptera)

Damage

- Both nymphs and adults lacerate the tender leaves in the margins and suck the sap from the exuding lacerated material.
- The infestation resulted in silvery white patches on leaves with black excreta leading to yellowing and withering.

Bionomics

- The adult female is dark brown with yellow legs and antennae.
- The male has yellowish abdomen.
- The nymph is reddish in colour.

Management

- Spraying profenophos @ 1ml/lit

2. Mealy bug - *Planococcus lilacinus* Ckll. (Pseudococcidae: Hemiptera)

- Mealybugs are important sucking pests of pomegranate.

Life history

- Adult females are small oval, elongate, soft bodied and wingless, covered with mealywax.
- Of the two common species, *Planococcus citri* is oval, elongate and lays eggs in a fluffy ovisac, while *P.lilacinus* is globose and the eggs are not laid in ovisac.
- The mealy bug lays 100-1000 eggs.
- The females attains maturity in about a month.

Damage

- Mealy bug attack nodes, spikes, berries, tender branches, leaves and roots leading to debilitation of the plant and crop loss. In some cases, the mealy bugs infest the roots.

Influence of weather

- Mealy bug population increases if warm and humid conditions prevail. Continuous monsoon, high humidity and low temperatures are detrimental to mealy bug development. The migration of mealybugs starts in September/October from the ground to the aerial parts of the coffee plant through the main stem. The attack of mealybugs becomes severe during summer and with intermittent showers/irrigation.

Ant association

- Mealybugs produce honeydew and ants are attracted to it. Ants provide sanitation and protection from natural enemies. In the absence of ants the nymphs get trapped in honeydew and the natural enemies activity also increases.

Control measures

- Maintain optimum shade.
- Control ants by dusting Quinalphos 1.5% or methyl parathion 2% or Malathion 5% dust around the base of the bush and shade trees and destroy ant nests.
- Remove and destroy weeds, as many of them harbor the pests.
- Spray the affected patches with Quinalphos 25 EC or Fenitrothion 50 EC @ 300 ml or Fenthion 1000 @ 150 ml or 4 liters of kerosene in 200 litres of water along with 200 ml of an agricultural wetting agent. While

spraying kerosene. The spray solution should be stirred frequently to avoid setting of kerosene. If the root zone is affected, drench it with any one of the above insecticide solutions, except kerosene emulsion.

- Release the parasitoid, *Leptomastix dactylopii* against *P. citri* or the preadtor, *Cryptolaemus montrouzieri* irrespective of the species of mealybugs.

3. Whitefly - *Siphoninus phillyreae* Halidy. (Aleyrodidae : Hemiptera)

Damage

- It infests the lower surface of leaves causing yellowing.

4. Spiralling whitefly - *Aleurodicus dispersus* Russell. (Aleyrodidae : Hemiptera)

- The spiralling whitefly *Aleurodicus dispersus* Russell poses threat to many agricultural and horticultural crops both in the glasshouse and field conditions in India.
- *Aleurodicus dispersus*, native to Caribbean islands and Central America, is reported to occur in North America, South America, Asia, Africa, Australia and several Pacific islands. In India, it was first recorded in 1993 at Thiruvananthapuram, Kerala on tapioca.

Biology

- Eggs are laid in a typical spiral pattern from which the whitefly derives its common name. Female whitefly lays yellowish white eggs, which hatch in

7 days and 4-6 days and 5-8 days. Fecundity ranges from 51.8 to 64.06 eggs/ female. There are four nymphal instars, which are greenish, white and oval.

- The duration of first, second, third fourth instar lasts for 2.15-6.50, 2.7-5.00, 2.9- 5.96 days and 6.5- 8.1 days. Fourth instar nymphs are covered with heavy wax material.
- The total nymphal period normally lasts for 12 to 14 days and pupal period lasts for 2 to 3 days. Development from egg to adult occupies 18 to 23 days and 22.5-29.66 days. Adults are larger with dark reddish brown eyes and fore wings with characteristic dark spots. Adults live for 13 to 22 days.

Host plants

- *Aleurodicus dispersus* is highly polyphagous and is known to attack about 500 plants in different countries and 280 in India alone. The host plants highly preferred by *A. dispersus* in India are tuber crop *viz.*, *Manihot esculenta*, vegetables *viz.*, *Capsicum annum*, *Solanum melongena*, *Lycopersicon esculantum*, *Abelmoschus esculentus*, *Cucurbita maxima*, oil seeds *viz.*, *Arachis hypogaea* and *Ricinis communis*, fibre crop *Gossypium spp*, fruit trees *viz.*, *Psidium guajava*, *Carica papaya*, *Musa spp*., *Punica granatum* and *Terminalia catappa*, ornamentals *viz.*, *Rosa indica*, *Hibiscus spp*., *Acalypha indica*, *Poinsettia pulcherrima*, *Michelia champaca* and shade trees *viz.*, *Ficus religiosa*, *Baunia purpurea*, *Cassia fistula*, *Thespesia populnea*, *Manihot glaziovii* etc.

Damage

- Nymphs and adults congregate generally on the lower surface, but sometimes on the upper surface of leaves of the host plants, stem (cassia) and fruits (papaya) and suck the sap. premature leaf fall and yellowing of leaves in groundnut in Tamilnadu. Yellow speckling, crinkling and curling of the leaves was noted when the infestation was severe on tapioca. The injury caused by heavy infestations was usually insufficient to kill the plants. The copious white, waxy flocculant material secreted by nymphs is readily spread elsewhere by wind and creates a very unsightly nuisance. Furthermore, honeydew is produced which serves as substrate for dense growth of sooty mould, which interfere with photosynthesis.

- The sticky honeydew carried by wind on the flocculant wax adheres to windows and cars and causes considerable annoyances. Complaints were received for allergies and dermatitis.

Management

- Management of polyphagous invasive pests like spiralling whitefly becomes all the more difficult because of the multitude of host plants that grow wild in nature and support the build-up of the pests.

Cultural control

- Use of clean planting material delays the appearance of the whitefly population. Pruning the heavily infested trees and shrubs was recommended to minimise the spiralling whitefly incidence. Subsequent to the pruning the population rapidly increased with in 4-5 months on guava.

Physical control

- Light trap was more appropriate tool for monitoring. A simple method for trapping large number of *A. dispersus* with light traps coated with Vaseline. Fluorescent light smeared with castor oil attracted and trapped large number of adults. Maximum adults were attracted and caught in yellow color sticky trap.

Chemical control

- Application of chemicals to the lower surface of infested leaves thoroughly reduces the whitefly abundance but temporarily. Tobacco extract (4%,) was found effective in minimising the spiralling whitefly. Spraying of neem oil (2%), fish oil rosin soap (4%) and detergent soap solution (5%) reduces the whitefly population. Contact insecticides like malathion and carbaryl at 0.10% were also found effective against young nymphs. Dichlorvos 0.08% was found toxic to various stages of spiralling whitefly.
- Triazophos 0.08% and phosalone 0.07% were equally effective against spiraling whitefly. Application of neem oil 2% and neem seed kernal extract 3% were found to be effective in suppressing the nymphal and adult whitefly population. Troazophos at 0.03% was found to be highly effective against spiralling whitefly Chorpyriphos at 0.04% was found to effective against *A.dispersus*.

Biological control

- Pruning the infested plants is only a temporary measure since the reinfestation starts after some time. Though certain chemicals were recommended, there are certain difficulties in managing pest by chemical means. Synthetic insecticides do not adequately control this whitefly since the nymphs are covered with heavy waxy flocculent materials. Only the adults are susceptible to the insecticidal applications.

- Application of insecticides would temporarily reduce the whitefly abundance. Even if the whitefly is controlled on some plants, there is heavy migration from roadside trees to the cultivated crops. Chemical control is impracticable because of abundance of host plants including extremely large size trees and wide spread distribution. Therefore, alternate methods such as biological control could help in the suppression of *A. dispersus*. As *A. dispersus* is an exotic pest in most countries, classical biological control is considered to be the best option for a sustainable management.
- The aphelinid parasitoids *Encarsia haitiensis* and *Encarsia guadeloupae* have given excellent control of spiralling whitefly in several countries Malaysia, Philippines, Benin, Togo, Ghana, Nigeria Guam, Taiwan, Australia, Hawaii and some other Pacific islands.

5. Aphid - *Aphis punicae* Pass. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults infest the leaves causing curling yellowing of leaves and wilting of terminal shoots and premature fruit drop.

Bionomics

- The aphids are greenish brown in colour.
- The winged as well as wingless form reproduces partheneogenetically and is viviparous.

Management

- Prune and burn the infested as well as water shoots to check the further multiplication.
- Spray dimethoate 30 EC at 1.75 ml or monocrotophos 36 SL at 1 ml or oxymteyl demeton 25 EC at 1 ml or imidachloprid 200 SL at 0.4 ml flitre of water 2 - 3 times at an interval of 10-12 days.
- Apply carbofuron 3 G at 130 g fplant to control this pest effectively.
- Releases of first instar larvae of green lace wing bug. *Chrysoperla carnea* at 15 larvae f flowering branch four times at 10 days interval starting from flower initiation during April.

6.Thrips - *Anaphotrhips oligochaetus* Kerny (Thripidae: Thysanoptera)

Damage

- Nymphs and adults of the species were seen on the under surface of the leaves, on fruits and flowers.
- The lacerating and sucking by the thrips resulted in shriveling of leaves and fruits.
- Scarring of rind was also observed on fruits due to desapping, resulting in decreased marketability of fruits.

II. Leaf feeders

1. Bagworm - *Clania cramari* Westw. (Psychidae: Lepidoptera)

Damage

- The caterpillar scrapes the tissues of leaves causing circular holes on the leaf surface.
- It causes severe defoliation.

Bionomics

- The female moth is apterous, maggot like and the male moth is winged.
- The eggs are laid within the pupal case.
- The larva constructs its case and remaining within it feed on the leaves.
- It becomes full-grown in about five weeks.

2. Hairy caterpillar - *Euproctis fraterna* M.(Lymantriidae :

Lepidoptera)

Damage

- The larva feeds on leaves causes defoliation.

3. Slug caterpillar - *Parasa lepida* Cramer. (Cochlididae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves gregariously in the beginning, subsequently they disperse.
- It causes severe defoliation.

Bionomics

- The adult moth is stout with wing expanse of 4.0 cm and having green wings fringed with brown patches.
- The eggs are laid in batches of 10-15 on the under surface of leaves.
- The eggs are ovals flat scale- like in shape. The fecundity is on an average 167 eggs / female.
- The egg period is 7 days.
- The caterpillar is fleshy, slug-like with yellowish green body bearing a greenish blue stripe dorsally and yellowish green stripes laterally.
- The larval period is 5-6 weeks undergoes seven instars.
- It pupates in a hard shield - like greyish cocoon on the tree trunks for 4-5 weeks.

Management

- Set up light traps to monitor and kill the adult moths.
- Spray the crown with carbaryl 0.1 % (or) dichlorovos 0.02 % or malathion 0.05 % solution.
- In severe cases, root feeding of monocrotophos as explained earlier under leaf eating caterpillar may be taken up with safety precautions.
- Collect all the stages of pests *viz.*, eggs on tree trunks, leaves, larvae during migration stage, pupae in soil and leaf sheath and adult moth during emergence and destruction.
- Organise mass collection campaign involving farmers, school children and college students.
- Spray dichlorovos @ 2 ml / litre using specially designed tractor mounted tall tree sprayer.
- Dust methyl parathion or endosulfan dust @ 1 kg / tree using power operated bellowed crane duster to reach tall trees.
- Encourage the predatory birds to pick up the larval stages.

4. Semilooper - *Achaea janata* Linn. (Noctuidae: Lepidoptera)

Damage

- The semilooper caterpillar feeds on leaves while the adult moth pierces the

5. Ash weevil - *Myllocerus maculosus* Desb. (Curculionidae : Coleoptera)

Damage

- The adult weevil scrapes the chlorophyll content of the leaves causing defoliation.

- fruits with its proboscis for feeding causing injury on the surface of fruits.

III. Borers

1. Anarbutterfly - *Virachola isocrates* Fab. (Lycaenidae: Lepidoptera)

Damage

- The larva bores inside the developing fruits and feeds on the pulp and seeds.
- The infested fruits are infected by fungi and bacteria causing fruit rot disease.
- The damaged fruits ultimately fall off and give an offensive odour.
- It causes 40-90 per cent damage to the fruits.

Bionomics

- The adult butterfly is medium sized with wing expanse of 40-50 mm.
- The female moth is glossy brownish violet while the male is bluish violet in colour.
- The female lays eggs singly on the calyx of flowers and on small fruits.
- The egg period is 7-10 days.
- The young larvae bore into the developing fruits.
- The larval period is completed in 18-47 days. It pupates inside the fruits.
- The pupal period last for 7-34 days.
- It completes four generations per year.

Management

- Grow less susceptible varieties.
- Remove calyx from the fruits to prevent the hatching of eggs and subsequent damage.
- Collect and destroy the infested fruits.
- Cover the fruits with polythene or muslin bags during flowering period to prevent egg laying when fruits are up to 5 cm diametre
- Spray NSKE 5% or neem oil 2% as oviposition deterrent, 2 to 3 times at 15 days interval commencing from flowering and during butterfly activity.

- Adopt ETL (5 eggs / plant with bearing capacity of 60 fruits).
- Release egg parasitoid, *Trichogramma chilonis* at 1 lakh / acre.
- Spray thiochlopril 2 ml/ litre of water.
- Ensure minimum waiting period of 10 days between the day of insecticide application and harvesting of fruits in the field.

2. Fruit borer - *Dichocrocis* (= *Conogethes*) *punctiferalis* Guen. (Pyraustidae: Lepidoptera)

Damage

- The caterpillar occasionally causes the damage by boring into the fruits and feeding on the pulp.

Bionomics

3. Fruit fly - *Bactrocera zonatus* Saund. (Tephritidae: Diptera)

Damage

- The maggot destroy and convert the pulp into a bad smelling, discoloured semi liquid mass unfit for human consumption.
- The infestation results in fruit drop and start rotting from inside.
- On complete rotting of the fruits, the damaged fruit develop yellow spots with black centers through which liquid oozes out on pressing.

Bionomics

- The adult fly is brown or dark brown with hyaline wings and yellow legs.
- The female fly lays eggs in clusters of 2-15 just beneath the skin of the ripening fruits.
- A single female lays up to 200 eggs during oviposition period of one month.

- The egg period is 22-23 days.
- The maggot feeds on pulp and become full grown in about 7 days.
- It pupates 3-7 inches below the soil.

Management

- Plough the interspaces to expose the pupae during the off - season.
- Collect and destroy the fallen fruits.
- Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/ 1 litre of water + 1 ml of Malathion solution. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the adult flies.
- Conserve parasitoids like *Optius compensates* and *Spalangia philippinensis.*
- Use bait spray combining molasses or jiggery 10g/1 and one of the insecticides, fenthion 100 EC 1 ml/1, malathion 50 EC 2 ml/1, dimethoate 30 EC 1 ml/1, carbaryl 50 WP 4g/1, two rounds at fortnightly intervals before ripening of the fruits.
- Spray fenthion 2 ml / litre or Malathion 2 ml / litre of water.

IV. Non - insect pests

1. Eriophyid mite - *Aceria granati* Can and Massal. (Eriophyidae: Acarina)

Damage

- Both nymphs and adults live inside the rolls at the edges of leaves.

- The infested leaves become linear and deformed.

2. Red spider mite - *Tetranychus punicae* Hirst. (Tetranychidae: Acarina)

Damage

- It infests the leaves from the under surface of leaves causing yellowing and dropping of leaves.

Lecture No.18

Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Fig and Star gooseberry

FIG

I. Leaf feeders

1. Wild silk worm - *Opcinara varians* Wlk. (Bombycidae: Lepidoptera)

Damage

- The caterpillar defoliates the trees.

Bionomics

- The adult moth is pale whitish.
- The full-grown larvae are smooth, pale grey in colour measuring 30 mm long.

2. Leaf caterpillar - *Glyphodes phyloalis* W. (Pyraustidae: Lepidoptera)

Damage

- The larva infests the leaves causing defoliation.

3. Hairy caterpillar - *Hypsa ficus* F. (Hypsidae: Lepidoptera)

Damage

- The larva defoliates the trees.

Bionomics

- The adult moth is yellow with black dots on the wings.
- The caterpillar is about 25 mm long, black in colour with yellowish brown warts bearing white hairs.
- It pupates in soil.

Management

- Collect and destroy damaged leaves along with larvae.
- Use light trap @ 1 / ha to attract and kill adults.
- Spray monocrotophos 36 WSC 2 ml /litre or malathion 50 EC 0.1%.

4. Leaf roller - *Phycodes radiata* Ochs and *P. minor* Moore. (Glyphipterygidae : Lepidoptera)

Damage

- The caterpillar rolls the leaf and feeds within.

Bionomics

- The adult moth is greyish brown in colour.
- The eggs are laid singly or in batches of 2-15 on either side of leaves.
- The egg period is 4-6 days. The caterpillar of *F. radiata* is yellowish-white with a dark stripe on each side, while the caterpillar *F. minor* is light green with yellow shiny head.
- The larval period is 30-35 days.
- It pupates within the leaf fold for 8 - 10 days.

4. Leaf roller - *Phycodes radiata* Ochs and *P. minor* Moore. (Glyphipterygidae : Lepidoptera)

Damage

- The caterpillar rolls the leaf and feeds within.

Bionomics

- The adult moth is greyish brown in colour.
- The eggs are laid singly or in batches of 2-15 on either side of leaves.
- The egg period is 4-6 days. The caterpillar of *F. radiata* is yellowish-white with a dark stripe on each side, while the caterpillar *F. minor* is light green with yellow shiny head.
- The larval period is 30-35 days.
- It pupates within the leaf fold for 8 - 10 days.

II. Sap feeders

1. Spittle bug - *Cosmoscarta niteara* D. (Cercopidae : Hemiptera)

Damage

- The nymphs infest the leaves of fig.

2. Psyllid bug - *Pauropsylla depressa* C. (Psyllidae : Hemiptera)

Damage

- The nymphs and adults desap the leaves producing galls on the leaves.

3. Mealy bug - *Drosicha mangiferae* Green. (Margarodidae : Hemiptera)

Damage

- Both nymphs and adults desap the leaves.

4. Mealy bug - *Planococcus lilacinus* Ckll. (Pseudococcidae : Hemiptera)

Damage

- It infests foliage causing yellowing symptom.

5. Hard scale - *Aspidiotus cycloniae* C. (Diaspididae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from leaves and tender twigs.

6. Thrips - *Gigantothrips elegans* Z. (Phloeothripidae : Thysanoptera)

Damage

- Both nymphs and adults desap the tender leaves and results in curling and drying up of the same.

III. Borers

1. Mango stem borer - *Batocera rufomaculata* Dejean. (Cerambycidae : Coleoptera)

Damage

- The larva tunnel into the main stem or branches and makes *zig - zag* tunnels in the wood.

- The tunnels interfere the sap flow affecting the foliage and fruit production.
- In severe cases, the infested trees ultimately dry and dies.

Management

- Keep orchards clean.
- Collect loose and damaged barks and destroy them.
- Kill grubs by inserting a thin iron spike or wire into the hole.
- Spot application of 10 ml of monocrotophos or fenthion or methyl parathion diluted in 1 1 of water.

2. Fruit fly - *Dacus (= Strumeta) dorsalis* Hend. (Tephritidae : Diptera)

Damage

- The maggot destroy and convert the pulp into a bad smelling, discoloured semi liquid mass unfit for human consumption.
- The infestation results in fruit drop and start rotting from inside.
- On complete rotting of the fruits, the damaged fruit develop yellow spots with black centers through which liquid oozes out on pressing.

Bionomics

- The adult fly is brown or dark brown with hyaline wings and yellow legs.
- The female fly lays eggs in clusters of 2-15 just beneath the skin of the ripening fruits.

- A single female lays up to 200 eggs during oviposition period of one month.
- The egg period is 22-23 days. The maggot feeds on pulp and become full grown in about 7 days.
- It pupates 3-7 inches below the soil.

Management

- Plough the interspaces to expose the pupae during the off - season.
- Collect and destroy the fallen fruits.
- Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/ 1 litre of water + 1 ml of Malathion solution. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the adult flies.
- Conserve parasitoids like *Optius compensates* and *Spalangia philippinensis*.
- Use bait spray combining molasses or jiggery 10g/1 and one of the insecticides, fenthion 100 EC 1 ml/1, malathion 50 EC 2 ml/1, dimethoate 30 EC 1 ml/1, carbaryl 50 WP 4g/1, two rounds at fortnightly intervals before ripening of the fruits.

3. Fig midge - *Anjeerodiplosis peshawaransis* Mani.(Cecidomyiidae : Diptera)

Damage

- The maggot bores inside the fruit and feeds on the pulp within.
- The infested fruits become hard, and deformed.
- The damaged fig ultimately shrivels, withers and dropped down prematurely.

Bionomics

- The adult fly is small, light brown in colour with small head and bear two jointed antennae.
- The female fly lays minute, oval, pedicellate eggs on one week old fruit.
- The eggs are laid in cluster of 10 eggs.
- The egg period is 3 days.
- The maggot is creamy white in colour.
- The larval period is 3-4 weeks.
- The maggot drop down to the soil for pupation.
- The pupal period lasts 10-26 days.

Management

- Collect damaged fruits along with maggots and destroy.
- Rake up soil to expose pupae and apply lindane 1.3 D at 25kg/ha.
- Spray dimethoate 30 EC 2 ml/ litre or malathion 50 EC 0.1%.

STAR GOOSE BERRY

I. Sap feeders

1. Aphid - *Setaphis bongainis* (Aphididae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from the leaves causing yellowing symptom.

2. Whitefly - *Trialeurodes rara* Singh. (Aleyrodidae: Hemiptera)

Damage

- The colonies of whitefly desap the leaves from the ventral surface causing yellowing of leaves in patches on the corresponding upper surface.

3. Bug - *Scutellera nobilis* Fab. (Scutelleridae : Hemiptera)

Damage

- Both nymphs and adults nymphs and adults suck the sap from leaves and cause yellowing symptoms.

4. Mealy bug - *Ferrisia virgata* Ckll. (Pseudococcidae : Hemiptera)

Damage

- Both nymphs and adults desap the leaves causing yellowing.

II. Leaf feeders

1. Leaf roller - *Caloptilia (=Gracillaria)* acidula (Gracillaridae: Lepidoptera)

Damage

- The caterpillar rolls the leaves and feed on them causing defoliation.

Bionomics

- The adult moth is small brownish in colour.
- The larva is cylindrical yellow with thin scattered hairs.

Lecture No.19

Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Custard Apple and Wood Apple

CUSTARD APPLE

I. Borers

1. Fruit borer - *Heterographis (= Anonaepestis) bengalella* Rogonot. (Phycitidae: Lepidoptera)

Damage

- The larva bores into the fruits making irregular tunnels.
- The development of fruits is arrested and fruits fall down.
- The bore holes on fruits are plugged with excreta.

Bionomics

- The female moth lays eggs singly in the sutures or on the peduncle of immature fruits.
- The egg period is 4-5 days.
- The larva bores inside the fruits.
- The larval period is 12-19 days.
- It pupates in the tunnels within the fruits.
- The pupal period lasts in 12 days.

Management

- Collect and destroy damaged fruits.
- Spray thiodicarb 2 ml/ litre or malathion 0.1% two times once at flower formation and second at fruit set.

2. Fruit fly - *Dacus zonatus*. Saund. (Tephritidae: Diptera)

Damage

- The maggot destroy and convert the pulp into a bad smelling, discoloured semi liquid mass unfit for human consumption.
- The infestation results in fruit drop and start rotting from inside.
- On complete rotting of the fruits, the damaged fruit develop yellow spots with black centers through which liquid oozes out on pressing.

Bionomics

- The adult fly is brown or dark brown with hyaline wings and yellow legs.
- The female fly lays eggs in clusters of 2-15 just beneath the skin of the ripening fruits.
- A single female lays up to 200 eggs during oviposition period of one month.
- The egg period is 22-23 days.
- The maggot feeds on pulp and become full grown in about 7 days.
- It pupates 3-7 inches below the soil.

Management

- Plough the interspaces to expose the pupae during the off - season.

- Collect and destroy the fallen fruits.
- Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/ 1 litre of water + 1 ml of Malathion solution. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the adult flies.
- Conserve parasitoids like *Optius compensates* and *Spalangia philippinensis*.
- Use bait spray combining molasses or jiggery 10g/1 and one of the insecticides, fenthion 100 EC 1 ml/1, malathion 50 EC 2 ml/1, dimethoate 30 EC 1 ml/1, carbaryl 50 WP 4g/1, two rounds at fortnightly intervals before ripening of the fruits.

II. Sap feeders

1. Striped mealy bug - *Ferrisia virgata* Cockerell. (Pseudococcidae: Hemiptera)

Damage

- Both nymphs and adults cover on the fruits and suck the sap causing shriveling and dropping of fruits.

Management

2. Collect and destroy mealy bug infested leaves, shoots and fruits.
3. Spray dichlorovos 0.05%, two times first at new flush and shoot formation and second at fruit set by using fish oil rosin soap 25 ml/litre.
4. Release *Cryptolaemas montrouzieri* @ 10 beetles per tree.

2. Mealy bug - *Maconellicoccus hirsutus* Green (Pseudococcidae: Hemiptera)

Damage

- Pinkish nymphs and adults desap the fruits causing the shriveling and dropping of fruits.

WOOD APPLE

I. Borer

1. Wood apple borer - *Euzophera plumberijascilla* (Phycitidae: Lepidoptera)

Damage

- The caterpillar bores into the fruits and feeds on the pulp causing fruit drop.

2. Fruit borer - *Argyroploce illipida* Meyr. (Eucosmidae : Lepidoptera)

Damage

- The larva bores into the fruits causing fruit drop.

Lecture No. 20

Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Jamun, Pineapple, Papaya and Tamarind

JAMUN

1. Psyllid - *Trioza jambolanae* C. (Psyllidae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from the leaves causing yellowing and malformation.

2. Whitefly - *Dialeurodes eugeniae* M. (Aleyrodidae: Hemiptera)

Damage

- It infests the leaves in seedlings causing yellowing and malformation

3. Thrips - *Leeuwenia ramakrihmae (=karyani)*R. (Thripidae :Thysanoptera)

Damage

- Both nymphs and adults lacerate the leaves and suck the sap causing yellowing with silvery patches on leaves.

1. Leaf miner - *Acrocercops telestis* Meyr. (Gracillaridae : Lepidoptera)

Damage

- The caterpillar mines into the leaves causing blister like swelling on upper surface of leaves.

2. Leaf webber - *Argyroploce aprobola* Meyr. (Eucosmidae : Lepidoptera)

Damage

- The larva webs together the leaves at the shoot tips and feeds within the web causing defoliation.

3. Purple winged moth - *Bombotelia delatrix* Gr. (Noctuidae : Lepidoptera)

Damage

- The caterpillar infests the leaves and causes defoliation.

Bionomics

- The adult moth is brownish black in colour.
- The female lays eggs singly on leaves.
- The incubation period is 3-4 days.
- The larva is green and takes 12-14 days to become full grown.
- It pupates in a cocoon for 13 days.

4. Looper - *Thalassodes flavifusata* Wlk. (Geometridae : Lepidoptera)

Damage

- The caterpillar feeds on tender foliage causing defoliation.

Bionomics

- The female moth lays eggs in small groups on the edges of tender leaves.
- A single female lays 20-30 eggs.
- The egg period is 2-3 days.
- The larva is greenish in colour measuring 3.8 cm long.
- The larval period is 17¬18 days.
- It pupates within rolled up leaves for 7-8 days.

Management

- Collect and destroy damaged leaves.
- Use light trap at 1/ha to attract and kill adults.
- Spray phaslone 2 ml/1 or malathion 50 EC 2 ml/1.

1. Fruit fly - *Dacus correctus* Bezzi. (Tephritidae: Diptera)

Damage

- The maggot feeds on pulp of fruit and cause rotting and dropping of fruits.

2. Bark caterpillar - *Indarbela tetraonis* Moore. (Metarbelidae : Lepidoptera)

Damage

- The caterpillar bores inside the stem making irregular galleries which interfere the translocation of cell sap.
- The growth of the plant remains stunted and the fruiting capacity is drastically reduced.

Bionomics

- The adult moth is stout, pale brown moth with wavy marking on the wings.
- The female lays eggs in groups in cracks and crevices on the bark.
- The egg period is 8-10 days.
- The larva is brownish in colour measuring 3.8 mm long.
- Pupation takes place in the galleries for 3-4 weeks.
- It has only generation per year.

1. Red spider mite - *Oligonychuszus mangiferae* Rah and Sap. (Tetranychidae: Acarina)

Damage

- It infests the leaves of Jamun trees.

PINEAPPLE

1. Rhinoceros beetle - *Oryctes rhinoceros* Linn. (Scarabaeidae: Coleoptera)

Damage

- The adult beetles bores into the stem causing wilting of plants.

Management

- Remove and destroy damaged plants.
- Collect and destroy various bio-stages from manure pits.
- Mix entomogenous fungal culture of *Metarhizium anisopliae* in the manure pits during cooler months to attack grubs.

- Encourage Reduviid bugs, *Platymeris laevicollis* to attack adults.
- Hook out and kill adults from the base of stems.
- Set up light traps following first rains in summer and monsoon period to attract adults.
- Soak castor cake at 1 kg in 5 1 of water in small mud pots and keep them in the pineapple garden to attract the adults.
- Use Rhinolure vane trap for attracting adults.

1. Thrips - *Thrips tabaci* Lind. (Thripidae : Thysanoptera)

Damage

- The nymphs and adults which shelter between the leaf sheaths and stems lacerate the epidermis and suck the exuding sap.
- The affected leaves exhibit silvery which blotches leading to distortion, wilting and drying from tip down wards.
- The seedlings show retarded growth.
- The bulbs remain undersized and appear distorted in shape.

Bionomics

- It reproduces parthenogenetically.
- The adult female inserts the eggs into the tender leaves.
- The egg period is 10-15 days.
- The nymphs and adults are yellow in colour.
- The nymphal period is 4-6 days.
- It pupates in soil. The pupal period is 3 days.

- The pest undergoes 10 generation per year.

Management

- Grow resistant varieties *viz*., White Persian, Grano, Sweet Spanish, and Crystal wax.
- Use neem coated urea which reduce the infestation of pest.
- Set up sky-blue colour sticky traps which attract more adults than yellow colour traps.
- Spray methyl demeton or dimethoate at 1 ml/litre or monocrotophos 1 ml/litre with teepol 0.5 ml/litre of water.

2. Mealybug -*Dysmicoccus brevipes* Cockerell. (Pseudococcidae : Hemiptera)

Damage

- Both nymphs and adults desap the leaves and fruits result yellowing of leaves and shriveling of fruits.

Management

- Cultivate resistant varieties like Red Spanish and Queen.
- Collect planning material from unaffected plantations.
- Remove basal brownish leaves of cured planting materials at the time of planting
- Dip basal portion of planting material in methyl parathion 0.2% solution as a prophylactic measure.

- Apply phorate 10 G at 17.5 kg/ha at 100-125 days interval in the affected plantations.

PAPAYA

1. Milk weed grasshopper - *Poecilocerus pictus* F. (Acrididae: Orthoptera)

Damage

- Both nymphs and adults feed on leaf voraciously and cause severe defoliation.
- In the case of severe infestation, it feeds on the bark of the plant.

Bionomics

- The female thrusts its abdomen deep into the soil and lay eggs to a depth of 18-20 cm.
- A single female lays about 145-170 eggs.
- The eggs are elongate and orange in colour.
- The eggs are covered by frothy secretion, which hardens later on.
- The egg period is 30 days. The nymphal period is 60 days.
- It becomes adult in another 75 days.

2. Grey weevil - *Myllocerus subfasciatus* G.M., *M.discolor* Fab and *M.viruidu* Fab. (Curulionidae: Coleoptera.)

Damage

- Adult weevil cause notching of leaf margins. Grub feeds on roots resulting wilting of plants.

Bionomics

- *M.Subfasciatus* – Brownish weevil;
- *M.discolor* – Brown with white spot on elytra; .
- *M.viridanus* – Small light green weevil.

Management

- Collect & destruct the adult weevils
- Apply carbofuran 3 G at 15 kg/hectare at 15 days after planting.
- Dust lindane 1.3D at 25kg/ha to kill grubs.
- Spray carbaryl 50WP at 2g/1 on plants.

1.Whitefly *Bemesia tabaci* Genu. (Aleyrodidae: Hemiptera)

Damage

- Both nymphs and adults feed on cell sap from leaves causing chlorotic sopts and yellowing and drying of leaves.
- Pre-mature defoliation, yellowing and sooty mould are typical symptoms.

Bionomics

- Adults are minute with yellow body covered with white waxy bloom.
- Stalked eggs are laid on the undersurface of leaves.
- EP: 3-5 days; NP: 9-14 days during summer, EP:5-33 days ; NP:17-33 days during winter. PP: 2-8 days. LC: 14-107 days.

Management

- Avoid growing of brinjal in summer if the whitefly is a serious problem in that area.
- Adopt crop rotation using non-host like cereals which helps to reduce whitefly population.
- Remove alternative hosts and weed hosts.
- Use nitrogenous fertilizers judiciously to avoid excessive growth.
- Set up yellow sticky traps @ 12 per hectare to manage whitefly
- Avoid the usage of resurgence causing insecticides *viz*., pyrethriods, dimethoate, endosulfan, phosalone and monocrotophos.
- Use entomophopathogenic fungus, *Paecilomyces farinosus*.
- Spray fish oil rosin soap @ 1 kg in 40 litre of water + teepol.
- Spray dimethoate @ 1 0:1 or malathion 2 ml or methyl demeton 1 ml or triazophos 1.5 ml / litre of water.

2. Green peach aphid - *Myzus persicae* Sulz. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults desap the leaves.
- As a result of infestation, leaves get curled and crinkled, coated with honeydew and sooty mould.
- It acts as a vector for the disease "Papaya mosaic virus".

Management

- Remove and destroy damaged plant parts along with nymphs and adults.

- Encourage parasitoid, Aphelinus mali and predators, Coccinella septumpunctata and Ballia eucharis.
- Spray dimethoate 0.03% or methyl demeton 0.025%.

3. Aphid - *Aphis gossypii* Glover. (Aphididae: Hemiptera)

Damage

- It is a potential pest on cotton infesting tender shoots and under surface of the leaves.
- They occur in large numbers suck the sap and cause stunted growth, gradual drying and result in death of the plants.
- Development of black sooty mould due to the excretion of honey dew giving the plant a dark appearance.
- Being a polyphagous pest, it is recoreded in brinjal, bhendi, chillies,guava and gingelly.
- Curling and crinkling of leaves are typical symptoms.

Bionomics

- Yellowish or greenish brown nymphs found on the under surface of leaves.
- They are often attended by ants for the sweet honey dew secretion.
- Winged forms may be seen under crowded conditions.

4. Coconut scale - *Aspidiotus destructor* Sign. (Diaspididae: Hemiptera)

Damage

- The nymphs and adult desap the leaflets resulting yellowing, withering and drying up of leaflets.

Bionomics

- It is circular hard scale occurs as persistent pest of coconut.
- A female lays up to 90 eggs under its shield like scale.
- The crawlers move out and distribute themselves to health leaf lets.
- The life cycles 3.2 days for male and 35 days of female.

1. Fruit fly - *Dacus diversus* Coq and *D.cucurbitae* (Tephritidae: Diptera)

Damage

- The maggot tunnel into the fruits and cause rotting and pre-mature fall of the developing fruits. The fly seems to prefer green and tender fruits of pumpkin as it is not able to pierce the hard rind of some other fruits.
- The infested fruits can easily be recognized by the distortion or rotting area around the site of oviposition.
- Sometimes the young maggot can also be seen eating on the flowers and rarely they may feed on the curcurbit veins with consequent formation of galls.
- It attacks all fruits of cucurbitaceous besides attacking tomato, chillies, brinjal, papaya, guava, peach, dates, citrus etc.

Bionomics

- The adult of *B.cucurbitae* a reddish brown fly with lemon yellow curved vertical markings on the thorax and fuscous shading on outer margins of wings *B. ciliates* smaller than *B.cucurbitae*.
- It thrusts 5 to 15 cylindrical white eggs singly or in groups into flowers or tender fruits.
- The fly makes a number of punctures with her ovipositor before the eggs are laid. A resinous secretion ooze out from the injured fruit to repair the punctures.
- The eggs hatch out in 1 to 9 days liberating small, dirty white apodous maggots and become full grown in 3-21 days.
- Pupation takes place in soil.
- Some time it may pupate in the fruit itself.
- Pupal period is 3-9 days in summer and 30 days in winter.
- The adults are free living on flower vector and can very often be seen congregating on the undersurface of the leaves during morning hours.

Management

- Remove and dispose ripe fruits from trees and ground to suppress fruit fly population.
- Use methyl eugenol traps to attract and kill adult flies.
- Cover fruits with a semi-permeable shrink-wrap film.
- Spray fenthion 1 ml/1 or malathion 2 ml/1 on semi-ripe fruits.

1. Red spider mite - *Tetranychus telarius* L. (Tetranychidae:

Acarina)

Damage

- It infests the under surface of leaves and occasionally on fruits. Both nymphs and adults remain the protected web and suck the sap resulting yellowing of leaves.

2. Papaya Mealybug -*Paracoccus marginatus*

- The papaya mealybug, *Paracoccus marginatus* is a small hemipteran that attacks several genera of host plants, including economically important tropical fruits and ornamentals.
- The papaya mealybug was discovered in Manatee and Palm Beach counties in Florida in 1998 and subsequently spread rapidly to several other Florida countries.
- It potentially poses a multi-million dollar threat to numerous agricultural products in Florida, as well as other states, if not controlled.
- Biological control was identified as a key component in a management strategy for the papaya mealybug, and a classical biological control program was initiated as a joint effort between the US Department of Agriculture, Puerto Rico Department of Agriculture, and Ministry of Agriculture in the Dominican Republic in 1999.

Distribution

- The papaya mealybug is believed to be native to Mexico and/or Central America.

- It has never gained status as a serious pest there, probably due to the presence of an endemic natural enemy complex.
- The first specimens were collected in Mexico in 1955.
- The papaya mealybug was described in 1992 from the Neotropical Region in Belize, Costa Rica, Guatemala, and Mexico.
- When the papaya mealybug invaded the Caribbean region, it became a pest there; since 1994 it has been recorded in the following 14 Caribbean countries: St.Martin, Guadeloupe, St. Martin, Guadeloupe, St.Batthelemy, Antigua, Bahamas, British Virgin Islands, Cuba, Dominican Republic, Haiti, Puerto rico, Montserrat, Nevis, St. Kitts, and the U.S. Virgin Islands. More recently, specimens have turned up in the Pacific regions of Guam and the Republic of Palau.
- The papaya mealybug was discovered in Bradenton, Florida in 1998 on hibiscus. By January 2002, it had been collected 80 times on 18 different plant species in 30 cities throughout Alachua, Brevard, Broward, Collier, Dade, Hillsborough, Manatee, Martin, Monroe, Palm Beach, Pinellas, Polk, Sarasota, and Volusia counties.
- Specimens also have been intercepted in Texas and California, and it is expected that papaya mealybug could rapidly establish throughout Florida and through the Gulf states to California.
- It is possible that certain greenhouse crops could be at risk in areas as far north as Delaward, New Jersey and Maryland.
- It has already been identified on papaya plants in the Garfield Conservatory in Chicago, Illinois in late August of 2001.

- A biological control program was implemented in December of 2001 with very successful results.

Description

- Papaya mealybug infestations are typically observed as clusters of cotton-like masses on the above-ground portion of plants.
- The adult female is yellow and is covered with a white waxy coating. Adult females are approximately 2.2 mm long (1/16 inch) and 1.4 mm wide.
- A series of short waxy caudal filaments less than ¼ the length of the body exist around the margin.
- Eggs are greenish yellow and are laid in an egg sac that is three to four times the body length and entirely covered with white wax.
- The ovisac is developed ventrally on the adult female.
- Adult males tend to be colored pink, especially during the pre-pupal and pupal stages, but appear yellow in the first and second instar.
- Adult males are approximately 1.0 mm long, with an elongate oval body that is widest at the thorax (0.3 mm), Adult males have ten-segmented antennae, a distinct aedeagus, lateral pore clusters, a heavily sclerotized thorax and head, and well-developed wings.
- Two characteristics that are important in distinguishing P.marginatus adult females from all other species of Paracoccus are: the presence of oral-rim tubular ducts dorsally restricted to marginal areas of the body, and the absence of pores on the hind tibiae.

- Adult males may be distinguished from other related species by the presence of stout fleshy setae on the antennae and the absence of fleshy setae on the legs.
- The papaya mealybug can easily be distinguished from Maconellicoccus marginatus (Green), the pink hibiscus mealybug, because papaya mealybug females have eight antennal segments, in contrast to nine in the latter species.
- Specimens of papaya mealybug turn bluish-black when placed in alcohol, as is characteristic of other members of this genus.

Biology

- Details on the biology and life cycle of the papaya mealybug are lacking.
- In general, mealybugs have piercing-sucking mouthparts and feed by inserting their mouthparts into plant tissue and sucking out sap. Mealybugs are most active in warm, dry weather.
- Females have no wings, and move by crawling short distances or by being blown in air currents.
- Females usually lay 100 to 600 eggs in an ovisac, although some species of mealybugs give birth to live young.
- Egg-laying usually occurs in about 10 days, and nymphs, or crawlers, begin to actively search for feeding sites.
- Female crawlers have four instars, with a generation taking approximately one month to complete, depending on the temperature.

- Males have five instars, the fourth of which is produced in a cocoon and referred to as the pupa.
- The fifth instar of the male is the only winged form of the species capable of flight.
- Adult females attract the males with sex pheromones. Under greenhouse conditions, reproduction occurs throughout the year, and in certain species may occur without fertilization.

Host Plants

- The papaya mealybug is polyphagous and has been recorded on > 55 host plants in more than 25 genera. Economically important host plants of the papaya mealybug include papaya, hibiscus, avocado, citrus, cotton, tomato, eggplant, peppers, beans and peas, sweet potato, mango, cherry, and pomegranate.

Damage

- The papaya mealybug feeds on the sap of plants by inserting its stylets into the epidermis of the leaf, as well as into the fruit and stem.
- In doing so, it injects a toxic substance into the leaves.

- The result is chlorosis, plant stunting, leaf deformation, early leaf and fruit drop, a heavy build up of honeydew, and death.
- Heavy infestations are capable of rendering fruit inedible due to the buildup of thick white wax.
- Papaya mealybug has only been recorded feeding on areas of the host plant that are above ground, namely the leaves and fruit.

Management

Chemical control

- A number of chemical controls are available to control mealybug, although none are currently registered specifically for control of papaya mealybug. Active ingredients in registered pesticide formulations include acephate, carbaryl, clorpyrifos, diazinon, dimethoate, malathion, and white mineral oils.
- Typically, twice the normal dose is applied when treating for mealybugs because mealybugs are protected by thick waxy, cottony sacs, and often are concealed inside damaged leaves and buds.
- Thus, chemical controls are only partially effective and require multiple applications. Furthermore, problems with insecticide resistance and non-target effects on natural enemies make chemical control a less desirable control option to combat the papaya mealybug.

Biological control

- Natural enemies of the papaya mealybug include the commercially available mealybug destroyer (*Cryptolaemus montrouzieri*), lady beetles, lacewings, and hover flies, all which are generalist predators that have a potential impact on mealybug populations. In addition to predators, several parasitoids may attack papaya mealybug.
- In 1999, the USDA Animal and Plant Health Inspection Service (APHIS) and USDA Agricultural Research Station (ARS) initiated a classical biological control program for the papaya mealybug.
- Four genera of encyrtid endoparasitoid wasps specific to mealybugs were collected in Mexico by USDA and ARS researchers and Mexican cooperators as potential biological control agents:
- *Acerophagus papaya* @ 100 numbers / small village as inculative release, *Anagyrus californicus* Compere, and *Pseudaphycus sp*. A fifth collected species was later reared and identified as *Pseudleptomastix Mexicana*.
- All four species were screened in USDA/ARS quarantine facilities in Newark, Delaware and environmental assessments were completed. Specimens were then shipped to Puerto Rico where they were cultured and mass-reared for experimental release in Puerto Rico and the Dominican Republic.
- The first releases of these four parasitoids were made in Florida in October 2000.

- To date, APHIS has found that the release of the four genera of parasitoid wasps has brought a 99.7% reduction in the density of mealybug populations at research sites in the Dominican Republic, and a 97% reduction at research sites in Puerto Rico, with parasitism levels between 35.5% and 58.3%.
- All four species of parasitoids have been observed attacking second and third instars of *P.marginatus*. However, *Acerophagus sp*. emerged as the dominant paraditoid species in both Puerto Rico and the Dominican Republic.
- The outcome of releases of the four parasitoids in Florida is yet to be determined as of March 2003.

TAMARIND

1. Tamarind fruit borer - *Phycita orthoclina* Meyr. (Phycitidae : Lepidoptera)

Damage

- The larva bore into the tender fruits and feeds on the pulp. The infestation makes the fruit unfit for consumption.

Bionomics

- A female moth lays up to 190 eggs in about 3 days on the pulp inside the hard shelled pods through cracks and crevices found on them.
- The incubation period is 4 - 5 days.
- The larvae bore into the pulp and remain in a silken web.

- The larval period is 27 - 40 days.
- It pupates in a silken cocoon inside the infested pod.
- The adult emerges in about 6-8 days.

2. Anar butterfly - *Virachola isocrates* F. (Lycaenidae : Lepidoptera)

Damage

- The caterpillar bore into the developing fruits and feed on the pulp below the rind of infested fruits ultimately fall off and infested fruit which gives an offensive smell.

Bionoinics

- The adult moth is brown butterfly.
- The female moth has' V ' shaped patch on fore wings.
- It lays shiny white, oval shaped eggs singly on developing fruits.
- The egg period is 7 -10 days.
- The larva is dirty dark brown, short and stoutly build covered with short hairs.
- The larval period is 18 - 47 days. It pupates insides the fruit.
- The pupal period ranges from 7-34 days.

Management

- Collect and destroy the infested fruits.

- Spray NSKE 5% or neem oil 2% as oviposition deterrent, 2 to 3 times at 15 days interval commencing from flowering and during butterfly activity.
- Adopt ETL (5 eggs / plant with bearing capacity of 60 fruits).
- Release egg parasitoid, *Trichogramma chilonis* at 1 lakh / acre.
- Spray thiochloprit 2 ml/ litre of water.
- Ensure minimum waiting period of 10 days between the day of insecticide application and harvesting of fruits in the field.

3. Fruit borer - *Argyroploce illipida* Meyr. (Eucosmidae : Lepidoptera)

Damage

- The larva bores into the fruits causing fruit drop

4. Castor capsule borer - *Dichocrosis (= Conogethes) punctiferalis* Guen. (Pyraustidae : Lepidoptera)

Damage

- The larva borers into the central core of the pseudostems resulting in the death of the central spindle causing characteresic "dead heart" symptom.
- In the case of capsules, the caterpillars bore into the immature capsules and feed on the seeds rendering them empty.
- The caterpillars occasionally tunnel into the panicle also. A characteristic indication for the presence of the larvae is the oozing out of excreted frass materials at the mouth of the bore hole, which are very conspicuous on the stem or pods.

Bionomics

- The adult is a medium sized brownish yellow coloured moth with a number of dark spots on the wings.
- It lays eggs on the top leaf axils of young pseudostem.
- The larva bore into the tender parts of the panicle, flower buds and immature capsules only, the later stage larva bore into the stem.
- The full grown larva is measuring 15-25 mm long and it pupates within the larval tunnel inside the pseudostems.
- The life cycle is completed within 25-40 days.

Management

- Collect and destroy the affected plant parts.
- Destroy the alternate host plants from the vicinity of the plantation
- Spray phosalone 3 ml/litre or Dimethoate 0.03 % /litre or quinolphos 4 ml/litre or fenthion 1.25ml / litre of water.

1. Inflorescence caterpillar - *Laspeyresia palamedes* M. (Eucosmidae : Lepidoptera)

Damage

- The larva webs the inflorescence and bores into the stalks causing shedding of floral parts.

2. Flower webber - *Eublemma angulifera* Moore. (Noctuidae : Lepidoptera)

Damage

- The caterpillar webs the inflorescence and tunnel into the stalks.

3. Looper - *Thalassodes quadraria* Guen. (Geometridae : Lepidoptera)

Damage

- The caterpillar webs the inflorescence and base into the stalk

1. Hard Scale - *Aspidiotus tamarindus* Green. (Diaspididae : Hemiptera)

Damage

- It covers the leaves, fruits, and the twigs and sucks the sap.

2. Soft scale - *Saisettia oleae* Ber. (Coccidae: Hemiptera)

Damage

- Both nymphs and adults desap the developing fruits result the yellowish encrustation over the infested fruit, ill filled and hard fruits.

3. Mealy bug - *Planococcus lilacillus* Ckll. (Pseudococcidae: Hemiptera)

Damage

- Both nymphs and adults cover on the developing fruits and suck the sap causing shriveling of fruits.

1. White grub - *Holotrichia insularis* Brensk. (Melolonthidae: Coleoptera)

Damage

- The grub feeds on rootlets causing withering and drying of young plants.
- In case of severe, attack the entire seedling is killed.

- The adult beetles feed on leaves causing severe defoliation.

Bionomics

- The adult beetles are brownish black in colour.
- The beetles emerge from the soil with the onset of monsoon during June-July.
- It lays shiny white, oval shaped eggs in the soil. The egg period is 8-12 days.
- The young grub feeds on roots of host plants the grown up grub is white, fleshy, 'C' shaped. The grub period is 55-80 days.
- It pupates in earthern for 8-12 days.
- It hibernates in pupal stage from November-June and later on emerges as adult.

Lecture No.21

Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Apple, Pear, Peach, Plum

- **TEMPERATE FRUITS**

APPLE• I. Borers

- 1. Stem borer Resource
- 2. Shot hole borer Resource
- 3. Fruit borer Resource
- 4. Bark borer Resource
- 5. Fruit fly Resource
- **II. Sap feeders**
- 1. Apple woolly aphid Resource
- 2. San Jose scale Resource
- 3. Cottony cushion scale Resource
- 4. Thrips Resource
- 5. Pentatomid bug Resource
- **III. Leaf feeders**
- 1. Tent Caterpillar Resource
- 2. Apple codling moth Resource
- 3. Indian gypsy moth Resource
- **IV. Root feeders**
- 1. Apple root borer Resource
- 2. White grub Resource
- **V. Non - insect pest**
- 1. European mite

1. Stem borer - *Apriona cinerea* Chaverlot. (Lamidae: Coleoptera)

Damage

- The grub bores into twigs causing circuitous galleries.
- The infested branches have small circular hole and mass of excreta and chewed up wood particles protruding out.
- The barks of branches are gnawed and leaves defoliated.

Bionomics

- The adult beetle is ashy grey with numerous black tubercles at the base of elytra.
- The female lays eggs inside the cavity, which is excavated on shoots.
- The incubation period is 7-8 days.
- The grub is creamy yellow with the dark brownish head.
- The grub undergoes hibernation during winter and resumes feeding in March, reaching the tree trunk by autumn (September-October) again go in hibernation during winter.
- It pupates inside the tunnel. The pupal period is 30-35 days.

2. Shot hole borer - *Scolytoplatypul raja* Bland. (Scolytidae: Coleoptera)

Damage

- The grub burrows in the trunks of apple.

3. Fruit borer - *Xylotrupes gideon* Linn. (Dynastidac: Coleoptera)

Damage

- It bores into the fruits

4. Bark borer - *Aeolesthes holosericea* Fab. (Cerambycidae: Coleoptera)

Damage

- The grub feeds inner layers of bark and outer layer of sapwood.
- The larval tunnel is plugged with excreta.

Bionomics

- A female beetle lays about 92 eggs in the injured parts of the incubation period is 7-12 days.
- The grubs feed on the barks and sap the larval development is completed in 27-32 months.
- It pupates inside wood for 3-25 days.
- The pupal period lasts for 40-100 days.
- The total cycle is completed in 31-36 months.

5. Fruit fly - *Bactrocera zonatus* Saund. (Tephritidae : Diptera)

Damage

- The maggot feeds on the fruits causing rotting and dropping of fruits.

Bionomics

- The adult fly is small, reddish brown with yellowish cross band on the abdomen.
- It inserts white cylindrical eggs on the fruits in group of 2-9.

- The fecundity of the fly is 137 eggs / female.
- The eggs are covered by resinous secretion.
- The egg period is 2-4 days.
- The maggot is dirty white, acephalic and apodous measuring 1 cm in length.
- The larval period is 4-16 days.
- The maggot crawls out of fruits and pupates in the soil.
- The pupal stage over winters in cold months.
- The pupal period last for 7 days.

1. Apple woolly aphid - *Eriosoma lanigarum* Hausmn. (Pemphigidae : Hemiptera)

Damage

- Both nymphs and adults suck the sap from the bark fruit stalk, calyx and roots.
- The affected plants become weak and cause death of the plants in the nursery.
- It causes gall like swellings on the stem and roots.
- It crowds together covered with woolly white patches on the trunk.

Bionomics

- The aphid is purplish aphid covered with white cottony mats.
- It reproduces both sexually and asexually.
- Generally it develops parthenogenetically.

- Apterous forms are present throughout the year.
- Each female may produce up to 116 young ones in her life time.
- The nymph undergoes four instars.
- The nymphal period is 35 - 42 days.
- Alate form disperses by flight and gives rise to apterous forms by sexual reproduction.

Management

- Use tolerant or resistant root stocks; M778, M779, MM 14, MM 110, MM 112, MM 114 and MM 115.
- Release specific eulophid parasitoid *Aphelinus mali* during December and
- June to obtain maximum parasitization and predators, *Chilomenes bijugus* and *Coccinella septumpunctata*.
- Spray nicotin sulphate 40EC 500 ml or malathion 50 EC 750 ml in 500 litres of water.
- Apply the fumigant paradichlorobenzene at 30-110 gram / tree in a 15 cm deep trench around the tree about two metres away from the base of the affected tree.
- Remove the aphids mechanically by rubbing with clothes without causing
- any damage to the developing buds.
- Follow nursery bed treatment of carbofuran 3 G 0.5 g a.i./plant or spray dimethoate 0.03% or methyl demeton 0.025% in March to April and June to control aerial forms.

2. San Jose scale - *Quadraspidiotus perniciosus* Comst.(Diaspididae: Hemiptera)

Damage

- Both nymphs and adults infest the bark and desap the same.
- The infested region of the bark becomes reddish pink and purple colouration in fruits.

Bionomics

- The female scale is round slightly convex with a black pustule and the male is linear.
- The hibernating nymphs become active in March and the males emerge in April.
- The females reproduce in mid May producing 200-400 nymphs within a month.
- The nymphal period is 20 days. The total life cycle is completed in 35-40 days.

Management

- Spray diazinon 20 EC 1250 ml or methyl demeton 5 EC 625 ml /hectare.
- Select nursery stock free from scale infestation.
- Encourage activity of parasitoids, *Prospaltella perniciosi* and *Aspidiotophagus sp.* and / or coccinellid *Chilocorus circumdatus* predator.
- Fumigate nursery stocks with HCN gas or methyl bromide.

- Summer spray with contact or systemic insecticides like phosalone 0.05%, fenitrothion 0.05% and methyl demeton 0.025%.
- Winter spray with diesel oil emulsion at 8 to 12 1/tree (diesel oil 4.5 1, soap 1 kg, water 54-72 1).

3. Cottony cushion scale - *Icerya purchasi* Maskell. (Margarodidae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from the leaves causing yellowing.

Bionomics

- The female has a cottony ovisac and the pinkish nymph has long antenna with group of hairs.

4. Thrips - *Taeniothrips rhapalantennalis* Shum. (Thripidae : Thysanoptera)

Damage

- The nymphs and adults infest the flowers and causes distortion of the flowers and reduction of fruit-setting.

5. Pentatomid bug - *Tessaratoma quadrata* Dist. (Pentatomidae : Hemiptera)

Damage

- The nymphs and adults desap the fruits causing the dropping of the fruits.

1. Tent Caterpillar - *Malacosoma indica* Wlk. (Lasiocarapidae:

Lepidoptera)

Damage

- The caterpillar constructs a tent like shelters at the forking twigs and hide within during the day time.
- The caterpillar feeds on the leaves gregariously during the night hours causing severe defoliation.

Bionomics

- It is active only from March to May and passes the remaining
- months of the year during eggs stage.
- The adult female moth is light brown with a wing expanse of 29-32 mm.
- It lays eggs in masses of 300-400 on branches of the tree during May-June.
- The eggs are hatched in the following month.
- The larva has black head and abdomen.
- The larval period is 40-70 days.
- It pupates on stem and on ground in cocoon during May for 7-21 days.

Management

- Destroy all the egg bands on the branches during pruning.
- Spray carbaryl 50 WP 4 g / lit of water.

2. Apple codling moth - *Carpocapsa pomonella* Linn. (Tortricidae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves first, then it borer in to fruits, feeds on the pulp of fruits.
- The female lays white coloured, flattened eggs singly on developing fruits, leaves and the twigs.
- The egg period is 4-12 days. The larva is pinkish to creamy white in colour with a brown head.
- The larval period last for 21-30 days.
- The grown up larvae comes out of the fruit and falls on the ground and then it reach the bark of the tree for shelter in cracks and crevices to construct a silken cocoon for pupation. The pupal period is 8-14 days.

Management

- Collection and destruction of cocoons and fallen fruits.
- Mass trap males with codling moth lure traps.
- Spray DDVP 0.04%.
- Release egg parasitoids, *Trichogramma embryophagum* at 2000/tree.

3. Indian gypsy moth - *Lymantria obfuscata* Wlk. (Lymantriidae : Lepidoptera)

Damage

- The larva feeds on the leaves gregariously which results in failure of fruit formation.

Bionomics

- The adult female is dark grey in colour. It settles down on the bark of the tree and days eggs in masses of 200-400 under the bark which are covered with yellowish brown hairs.
- The egg stage overwinters during cold months and hatch in March - April.
- The larvae complete the development in 66-100 days.
- It pupates in the soil among the debris. The pupal period is 9-21 days.

1. Apple root borer - *Dorysthenus hiigelii* Redt.(Cerambycidae: Coleoptera)

Damage

- The grub borers into the roots or girdles around the roots and feed on the internal tissues.
- It resulted in shaking of plants, withering and drying of branches.

Bionomics

- The adult beetle is chestnut -red in colour with head and thorax darker than elytra.
- It lays oval shaped yellow white eggs below the soil.
- A female can lay up to 200 eggs. The egg period is 30-40 days.
- The newly hatched out grub goes down to the soil, 100-250 mm deep and feed on the roots of the tree.
- The full grown grub is creamy-white with black head and mandibles measuring 75-100 mm in length.

- The larval duration extends up to 3 ½ years and it can live without food for 24 - 90 days.
- It pupates in earthern cocoon inside the soil. Its pupal period is about 3 months.

Management

- Avoid dry sandy soils for planting apple orchards

2. White grub - *Lachnosterna longipennis* Blan.(Melolonthidae: Coleoptera)

Damage

- The grub feeds on the roots while the adult feeds on leaves.

Bionomics

- The adult female beetle lays the eggs in soil, 2.5-5.0 cm a deep near the host roots.
- The incubation period is 13-18days. Grubs remain in soil, feeding on the organic matter and roots of apple tree.
- The larval period is 243-277 days. It pupates in soil for 22-27 days.

1. European mite - *Panonychus ulmi*. (Tetranychidae: Acarina)

Damage

- The nymphs and adults infest the leaves, which resulted in leaves with white streaks on the upper surface, the infested leaves become rolled.

PEAR

1. Stemborer - *Sahydrassus (= Phassus) malabaricus* M. (Hepialidae: Lepidoptera)

Damage

- The caterpillar bores in the stem at the base of the tree resulting bore hole with circular particle mat covering on the stem and wilting of the tree.

Bionomics

- The adult moth is big brownish white in colour. The larva is stout caterpillar.

Management

- Remove and destroy damaged branches and trees along with larvae.
- Use light trap at 1/ha attract and kill adults.
- Locate live hole and kill caterpillar by spiking with an iron hook.
- Inject or pour monocrotophos 10 ml+water 10 ml mixture and cover with mud. Follow stem injection after harvest of fruits and subsequent harvest should be done 40 days later from first stem injection.

2. Fruit fly - *Bactrocera (= Dacus) zonatus* Saund. (Tephritidae: Diptera)

Damage

- The maggot feeds on the pulp of fruits causing rotting and dropping of fruits.

Bionomics

- The adult fly is small, reddish brown in the yellow cross bands on the abdomen.
- The female lays white cylindrical eggs on the skin of a fruit in masses of 2-9.
- The fecundity is about 137 eggs per female.
- The egg period is 2-4 days.
- The maggot is dirty white, apodous and elongated measuring 1 cm in length.
- The larval period is 4-16 days.
- The maggot come out from the rotting fruit and pupates in the soil at a depth of 25.4 -76.2 mm.
- The pupal period last for 7 days. The life cycle is completed in 13-27 days.

3. Fruit borer - *Virachola isocrates* F. (Lycaenidae: Lepidoptera)

Damage

- The larva bores inside the developing fruits and feeds on the pulp and seeds.
- The infested fruits are infected by fungi and bacteria causing fruit rot disease.
- The damaged fruits ultimately fall off and give an offensive odour.
- It causes 40-90 per cent damage to the fruits.

Bionomics

- The adult butterfly is medium sized with wing expanse of 40-50 mm.
- The female moth is glossy brownish violet while the male is bluish violet in colour.
- The female lays eggs singly on the calyx of flowers and on small fruits.
- The egg period is 7-10 days.
- The young larvae bore into the developing fruits.
- The larval period is completed in 18-47 days.
- It pupates inside the fruits.
- The pupal period last for 7-34 days.
- It completes four generations per year.

Management

- Grow less susceptible varieties.
- Remove calyx from the fruits to prevent the hatching of eggs and subsequent damage.
- Collect and destroy the infested fruits.
- Cover the fruits with polythene or muslin bags during flowering period to prevent egg laying when fruits are up to 5 cm diametre
- Spray NSKE 5% or neem oil 2% as oviposition deterrent, 2 to 3 times at 15 days interval commencing from flowering and during butterfly activity.
- Adopt ETL (5 eggs / plant with bearing capacity of 60 fruits).
- Release egg parasitoid, *Trichogramma chilonis* at 1 lakh / acre.
- Spray thiochlopril 2 ml/ litre of water.

- Ensure minimum waiting period of 10 days between the day of insecticide application and harvesting of fruits in the field.

1. Eye spotted bud moth - *Eucosma (= Spilonota) ocellana* Schiff. (Eucosmidae: Lepidoptera)

Damage

- The larva bores into shoots, flowers, and fruit buds and feeds on them.

Bionomics

- The adult moth emerges during May and June.
- It lays eggs on the floral parts.
- The incubation period is 8-11 days.
- The caterpillar bores in to the floral parts, feeds till September and overwinters from October - March.
- It pupates in April for 9-13 days.

2. Codling moth - *Carpocapsa potnonella* Linn. (Tortricidae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves first, then it borer in to fruits, feeds on the pulp of fruits. The female lays white coloured, flattened eggs singly on developing fruits, leaves and the twigs. The egg period is 4-12 days. The larva is pinkish to creamy white in colour with a brown head. The larval period last for 21-30 days. The grown up larvae comes out of the fruit and falls on the ground and then it reach the bark of the tree for shelter in cracks and crevices to construct a silken cocoon for pupation. The pupal period is 8-14 days.

Management

- Collection and destruction of cocoons and fallen fruits.
- Mass trap males with codling moth lure traps.
- Spray DDVP 0.04%.
- Release egg parasitoids, *Trichogramma embryophagum* at 2000/tree.

3. Wild silk worm moth - *Actias selene* Hb. (Saturnidae: Lepidoptera)

Damage

- It causes defoliation.

4. Sphinx moth - *Langia zeuzerrides* Moore. (Sphingidae : Lepidoptera)

Damage

- It causes defoliation.

5. Hairy caterpillar - *Euproctis fraterna* Moore. (Lymantriidae: Lepidoptera)

Damage

- The caterpillar feeds on the leaf voraciously causing severe defoliation.

6. Grey weevil - *Myllocerus spp* (Curculionidae: Coleoptera)

Damage

- Adult weevil cause notching of leaf margins. Grub feeds on roots resulting wilting of plants.

Bionomics

- *M.Subfasciatus* – Brownish weevil;
- *M.discolor* – Brown with white spot on elytra;
- *M.viridanus* – Small light green weevil.

Management

- • Collect & destruct the adult weevils
- • Apply carbofuran 3 G at 15 kg/hectare at 15 days after planting.

1. San Jose scale - *Quadraspidiotus perniciosus* Comst (Diaspididae: Hemiptera)

Damage

- Both nymphs and adults infest the bark and desap the same.
- The infested region of the bark becomes reddish pink and purple colouration in fruits.

Bionomics

- The female scale is round slightly convex with a black pustule and the male is linear.
- The hibernating nymphs become active in March and the males emerge in April.

- The females reproduce in mid May producing 200-400 nymphs within a month.
- The nymphal period is 20 days. The total life cycle is completed in 35-40 days.

Management

- Spray diazinon 20 EC 1250 ml or methyl demeton 5 EC 625 ml /hectare.
- Select nursery stock free from scale infestation.
- Encourage activity of parasitoids, *Prospaltella perniciosi* and *Aspidiotophagus sp*. and / or coccinellid *Chilocorus circumdatus* predator.
- Fumigate nursery stocks with HCN gas or methyl bromide.
- Summer spray with contact or systemic insecticides like phosalone 0.05%, fenitrothion 0.05% and methyl demeton 0.025%.
- Winter spray with diesel oil emulsion at 8 to 12 1/tree (diesel oil 4.5 1, soap 1 kg, water 54-72 1).

2. Aphid - *Dilachnus krishnii* George and *Aphis gossypii* Glover. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults feed on leaves and tender shoots causing yellowing symptom.

3. Psyllid bug - *Cacopsylla mali* (Psyllidae: Hemiptera)

Damage

- It causes yellowing of shoots

PEACH

1. Peach leaf curl aphid - *Brachycaudus helichrysi* Kalt (Aphididae: Hemiptera)

Damage

- Both nymphs and adults desap the leaves, petioles, blossom and fruits.
- The infested leaf turn pale and curl up, blossom wither and fruits do not develop and drops prematurely.

Bionomics

- It appears in cooler regions after the middle of March and from June to October it feeds on golden rod a alternative host.
- The egg stage over winters from October-December.
- During spring the egg hatch and nymphs moves out on to the primordial leaves and suck the sap.
- The eggs are produced parthenogenetically which hatch inside the body of mother.
- Each viviparous female produces about 50 nymphs in 13 days of life span.
- After completing 3-4 asexual generations, the aphid migrates to its alternative host to pass summer.
- They again reproduce asexually and complete 4-5 generation from June-October.
- The winged females are again produced in November.

2. Green peach aphid *Myzus persicae* Sulz. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from the leaves curling and crinkling and sooty mould development of leaves are the typical symptoms of damage.

Bionomics

- Adults are both wingless and winged forms.
- Nymphs are in different colour forms mostly yellow, green and red. Yellow forms are more dominant.

3. Soft scale - *Eulecanium tiliae* L. (Coccidae: Hemiptera)

Damage

- Both nymphs and adult scale insects infest leaves and twigs.

Bionomics

- It is a soft, hemispherical dark brown scale.
- It lays the eggs during March-April and they hatch in 12-15 days.
- The crawlers settle on leaves and nymphs migrate to twigs during July-December.
- The adult female emerge in February and males in March or April.

4. San jose Scale - *Quadraspidiotus pernicious* Comst. (Diaspididae: Hemiptera)

Damage

- Both nymphs and adults infest the bark and desap the same.
- The infested region of the bark becomes reddish pink and purple colouration in fruits.

Bionomics

- The female scale is round slightly convex with a black pustule and the male is linear.
- The hibernating nymphs become active in March and the males emerge in April.
- The females reproduce in mid May producing 200-400 nymphs within a month.
- The nymphal period is 20 days. The total life cycle is completed in 35-40 days.

Management

- Spray diazinon 20 EC 1250 ml or methyl demeton 5 EC 625 ml /hectare.
- Select nursery stock free from scale infestation.
- Encourage activity of parasitoids, *Prospaltella perniciosi* and *Aspidiotophagus sp.* and / or coccinellid *Chilocorus circumdatus* predator.
- Fumigate nursery stocks with HCN gas or methyl bromide.
- Summer spray with contact or systemic insecticides like phosalone 0.05%, fenitrothion 0.05% and methyl demeton 0.025%.

- Winter spray with diesel oil emulsion at 8 to 12 1/tree (diesel oil 4.5 1, soap 1 kg, water 54-72 1).

1. Codling moth - *Carpocapsa pomonella* Linn. (Tortricidae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves first, then it borer in to fruits, feeds on the pulp of fruits.
- The female lays white coloured, flattened eggs singly on developing fruits, leaves and the twigs.
- The egg period is 4-12 days.
- The larva is pinkish to creamy white in colour with a brown head.
- The larval period last for 21-30 days.
- The grown up larvae comes out of the fruit and falls on the ground and then it reach the bark of the tree for shelter in cracks and crevices to construct a silken cocoon for pupation. The pupal period is 8-14 days.

Management

- Collection and destruction of cocoons and fallen fruits.
- Mass trap males with codling moth lure traps.
- Spray DDVP 0.04%.
- Release egg parasitoids, *Trichogramma embryophagum* at 2000/tree.

2. Peach butterfly - *Kallima inachus* Boisd. (Nymphalidae : Lepidoptera)

Damage

- The adult butterfly, which mimics the dry leaf in suspended, which desap the peach fruits.

3. Hairy caterpillar - *Dasychira mendosa* Hb. (Lymantriidae: Lepidoptera)

Damage

- The caterpillar feeds on leaves and cause defoliation.

1. Peach Stem borer - *Sphenoptera lafertei* Thomson.(Buprestidae: Coleoptera)

Damage

- The grubs feed below the bark making minute irregular galleries causing loosening and splitting of barks.
- The beetle feeds on leaves, which turn pale and dry up.

Bionomics

- The adult beetle is blackish bronze in colour measuring 10-13 mm long.
- The female lays small, spherical white eggs singly on the tree trunk and the main branches.
- The egg period is 20 days.
- The grub stage is completed in 2 months in summer and 6 months in winter.
- It pupates in a small chamber in woody tissues.
- The pupal period lasts for 8-12 days in summer.

Management

- Collect and destroy damaged shoots and branches.
- Swab trunk with carbaryl 50 WP at 0.2%.
- Spray malathion 0.1% or acephate 75 SP 2 g/litre

2. Peach fruit fly - *Bactrocera (= Dacus) zonatus Saund* (Tephritidae: Diptera)

Damage

- The maggot feeds on the pulp of fruits causing rotting and dropping of fruits.

Bionomics

- The adult fly is small, reddish brown in the yellow cross bands on the abdomen.
- The female lays white cylindrical eggs on the skin of a fruit in masses of 2-9.
- The fecundity is about 137 eggs per female.
- The egg period is 2-4 days. The maggot is dirty white, apodous and elongated measuring 1 cm in length.
- The larval period is 4-16 days. The maggot come out from the rotting fruit and pupates in the soil at a depth of 25.4 -76.2 mm.
- The pupal period last for 7 days.
- The life cycle is completed in 13-27 days.

PLUM

1. San Jose scale *Quadraspidiotus perniciosus* Comst. (Diaspididae: Hemiptera)

Damage

- Both nymphs and adults infest the bark and desap the same. The infested region of the bark becomes reddish pink and purple colouration in fruits.

Bionomics

- The female scale is round slightly convex with a black pustule and the male is linear. The hibernating nymphs become active in March and the males emerge in April. The females reproduce in mid May producing 200-400 nymphs within a month. The nymphal period is 20 days. The total life cycle is completed in 35-40 days.

Management

- Spray diazinon 20 EC 1250 ml or methyl demeton 5 EC 625 ml /hectare.
- Select nursery stock free from scale infestation.
- Encourage activity of parasitoids, *Prospaltella perniciosi* and *Aspidiotophagus sp*. and / or coccinellid *Chilocorus circumdatus* predator.
- Fumigate nursery stocks with HCN gas or methyl bromide.
- Summer spray with contact or systemic insecticides like phosalone 0.05%, fenitrothion 0.05% and methyl demeton 0.025%.

- Winter spray with diesel oil emulsion at 8 to 12 1/tree (diesel oil 4.5 1, soap 1 kg, water 54-72 1).

2. Peach leaf curl aphid - *Brachycaudus helichrysi* Kalt. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults desap the leaves, petioles, blossom and fruits. The infested leaf turn pale and curl up, blossom wither and fruits do not develop and drops prematurely.

Bionomics

- It appears in cooler regions after the middle of March and from June to October it feeds on golden rod a alternative host. The egg stage over winters from October-December. During spring the egg hatch and nymphs moves out on to the primordial leaves and suck the sap.
- The eggs are produced parthenogenetically which hatch inside the body of mother. Each viviparous female produces about 50 nymphs in 13 days of life span. After completing 3-4 asexual generations, the aphid migrates to its alternative host to pass summer. They again reproduce asexually and complete 4-5 generation from June-October. The winged females are again produced in November.

1. Cherry stem borer - *Aeolesthes holosericca* F. (Cerambycidae: Coleoptera)

Damage

- The newly hatched out grub tunnels the bark and makes zig - zag galleries.
- The grown up grub bores in to the stem deeply and damages the woody tissues.
- The infested plant withers and gradually dies. The bore hole is plugged with excreta.

Bionomics

- The adult beetle is dark brown measuring 38-45 mm in length.
- It lays eggs on the dry wood portion or increases of out on the bark.
- The egg period is 7-12 days.
- The grubs is yellowish in colour and are covered with fine bristles, measuring 70-80 mm long the larval period is completed in 27-32 months.
- It pupates either in October-November or in March -April.
- The pupal period ranges from 40-100 days.
- The total life cycle is completed in 31% - 36 months.

2. Peach stemborer - *Spheroptera lafertei* Thomson. (Buprestidae - Coleoptera)

Damage

- The grubs feed below the bark making minute irregular galleries causing loosening and splitting of barks.
- The beetle feeds on leaves, which turn pale and dry up.

Bionomics

- The adult beetle is blackish bronze in colour measuring 10-13 mm long.
- The female lays small, spherical white eggs singly on the tree trunk and the main branches.
- The egg period is 20 days.
- The grub stage is completed in 2 months in summer and 6 months in winter.
- It pupates in a small chamber in woody tissues.
- The pupal period lasts for 8-12 days in summer.

Management

- Collect and destroy damaged shoots and branches.
- Swab trunk with carbaryl 50 WP at 0.2%.
- Spray malathion 0.1% or acephate 75 SP 2 g/litre

1. Almond weevil *Myllocerus lactivirens* Marshl. (Curculionidae: Coleoptera)

Damage

- The adult weevil cut the irregular holes and gradually eat away the entire leaf lamina from the ventral all surface of leaves resulting severe defoliation.

Bionomics

- The adult weevil is small pale metallic green in colour measuring 3-4 mm long.

- It lays eggs in soil in batches of 40-50 each.
- The eggs are broadly oval, creamy yellow, smooth, transparent and shiny.
- The egg period is 4-5 days.
- The grub is creamy white, stout, without legs but short erect setae which help in locomotion.
- The full grown grubs come up to the soil surface to pupate in the upper 25 mm of the soil.
- The larval and pupal periods last for 300 days and 5 days respectively.
- The pupal stage over winters in cooler months.

Lecture No. 22

- **Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Coconut, Oilpalm and Arecanut**

COCONUT

1. Rhinoceros beetle - *Oryctes rhinoceros* Linn. (Scarabaeidae: Coleoptera)

Damage

- The adult beetles cause severe damage to young as well as old trees.
- The beetles live in crevices between the leaf sheaths near the crown and burrow in to the softer portion feeding on the un opened fronds and inflorescence.
- The beetles chews the internal tissues and after injecting the juicy part throws out the fibrous part which comes out of holes is the indication for the presence of beetle in the crown.
- The infested fully opened fronds showing the characteristic 'v' shaped cuts on leaf lets.
- The young seedlings are often killed when the growing points are damaged.
- The repeated attack in old trees causes stunting of growth and present sickly appearance to the trees.
- Bore holes with chewed fibre sticking out at the base of central spindle is the typical symptom of attack.

Bionomics

- The adult beetle is black, stout measures 5 cm long and has a long horn projecting dorsally from the head.

- The horn is longer in male and shorter in female beetle.
- The female lays globular eggs singly in decaying organic matter such as manure pits, dead tree trunks compost heaps. T
- he fecundity of the insect is 140-150 eggs per female.
- The egg period is 8-18 days.
- The newly hatched grub feeds on decaying organic matter.
- The grown up grub is stout, white, 'C shaped, sluggish and has a pale brown head.
- The larval period is 100-180 days.
- It pupates in earthern cells at a depth of 30-90 cm or more.
- The pupal stage last for 10-25 days.
- The adults make their way out and fly to the trees.
- The adult beetles lives for more than 200 days.

Management

- Remove and burn all dead coconut trees in the garden to maintain good sanitation.
- Collect and destroy the various bio-stages of beetles from the manure pit whenever the manure is lifted from pits.
- Incorporate entomopathogenic fungus, Metarrhizium anisopliae in manure pits.
- Keep the mud pots having soaked castor cake 1 kg in 5 litres of water to attack and kill the adults.
- Keep the toddy treated longitudinally split tender coconut stem and green petioles of fronds in the garden to attack and trap the adult beetles.
- Hook out the beetles using a long iron rod and kill them at the time of harvest.
- Apply three naphthalene balls /palm (weighing 35 g each) at base of interspace in leaf sheath in the 3 inner most leaves of the crown once in 45 days for the seedlings.
- Set up light traps following the first rain in summer and monsoon period to attract and kill the adult beetles.
- Set up aggregation pheromone (ethyl 4-methyl octonate) trap (bucket type trap).
- Release *Baculovirus* inoculated beetles in the garden to reduce the leaf and crown damage.
- Apply the mixture of neem seed kernel powder + sand (1:2) @ 150 kg per palm in the base of the 3 inner most leaves in the crown effectively control the beetle.

2. Red palm weevil - *Rhynchophorus ferrugineus* Oliver. (Curculionidae: Coleoptera)

Damage

- The grub enters in to the stem and feeds on the internal tissue of the trunk causing a small hole on the stem with protruding chewed fibrous materials and oozing out of a brown liquid from such holes and eventually resulting in the toppling of the crown portion. In the advanced stage of attack, the central shoot shows sign of wilting and large mass of grubs, pupae and adults in fibrous cocoon could be seen inside the trunk at the damaged portion. In the grown up trees, the beetle causes damage by laying the eggs on the crown region. In such cases the grub easily enter into the growing point or cabbage of crown and causing yellowing of inner leaves and gradual drying of central shoot in the crown.

Bionomics

- The weevil is reddish brown with 6 dark spots on the thorax a conspicuous snout with tuft of hairs. The female weevil lays eggs in small holes scooped out by her on the soft regions of young palms up to 7 years of age. In the grown up trees the eggs are laid in the cuts or wounds present on the trunk or leaf stalk. The plant sap oozing out of wounds and cut attract the weevil for ovipositon. The eggs are creamy white in colour. The eggs hatch out in 2-3 days time into soft white grub. The grub is apodous which tunnel into the trunk and feeds on the internal succulent tissues. The larval period ranges between 45 and 75 days. The full-grown grub is stout, fleshy, and apodous with a conical body bulged in middle and tapering towards the ends. It pupates in a fibrous cocoon made out of fibrous strands.

- The pupal period last for 2-3 weeks. The total life cycle is completed in about 4 months. The adult weevils are reddish brown with long curved, pointed snout. The male weevil can be distinguished from the female by the presence of tuft of hairs along the dorsal aspect of snout.

Management

- Remove and burn all wilting or damaged palms in the garden.
- Avoid injuries or wound on stems as they serve as oviposition site for weevil.
- Fill all the holes with cement on the stem or trunk of coconut.
- Avoid the cutting of green leaves. If needed they should be cut about 120 cm away from the stem.
- Set up attractant traps (mud pots) containing sugarcane molasses 2.5 kg + toddy 2.5 litres + acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem/logs of green petioles of leaves of 30 numbers in one acre to trap weevil.
- Set up male aggregation pheromone, ferruginol (4 methyl 5 nonanol) trap - ferrolure to attract the weevil.

- Follow the root feeding of monocrotophos 36 WSC 10 ml + 10 ml of water per tree.
- Insert one or two tablets of aluminum phosphide inside the tunneled trunk and plug all the holes with clay and cement mixed with copper oxy chloride to kill the insect by the fumigant action.

3. Shot hole or bark borer - *Xyleborus parvulus* E and *X. perforans* (Scolytidae : Coleoptera)

Damage

- Both grubs and adults attack the base of the palm and extend to the upper regions. Deposits of white powdery materials on the ground, around the base of the palm and numerous small strings of frass and white powdery material hang downwards from the pin size holes are the symptoms of attack. Damaged palms loose their vigour and are prone to attack by ants. The infested palms die in six months.

Management

- Follow the root feeding of monocrotophos 10 ml + water 10 ml per palm.
- Clean the frass and other materials on the trunk base and brush with carbaryl 50% WP emulsion (10 gm. in 1 litre of water) on the trunk base from the ground level up to the infested region.
- Give stem injection through a stove wick soaked in 0.2% fenthion or 2% dichlorovos plugging the hole and repeating the treatment using the same wick and hole a month after.

1. Black headed caterpillar - *Opisina arenosella* Walker. (Cryptophagidae: Lepidoptera)

Damage

- The larva infests the under surface of leaves and it construct small galleries with silk frass and excreta and remain inside throughout. It feeds on the green parenchymatous tissues of leaflets from under surface leaving a thin parchment like upper epidermis undamaged. The infested leaflets slowly turn grey to brown and dry up in patches along the area where the each larva has been feeding. When a large number of leaves are affected the crown presents a scorched appearance from a distance. The damage by the caterpillar is severe during summer month

Bionomics

- The adult moth is small and greyish white. It lays eggs near the tip of the leaflets of the older leaves. The eggs are very small and hatch out in five days. The fecundity of the insect is 60-250 eggs /female. The newly hatched out larva construct silken tunnel or galleries. On the under surface of leaves where they live and feed. The larva is light green with a dark brown head measures 15 mm in length. The larval period is about 45 days. It pupates inside the galleries for 12 days. The total life cycle is completed in about two months.

Management

- Remove and burn all the affected leaves and leaf lets.
- Release larval parasitoids (Bethylids, Braconids and Ichneumonids) and pupal parasitoids (Eulopid) and predators periodically from January to check the build up of pest during summer.
- Release *bethylid, Gbniozus nephantitis* @ 3,000 per ha under the coconut trees when the pest is in the 2nd or 3rd instar larval stage. The optimum level of release is 1:8 host parasite ratio. Do not release the parasite in the crown region since they will be killed by spiders and reduvid bugs.
- Spray malathion 50EC 0.05% to cover the under surface of leaves thoroughly in case of severe epidemic out break of the pest in young plants.
- Harvest all mature nuts, and drill a downward slanting hole and inject 5.0 ml of monocrotophos 36 WSC into the stem at about 1.5 M above the ground level and plug with clay mixed copper oxy chloride.
- Inject monocrotophos based on age less than 10 years 5ml and above 10 years 10ml with equal quantity of water (5 ml) mixed in 20 ml of water into the stem. Plucking tender coconuts or harvesting the nuts should be strictly avoided for 45 days after treatment.
- Adopt the root feeding of monocrotophos for the control of black headed caterpillar.
- Select a fresh and live root, cut sharply at an angle and insert the root in the insecticidal solution containing monocrotophos 36 WSC 10 ml + water 10 ml in a 7x10 cm polythene bag. Secure the bag tightly to the root with a cotton thread.

Twenty-four hours later check whether there is any absorption. If there is no absorption selects another root and redoes the procedure. Follow the precaution for the insecticidal treatment.

2. Coconut skipper - *Gangara thyrsis* Moore. (Hesperidia: Lepideptera)

Damage

- The caterpillar constructed tubes out of the leaves and feed from within on the leaf blade leaving behind only the ribs.

Bionomics

- The adult butterfly is brownish, 80 mm in wing expanse with brownish wings bearing 6 yellow spots on fore wings.
- It lays eggs in irregular masses.
- The incubation period is 7 days.
- The caterpillar is pale green with reddish markings but the body is concealed in a covering of white waxy filaments.
- The larval period is 35 days.
- It pupates in the leaf tube for a period of about 10 days.

3. Slug caterpillar - *Parasa lepida* Cram. (Coehlididae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves gregariously in the beginning, subsequently they disperse.
- It causes severe defoliation.

Bionomics

- The adult moth is stout with wing expanse of 4.0 cm and having green wings fringed with brown patches.
- The eggs are laid in batches of 10-15 on the under surface of leaves.
- The eggs are ovals flat scale- like in shape.
- The fecundity is on an average 167 eggs / female. The egg period is 7 days.
- The caterpillar is fleshy, slug-like with yellowish green body bearing a greenish blue stripe dorsally and yellowish green stripes laterally.
- The larval period is 5-6 weeks undergoes seven instars.
- It pupates in a hard shield - like greyish cocoon on the tree trunks for 4-5 weeks.

4. Slug caterpillar - *Conthyla rotunda* H. (Cochlididae: Lepidoptera)

Damage

- The caterpillar feeds on leaves causing severe defoliation.
- Besides it also feeds and damages spathes, flowering shoots and rind of young fruits.

Bionomics

- The moth is greyish brown to dark grey in colour.
- It lays the eggs on the under surface of leaves.
- Fecundity is about 215 eggs / female.
- The egg period last for 3-6 days.

- The slug like caterpillar is spiny with two grey stripes dorsally.
- The larval period is 27-48 days.
- It pupates in shell like cocoon of brown silk for 10-14 days

5. Bagworm - *Manatha albipes* Moore. (Psychidae : Lepidoptera)

Damage

- The larva feeds on leaves causing small irregular holes on the leaves.

6. Leaf caterpillar - *Turnaca acuta* W. (Notodontidae : Lepideptera)

Damage

- The larva feeds on the leaflets leaving the stick alone.

1. Lace wing bug - *Stephanitis typicus* Dist. (Tingidae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from the under surface leaves causing white spots on the upper surface of leaves.

Bionomics

- The adult is white coloured with netted venation on the wings.
- The female lays on an average of 30 eggs, which hatch in 12 days.
- The nymphal period is 13 days.
- The nymphs are gregarious in nature.

2. Scale insect - *Aspidiotus destructor* Sign. (Biaspididae:

Hemiptera)

Damage

- The nymphs and adult desap the leaflets resulting yellowing, withering and drying up of leaflets.

Bionomics

- It is circular hard scale occurs as persistent pest of coconut.
- A female lays up to 90 eggs under its shield like scale.
- The crawlers move out and distribute themselves to healthy leaflets.
- The life cycle is 32 days for male and 35 days for female.

3. Mealy bug - *Pseudococcus longispinus* Targ. (Pseudococcidae: Hemiptera)

Damage

- It infests the tender unopened fronds, which fail to grow resulting stunted, deformed and suppressed.
- It also infests the inflorescence and nuts causing button shedding.
- The mealy bug colonies remain inside the perianth and suck the sap leading to the drying of nuts.
- When the nuts are completely dried the bugs are distributed by ants to the newly formed inflorescence.
- In bearing trees the damage is caused both to the spindle leaf and to the buttons.

Bionomics

- It is a tiny insect covered with white mealy coating.
- The mealy bug is attended by several species of ants, which feeds on the honey dew secretions of the bugs.

Management

- Spread open two or three leaf axils surrounding the spindle leaf.
- Clean the crown of all the dried bunches to prevent the spread of the-bugs to the newly formed bunches.
- Spray quinalphos or dimethoate or Dimethoate at 0.03 % covering the spindle leaf, leaf axis and young bunches.

1. Termites - *Odontotermes obesus* Ramb. (Termitidae: Isoptera)

Damage

- The termite damages the seedlings in the nursery and also transplanted seedlings.
- The infested seedlings wilt and die.
- The base of the trunk is plastered with runways made of soil and fibers.

Bionomics

- Green coloured tiny insects resembling ants with dark coloured head.

Management

- Apply soil insecticides on transplantation of the seedlings.
- Locate the termite mount in the coconut gardens and destroy it.

- Locate and kill the queen termite to provide good solution.
- Give adequate irrigation to the seedlings to minimize the problem.
- Soil drench with 0.1 % carbaryl in the standing crop.

2. White grub - *Leucophollis coneophora* Burm. (Mesolonthidae: Coleoptera)

Damage

- The grub feeds on roots causing yellowing of leaves, shedding of immature nuts and delayed flowering.

Bionomics

- The adult is cheshut coloured beetle.
- It lays eggs in soil a depths of 7.5-15 cm and they hatch in 20 days. The younger stage of grub feeds on grass roots and organic matter, the later stages feeding on coconut roots. The grub is white, fleshy, stout and 'C shaped. It pupates in the soil for about 25 days. The insect has an annual life cycle.

Management

- Collect and destroy the adults beetles attracted to trees like neem, Ailanthus and Acacia near coconut field on receipt of monsoon showers.
- Plant neem twigs with leaves in coconut gardens after first rain to attract and kill adults.
- Set up light trap or bonfire to attract the adults.
- Apply malathion 5% D 25 kg or endosulfan 4D 25 kg / hectare to the soil at the time of sowing.

3. Red ant - *Oecophylla smaragdina* F. (Formicidae: Hymenoptera)

Damage

- The worker ants stitch together the terminal leaves with silk threads in the form of nests which remain green.
- They move about in long train all over the trunks and they are attracted to mealy bugs.
- They also cause annoyance to the climbers.

1. Mite - *Raoiella indica* Hirst. (Tenuipalpidae: Acarina)

Damage

- It sucks the sap from the leaves causing yellowing of the same.

2. Rats - *Rattus rattus* wroughtoni (Muridae: Rodentia)

Damage

- They rest on leaves on the crown of trees, cut holes in tender nuts, drink the sweet liquid and eat away the pulp, resulting the dropping of nuts.

3. Flying fox - *Pteropus edwardsii* (Chiropterae: Mammalia)

Damage

- They feed on tender nuts during night times and affected nuts drop off

Management of Vertebrates

- Cover the trunk with tin.
- Use poison baits and trap for rats.
- Provide bird nests to encourage predation.

- Remove dry leaves, spathes and matrix regularly from the crown to expose to the nesting places of rat to predators.
- Place 10 gram of bromodialone 0.005 % cake on the crown of one palm out of every five palms twice on an interval of 12 days.

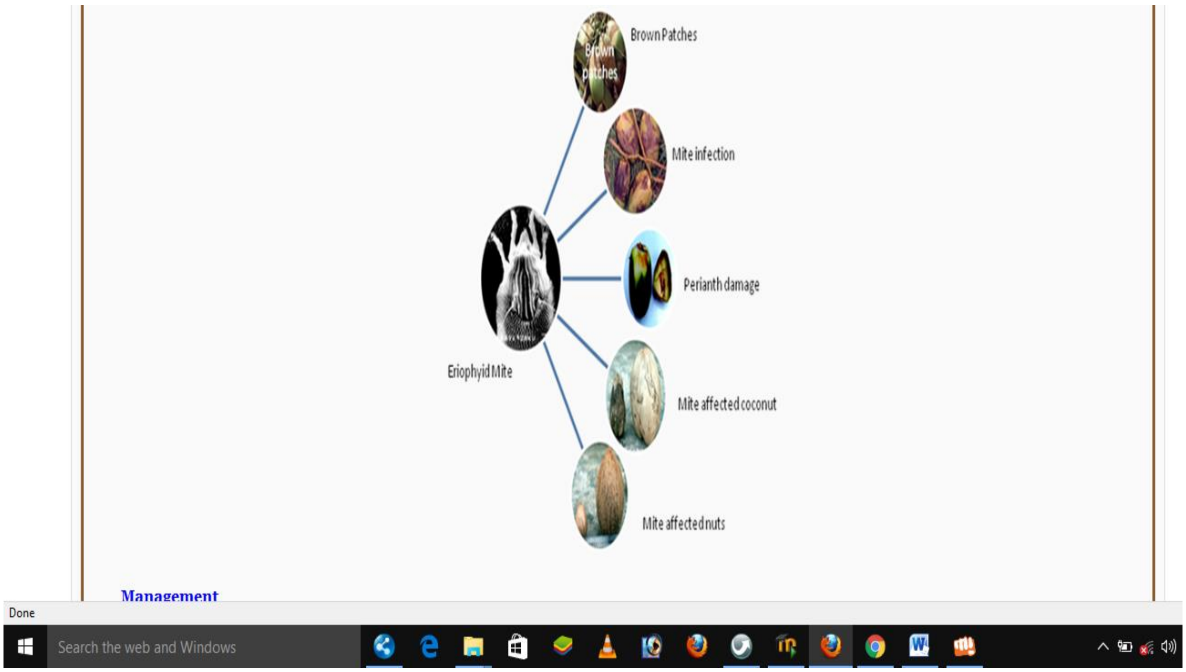
4. Eriophyid mite - *Aceria gurreronis* Keifer. (Eriophyidae: Acarina)

Damage

- The mite infests and develops on the meristematic tissues of the growing nuts under the perianth by desapping the soft tissues of the buttons.
- In the damaged buttons / nuts, an initial symptom will be exhibited in the form of triangular pale white or yellow patches close to each perianth.
- Different stages of mite live in white, tender portion covered by the inner tracts of the perianth and suck the sap continuously when the feeding activity is enhanced due to the increased population build up it results in physical damage to newly formed tissues which become necrotic.
- Intensive damage leads to the formation of brown coloured patches later on.
- In addition as the nut grows in size, longitudinal fissures and splits occur on the outer surface of the husk.
- Occasionally brownish gummy exudates are seen oozing out from the affected surface.
- Severe infestation results in poor growth reduced size and copra content and malformed nuts with cracks and hardened husk.

Bionomics

- It is found under the tracts of fertilized female flowers.
- It is very minute in size measuring 200-250 micron in length and 36-52 micron in width with two pairs of legs.
- It is pale in colour with elongate body and worm like in appearance.
- The life cycle of this mite consist of egg, two larval instars and one adult stage is completed in 10-12 days.



Management

- Apply urea 1.3 kg, super phosphate 2.0 and muriate of potash 3.5 kg/palm/year (Increased quantity of potash is recommended to increase the plan! resistant to the mite).
- Apply neem cake @ 5 kg and organic manure @ 50 kg / palm / year.
- Apply borax 50 g + gypsum 1.0 kg + manganese sulphate 0.5 kg / palm.

• Distribution, hosts and natural enemies of pests of Coconut and Cashew

Common name	Scientific name	Distribution	Hosts	Natural enemies
Rhinoceros beetle	*Oryotes rhinoceros* Linn.	India, Pakistan, South East Asia, Hainam, Taiwan, Philippines, Southern China, Australia Indonesia, fiji and	Coconut, talipot palm, date palm, African oil palm, palmyrah, sugarcane, pine apple,	**Parasitoids** *Sarcophaga fuscicauda* Bolt *Pheropsophus hilaris var sobrinus* Daj.

		Somoa.	banana and papaya	**Predators** *Agryphus sp* *Ctivina memnonia* Dej. *Omphra atrata* Klug *Oxyiobus spp.* **Pathogens** *Metarrhizium anisopliae* Metzch *Beauveria hassiana* Bals.
Red palm weevil	*Rhynchophorus ferrugineus* F.	India, Srilanka, Pakistan, Bangladesh Malaysia, Philippines, New Guinea, China and Taiwan.	Coconut, oil palm, date palm, sago and other species of palmae.	Egg **larval parasitoid** *Chelisoches moris* F, **predatory mite** *Pyemotes ventricosus* Newp.
Black-headed caterpillar	*Opisina arenosella* Walker	India (South India) Orissa & Bengal) Burma, Srilanka	Coconut, pal my rah, talipot palm, fish tail palm and *Phoenix sylvestris*	***Larval parasitoids*** *Apanteles taragamaeWm* *Bracon hrevicornis* Wesm. *Perisierola nephantidis* Meus *Elasmus nephantidis* Gahan ***Pupal parasitoid*** *Trichospilus pupivora* Ferr. *Stomatocera sulcatisscvtelluer* Gir. *Brachymeria nephantidis* Gah *Xanthopimpla punctata* F **Pathogens** Fungus

				Aspergillus flavus Bacteria *Serratia marcescens* Bizio
		Cashew		
Cashew tree borer	*Plocoderus ferrugineus* Linn.	South India	Cashewnut	
Shoot & blossom	*Macalla monocusalis* Wlk.	India	Cashewnut	
Leaf miner	*Acrocercops syngramma* M.	India	Cashewnut	
Re&banded thpps	*Selenothrips rubrocinctits* G.	India, Philippines	Cashewnut	

OILPALM

1. Spindle bug - *Carvalhoia areacae* Mill & China. (Miridae : Hemiptera)

Damage

- Both nymphs and adults feed on the spindle and unfolding leaves causing spindle necrosis.

Bionomics

- Eggs are laid within tender spindle.
- Egg and nymphal periods last for 9 to 10 and 15 to 20 days respectively.
- Nymphs are deep greenish to violet brown in colour with thorax and border of abdomen light violet brown and head is light yellow with red eyes.
- Adult bug is hairy dark violet brown with black tipped abdomen.

Management

- • Place one or two phorate sachets (0.2g a.i) in the axils of the new leaves when infestation is very high.
- • Spray the spindles with lindane 20 EC 2 ml / 1 or carbaryl 50% wP 2.5 g/l.

2. Scale - *Pinnapsis aspidistrae* S. (Diaspididae: Hemiptera)

Damage

- Both nymphs and adults infest the unripe fruits.

3. Mealy bug - *Palmiculator sp* (Pseudococcidae: Hemiptera)

Damage

- Both nymphs and adults desap the spear and unfolding leaves.

1. Hairy caterpillar - *Dasychira mendosa* Hb. (Lymantriidae: Lepidoptera)

Damage

- The caterpillar feeds on the leaf voraciously and cause defoliation.

2. Leaf eating caterpillar - *Spodoptera litura* Fab. (Noctuidae: Lepidoptera)

1. Hairy caterpillar - Dasychira mendosa Hb. (Lymantriidae: Lepidoptera)

Damage

- The caterpillar feeds on the leaf voraciously and cause defoliation.

2. Leaf eating caterpillar - *Spodoptera litura* Fab. (Noctuidae: Lepidoptera)

Damage

- The caterpillar causes defoliation.

3. Bagworm -Manatha albipes Moore., *Metisa plana* Wlk. and (Psychidae : Lepidoptera)

Damage

- The bag worm feeds on the leaf cause defoliation in nursery.
- The damage is noticed in outer whorl of fronds and occasionally in the middle whorl of fronds.

4. Smug caterpillar - *Darna jasea* and *Thosea andamanica* (Limacodidae: Lepidoptera)

Damage

- The slug caterpillar feeds on the leaf voraciously and causes defoliation in the nursery.

1. Rhinoceros beetle - *Oryctes rhinoceros* Linn. (Scarabaeidae: Coleoptera)

Damage

- The adult beetles cause severe damage to young as well as old trees. The beetles live in crevices between the leaf sheaths near the crown and burrow in to the softer portion feeding on the un opened fronds and inflorescence. The beetles chews the internal tissues and after injecting the juicy part throws out the fibrous part which comes out of holes is the indication for the presence of beetle in the crown. The infested fully opened fronds showing the characteristic 'v' shaped cuts on leaf lets. The young seedlings are often killed when the growing points are damaged. The repeated attack in old trees causes stunting of growth and present sickly appearance to the trees. Bore holes with chewed fibre sticking out at the base of central spindle is the typical symptom of attack.

Bionomics

- The adult beetle is black, stout measures 5 cm long and has a long horn projecting dorsally from the head. The horn is longer in male and shorter in female beetle. The female lays globular eggs singly in decaying organic matter such as manure pits, dead tree trunks compost heaps. The fecundity of the insect is 140-150 eggs per female. The egg period is 8-18 days. The newly hatched grub feeds on decaying organic matter. The grown up grub is stout, white, 'C shaped, sluggish and has a pale brown head. The larval period is 100-180 days. It pupates in earthern cells at a depth of 30-90 cm or more. The pupal stage last for 10-25 days. The adults make their way out and fly to the trees. The adult beetles lives for more than 200 days.

2. Red palm weevil - *Rhyhchophorus ferrugineus* Oliver. (Curculionideae: Coleoptera)

Damage

- The grub enters in to the stem and feeds on the internal tissue of the trunk causing a small hole on the stem with protruding chewed fibrous materials and oozing out of a brown liquid from such holes and eventually resulting in the toppling of the crown portion. In the advanced stage of attack, the central shoot shows sign of wilting and large mass of grubs, pupae and adults in fibrous cocoon could be seen inside the trunk at the damaged portion. In the grown up trees, the beetle causes damage by laying the eggs on the crown region. In such cases the grub easily enter into the growing point or cabbage of crown and causing yellowing of inner leaves and gradual drying of central shoot in the crown.

Bionomics

- The weevil is reddish brown with 6 dark spots on the thorax a conspicuous snout with tuft of hairs. The female weevil lays eggs in small holes scooped out by her on the soft regions of young palms up to 7 years of age. In the grown up trees the eggs are laid in the cuts or wounds present on the trunk or leaf stalk. The plant sap oozing out of wounds and cut attract the weevil for ovipositon. The eggs are creamy white in colour. The eggs hatch out in 2-3 days time into soft white grub. The grub is apodous which tunnel into the trunk and feeds on the internal succulent tissues. The larval period ranges between 45 and 75 days. The full-grown grub is stout, fleshy, and apodous with a conical body bulged in middle and tapering towards the ends. It pupates in a fibrous cocoon made out of fibrous strands.
- The pupal period last for 2-3 weeks. The total life cycle is completed in about 4 months. The adult weevils are reddish brown with long curved,

pointed snout. The male weevil can be distinguished from the female by the presence of tuft of hairs along the dorsal aspect of snout.

Management

- Remove and burn all wilting or damaged palms in the garden.
- Avoid injuries or wound on stems as they serve as oviposition site for weevil.

- Fill all the holes with cement on the stem or trunk of coconut.
- Avoid the cutting of green leaves. If needed they should be cut about 120 cm away from the stem.
- Set up attractant traps (mud pots) containing sugarcane molasses 2.5 kg + toddy 2.5 litres + acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem/logs of green petioles of leaves of 30 numbers in one acre to trap weevil.
- Set up male aggregation pheromone, ferruginol (4 methyl 5 nonanol) trap -ferrolure to attract the weevil.
- Follow the root feeding of monocrotophos 36 WSC 10 ml + 10 ml of water per tree.
- Insert one or two tablets of aluminum phosphide inside the tunneled trunk and plug all the holes with clay and cement mixed with copper oxy chloride to kill the insect by the fumigant action.

1. Termite - *Odontotermes obesus* Ramb. (Termitidae: Isoptera)

Damage

- The termite damages the seedlings in the nursery and also transplanted seedlings.
- The infested seedlings wilt and die.
- The base of the trunk is plastered with runways made of soil and fibers.
- It feeds on roots, inflorescence and fruit bunches.

Bionomics

- Green coloured tiny insects resembling ants with dark coloured head.

Management

- Apply soil insecticides on transplantation of the seedlings.
- Locate the termite mount in the coconut gardens and destroy it.
- Locate and kill the queen termite to provide good solution.
- Give adequate irrigation to the seedlings to minimize the problem.
- Soil drench with 0.1 % carbaryl in the standing crop.

2. White grub - *Apogonia sp* and *Adoretus sp* (Melolonthidae: Coleoptera)

Damage

- The grub feeds on the roots of seedlings causing death of the plants.

Management of oil palm pests

Cultural Methods

- Remove dead palm trunks and empty bunch heaps from the field and maintain good field sanitation.
- Hand picks the adults of rhinoceros beetle using iron hook.
- Collect and destroy all the various bio stages of the rhinoceros beetle from the manure pits.
- Set up light trap following the first rains in summer and monsoon period to attract the rhinoceros beetle and red palm weevil.

- Soak castor cake at 1 kg in 5 litres of water in small mud pots and keep them in the oil palm garden to attract and kill the adults of rhinoceros beetle.
- Keep the mud pots containing toddy, acetic acid, oil palm petioles and yeast to attract and kill the adult red palm weevil.
- Do not cut the green leaves of oil palm and cut them at 120 cm away from the base if it is needed.
- Avoid cuts and injuries on oil palm.

Biological Methods

- Release exotic predator reduvid bug, *Platymeris laevicollis* at 6 bugs per palm at regular intervals to reduce the population of rhinoceros beetle.
- Apply entomopathogenic fungus *Metarrhiziwn anisopliae* @ 5 x 10 spores 3 / m at the breeding site of the rhinocerous beetle.
- Release *Oryctes baculovirus* inoculated beetles in the oil palm plantation to minimize the pest incidence.

Chemical Methods

- Place 3-4 naphthalene balls in the youngest spear axils at weekly intervals to deter the rhinoceros beetle.
- Fill the crown and top most three-leaf axils with a mixture of carbaryl 10 D and fine sand (1:2 by volume) once in 3 months.
- Drench the manure pit with carbaryl 0.1 % solution once in three months.

- Follow root feeding of monocrotophos at 10ml + 10 ml water for 3 times at 3 weeks interval of time to control red palm weevil.
- Place 1 -2 phorate sachets (0.2g ai) in the axils of the new leaves to minimize the infestation of spindle bug.

ARECANUT

Introduction

- Arecanut is an integral part of pan-chewing in India.
- It is also a commodity of export earning sizable foreign exchange.
- Follwing are the details on important pests of arecanut.

4. Inflorescence caterpillar
5. Spindle bug
6. Inflorescence aphid
7. Scale
8. Scarlet mite
9. White grub
10. Black headed caterpillar
11. Leaf caterpillar

1. Inflorescence caterpillar-*Tirathaba mundella* Wlk. (Pyraustidae: Lpidoptera)

Damage

- Tender branches of inflorescence are webbed together with silken threads of caterpillar.
- Wet mass of excreta protrudes out of the web.

- Bore holes are seen at the base of unopened spathes and buttons, which are plugged with excreta.

Bionomics

- Larva is dirty yellow or white with brown head.
- Adult moth is small with ashy wings.
- Eggs are laid on tender spathes.
- Egg, larval and pupal periods last for 5, 25 and 10 days respectively.
- Pupation occurs within galleries.

2. Spindle bug- *Carvalhoia arecae* (Miridae: Hemiptera)

Damage

- Nymphs and adult suck sap, which results in linear black necrotic streaks on the central shoot, stunted and twisted growth.
- Affected central shoots do not open fully and leaves become dry and shed off.

Bionomics

- Eggs are laid within tender spindle.
- Egg and nymphal periods last for 9 to 10 and 15 to 20 days respectively.
- Nymphs are deep greenish to violet brown in colour with thorax and border of abdomen light violet brown and head is light yellow with red eyes.
- Adult bug is hairy dark violet brown with black tipped abdomen.

Management

- Spray the spindles with lindane 20 EC 2 ml / 1 or carbaryl 50% wP 2.5 g/l.

3. Inflorescence aphid - *Cerataphis lataniae* Boisd. (Aphididae: Hemiptera)

Damage

- Nymphs and adults suck sap from the inflorescence and young nuts, which results in sooty mould development and premature shedding of nuts.

4. Scale- *Icerya aegyptica* Dough (Margarodidae:Hemiptera)

Damage

- White mealy scale insects cover the stalks and base of ripe nuts and suck sap.
- Affected region becomes soft with black necrotic patches and watery exudation.

5. Scarlet mite - *Raoiella indica* Hirst. (Phytoaptipallidae: Acarina)

Damage

- White nymphs and light brownish yellow adults suck sap from the leaves, which result in yellow patches on the lower surface of leaves.

6. White grub - *Leucopholis coneophora* (Melolonthidae: Coleoptera)

Damage

- White, flesy and ‘C’ shaped grubs feed on the roots, which results in yellowing of leaves, tapering stem, stunted growth and shedding of nuts.

7. Black headed caterpillar - *Opisina arenosella* (Cryptophasidae: Lepidoptera)

Damage

- Caterpillars feed on under surface of leaves and form galleries with silken thread and frass.

8. Leaf caterpillar - *Elymnias caudate* Butl. (Satyridae: Lepidoptera)

Damage

- Irregularly clipped leaf blades are observed.

Bionomics

- Larva is green with deep grey head having a pair of black horns, rough body with dorsal yellow stripe.
- Adult is a medium sized butterfly with deep brown wings mingled with white and violet colour.

Lecture No. 23

Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Coffee and Tea

COFFEE

Introduction

- Though over a hundred species of insects, a few invertebrates and mammals have been recorded as pests on coffee in India, only a few of them are economically important. Among coffee pests, insects form the major group. Coffee is a perennial plant and is subjected to attack by passing as well as sedentary insects. Almost all portions of coffee plants are susceptible to one pest or the other.
- In India, coffee is cultivated under shade trees, which greatly influences the microclimate in the coffee ecosystem. Coffee pests could be kept below economic injury level by adopting integrated management strategies such as anticipation and continuous monitoring of pest outbreaks, maintenance of optimum over-head shade for judicious management of ecological factors, handling and pruning of coffee bush, conservation and augmentation of indigenous natural enemies, introduction of exotic natural enemies and timely use of need based biopesticides / insecticides.

Bioecology and management of the important coffee pests are briefed below.

- Major pests of coffee are the white stem borer (*Xylotrechus quadripes*), Coffee berry borer (*Hypothenemus hampei*), Short-hole borer

(*Xylosndrus compactus*), Mealybugs (*Planococcus citir* & *P.lilacinus*), Green scale (*Coccus viridis*) and root lesion nematode (*Pratylencbus coffeae*).

- Apart from the above mentioned manor pests a few other pests are also considered as minor pests occasionally found on coffee. They are brown scale (*Saissitia coffeae*), cockchafers or white grubs (*Holotricbia spp*.), coffee bean beetle (*Araecerus fasciculaturs*), hairy caterpillars (*Eupterote spp*.), read borer (*Zeuzera coffeae*), snail (*Ariophanta solata*), Tailed mealybug (*Ferrisia virgata*),Termites or white ants and Thrips (*Heliobtips baemorrboidalis*, *Retithrips syriacus*, *Scirtothrips bispinosus, Thrips nilgiriensis*)

1. White stem borer - *Xylotrechus quadripes* (Coleoptera: Cerambycidae)

- White stem borer is a very serious pest of Arabica coffee in India.

Life history and damage

- Adult is a slender beetle, 1 to 2 cm long.
- The forewings are black with white bands.
- Adults are active in bright day light.
- Female beetles deposit eggs in the cracks and crevices and under the loose clay bark of the main stem and thick primaries preferring plants exposed to sun light.

- Young grubs feed in the corky portion just under the bark for about two months.
- Consequentially, the bark splits and appears as a ridge on the stem.
- Later the larvae enter the hardwood and make the tunnels in all directions.
- In some cases the tunnels may extend even into the roots.
- The tunnels are tightly packed with excreta of the grubs.
- The grub stage lasts for about 9 to 10 months.
- Larva pupates in a chamber close to the periphery of the stem.
- The pupal stage lasts for 3 to 4 weeks after which it transforms into an adult.
- The adult remains in the tunnel for 3 to 7 days and emerges out by cutting an exit hole in the bark.
- The borer completes its life cycle in about a year.

Symptoms of attacks

- Infested plants show external ridges around the stem.
- Such plants may also exhibit signs like yellowing and wilting of leaves which will be distinct after the onset of monsoon when the healthy plants starts putting new growth.

- The young plants (7 to 8 year old) attacked by the borer may die in a year white older plants withstand the attack for a few seasons, yielding more of floats.

Borer infested farm

Nature of damage

Flight periods

- There are two flight (emergence) periods from April to May and October to December.

Control measures

- Maintain optimum shade
- Trace the infested plants prior to flight periods (*i.e.*,in March and September) every year by looking for ridges on the main stem and thick

primaries. Collar prune the infested plants, uproot if the borer has entered the root and burn the affected parts. Storing of infested stems on the estate will result in continuous infestation.

- Proper agronomic practices to retain plant vigour
- Remove loose scaly bark to discourage egg laying
- 10% lime application on main stem and thick primaries during flight periods
- Repeated application of neem oil on the stem
- Use of pheromone traps to monitor incidence
- Judicious and timely application of pesticides on the stem during flight period

2. Red borer-*Zeuzera coffeae* Nietn. (Cossidae: Lepidoptera)

Damage

- The red caterpillar bores into the stem and branches causing wilting of branches.
- Presence of bore, holes plugged with excreta at the base of the plant is the typical symptom of attack.

Bionomics

- The adult is white moth with black or steel blue spots in the wings. The larva is orange red and smooth

3. Coffee bean beetle *Araecerus fasciculatus* D. (Anthribidae : Coleoptera)

Damage

- The grub bores in to the ripening berries.
- The infested berries have small holes on them and become blackened and shrunk.
- The berries in store are more seriously attacked than those in field.

Bionomics

- Adult is pale grey, elongate, oval and slightly flattened tapering anteriorly entire body clothed with hairs.
- Grub is white, soft and apodous.

4. Coffee berry borer - *Hypothenemus hampei* (Coleoptera:Scolytidae)

- The coffee berry borer is the most serious pest of all coffee cultivars the world over.
- The pest was first noticed in India on a few plantations in Nilgiris in early 1990.

Life history

- The adult berry borer is a small black beetle with a sub-cylindrical body covered with thick hairs.
- Females are approximately 2.5 mm long. Males are smaller.
- The female beetle bores into the berry through the navel region.

- Though berries in various stages of development are attacked, tunneling an ovipositon occur only in hard beans.
- The mother beetle lays about 15 eggs in the tunnel.
- Eggs hatch in about 10 days.
- The larvae feed on the beans making small tunnels.
- Larval period lasts for about 20 days and the pupal period for a week.

- Development from egg to adult takes just over a month.
- The ratio of male to male is approximately 10:1.
- Mating takes place inside the berries.
- The short life cycle enables the pest to complete several generations in a year, in quick succession, under favorable conditions.
- The beetle in the berries either on the plant or on the ground can survive for more than five months.
- This enables the pest to carry over from one seasons crop to the next.
- The pest usually comes out and infests fresh berries in the evening hours.
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- The borer incidence could be pronounced at an altitude range of 500 m to 1000 m above sea level.

Damage

- A typical pin hole at the tip of the berries indicates the presence of the pest.
- In case of a severe infestation, two or more holes may be seen, either in the navel or on the sides.
- A powdery substance pushed out through the holes reveals the active tunneling and feeding within the beans.
- The pest damages young as well as ripe berries.

- Infested tender berries may fall due to injury or secondary infection by fungi.
- Breeding occurs in developed berries from the time the bean becomes hard and continues in the ripe and over-ripe berries either on the plant or on the ground.
- Generally only one of the beans in a berry is affected.
- Damage to both the beans could be noticed occasionally, especially during the fag end of the cropping season.
- In case of severe infestation 30 to 80% of the berries may be attacked, resulting in heavy crop loss.

Control measures

- Timely harvest – Reduces carry over inoculums and thorough harvest – breaks the life cycle.
- Removal of off-season berries to break the continuity of the breeding
- Spread gunny/plastic sheets (picking mats) below the plants minimizes the gleaning.
- If gleanings could not be collected they may be swept along with the mulch and buried below a depth of 0.75 m in the soil.
- Avoid excess shade. Train bushes properly.
- Avoid planting tree coffee
- Dry coffee to the prescribed specification:
    - Arabica/robusta parchment – 10.0% (15.5 kg/for lit)
    - *Arabica* cherry - 10.5% (16.0 kg/for lit)
    - *Robusta* cherry - 11.0% (18.0 kg/for lit)
- Do not transport infested crop to other areas.
- Dipping infested berries in boiling water for 2-3 minutes kills all the stages inside.
- Use only fumigated gunny bags to avoid cross infestation.
- Spray a suspension of the fungus *Beauveris bassiana* when the beetles are in the pulp.
- Use of parasitoids – *Cephalanomia stephanoderis*

5. Shot-hole borer: *Xylosandrus compactus* (Coleoptera : Scolytidae)

- The short hole borer is a major pest of robusta coffee.

Life history

- The adult beetle is brown to black with a short, sub-cylindrical body.
- The pest usually infests the green succulent branches of old plants.
- In young plants, the main stem also may be attacked.
- After entering into the twig through the shot hole made on the underside, normally between the nodes, the female makes a longitudinal tunnel.
- The beetle then lines the wall of the gallery with an 'ambrosia' fungus.
- After growing the fungus, the female lays about 50 eggs in batches.
- The eggs hatch in 2 to 3 days, the milky white larvae feed on the ambrosia.
- The larval stage lasts for 13 to 21 days, and the pupal stage for about 11 days. Egg to adult emergence takes four to five weeks.

- Matting occurs inside the gallery.
- Unmated females give birth to male progeny. Males have no functional wings.
- The short life cycle enables the pest to complete several generations, in quick succession, under favourable conditions.
- The incidence is generally low before the onset of the southwest monsoon, reaches a peak from September to January, and gradually declines during the dry period.

Damage

- Withered or dried branches with shot holes indicate the presence of the pest.
- The attacked branches dry up fast. Leaves distal to the point of attack fall prematurely.
- The terminal leaves wilt, droop and dry up.

Control measures

- Prune the affected twigs 5 cm to 7.5 cm beyond the shot hole and burn.
- This operation should be commenced from September onwards and continued as a routine measure at regular intervals.
- Remove and destroy all the unwanted/infested suckers during summer.
- Maintain thin shade and good drainage.

5. Shot-hole borer: *Xylosandrus compactus* (Coleoptera :

Scolytidae)

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- The pest usually infests the green succulent branches of old plants.
- In young plants, the main stem also may be attacked.
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- The beetle then lines the wall of the gallery with an 'ambrosia' fungus.
- After growing the fungus, the female lays about 50 eggs in batches.
- The eggs hatch in 2 to 3 days, the milky white larvae feed on the ambrosia.
- The larval stage lasts for 13 to 21 days, and the pupal stage for about 11 days. Egg to adult emergence takes four to five weeks.
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1. Leaf miner *Melanagromyza coffeae* H. (Agromyzidae: Diptera)

Damage

- The maggot mines into leaves.

2. Hairy caterpillar *Eupterote canaraica* M-, E.fabia Cram. (Bombycidae: Lepidoptera)

Damage

- It causes defoliation

Bionomics

- See under cardamom.

Management

- Collect and destroy the caterpillars and pupae from January - March. Set up
- light traps in June - July to attract and kill the moths.
- Spray Dimethoate 0.03 % or fenitrothion 50 EC 240 ml along with one litre of emulsified oil of 1 kg of fish oil rosin soap in 200 litres of water.

3. Leaf caterpillar *Agrotis segetum* Dams. (Noctuidae: Lepidoptera)

Damage

- The caterpillar feeds on the seedlings of coffee plant and destroys nurseries.

4. Coffee grasshopper *Autarches miliaris* D. (Acrididae: Orthoptera)

Damage

- It causes severe defoliation.

• 5. Wooly bears *Pericallia ricini* Fab. (Arctiidae: Lepidoptera)

See under potato.

1. Green Scale - *Coccus viridis* (Coccidae: Homoptera)

- Green scale is an important sucking pest of *Arabica*, but attacks *robusta* also.

Life history

- The adult scale is flat, oval, light green with an irregular dark distinct loop on the middle of the dorsum.
- The adult is sedentary and spends its whole life in one place, it lays 50-60 eggs.
- The duration of the life cycle is 4-6 weeks.
- Adult lives up to 2-5 months.

Damage

- The scale attacks tender parts, setting down on the underside of the leaves close to midrib, veins, and tips of green shoots.
- The continuous sucking results in excess loss of sap from the plant which leads to debilitation of the older plants and death of nursery plants.
- The honey dew secreted by the scale forms a film on the leaves and a black fungus (sooty mould) grows on it, which hinders photosynthesis.

Ant association

- Association of ants with green scale is similar to that explained for mealybugs.

Control measures

- Maintain optimum shade
- Control ants by dusting quinalphos 1.5% or methyl parathion 2% or malathion 5% dust around the base of the bush and shade trees. Destroy ant nests.
- Remove and destroy weeds, as many of them harbor the pest.
- Use recommended dose of insecticide when the attack is above ETL.

2. Root lesion nematode

- Plant parasitic nematodes are microscopic 'round worms' attacking almost every crop.
- The root lesion nematode is highly distractive to Arabica coffee.
- Robusta is tolerant to Arabica coffee. Robusta is tolerant to nematodes.

Life History

- The nematode lays eggs in the root-lesions. Development from egg to adult takes about a month.
- All stages of the nematodes are attracted to the young and vigorously growing roots but only the second stage juveniles enter the roots at the piliferous zone.
- Robusta exhibits tolerance to the nematodes at all stages, and the nematode takes more time to complete its life cycle in robusta than in Arabica.
- The nematode spreads to other areas through estate implements, rain water, plants taken from the infested nurseries and soils taken from infested blocks.
- The pest is persistent in the soil and roots all round the year. Higher population is noticed during the months of July, August and September when there is heavy rainfall and increased root activity.
- The population declines from December to March.
- Damage and symptoms of attack
- Nematodes feed and destroy the tap root, secondary roots and feeder roots.

- Affected plants put forth adventitious roots at the collar region during rainy season.
- Such plants have loose anchorage and could be easily dislodged.
- Affected old plants lack secondary and tertiary roots.
- Affected young plants become unhealthy with lean and lanky stem.
- Older leaves become yellow and drop, leaving very few undersized, chlorite and crinkled leaves at the tip of the main stem giving a 'tufted' appearance.
- Affected bearing plants show thinner main stem and have inadequate foliage to support the crop.
- Fresh leaves produced during pre-monsoon period are smaller, crinkled, chlorotic and leathery, but the leaves produced during monsoon are normal and healthy.
- Death of leaves will continue till December, leaving one or two pairs of leaves at the tip during next summer or producing a 'goose-neck' after the receipt of rains.

Control Measures

- In The Nursery
- Dig up the nursery site and expose the soil to the sun during summer.
- Sieve and dry jungle soil and farmyard manure thoroughly before use.
- Avoid obtaining nursery plants from infested areas.
- In The Filed
- Uproot and burn the affected plants.
- Dig up pits and expose the soil to the sun for at least one summer

- Take care to keep the pits free from weeds.
- Plant the area with Robusta (if suitable) or Arabica – Robusta grafted plants (Arabica scion grafted on to Robusta root stock at 'topee' stage)

3. Brown scale - *Saisettia coffeae* Wlk. (Coccidae Hemiptera)

Damage

- Both nymphs and adults infest the leaves and tender shoots causing yellowing and drying of leaves.

Bionomics

- Adult is hemispherical and the body covered by a snuff coloured hard shield.
- Nymph is yellow or greenish brown in colour.

4. Aphid *Toxoptera aurantii* Boyen. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from the leaves resulting stunting, curling of leaves and falling of flower buds and developing fruits.
- The infested leaf attracts sooty mould due to honeydew secretion of the insect.

Bionomics

- The adult fly is dark orange with smoky wings and fore wings having four whitish areas of the irregular shape.
- The female fly lays yellowish brown, oval eggs arranged in spiral on broad leaves.

- The egg period is 7-14 days. The nymphal period is 38-60 days with four nymphal instars.
- It pupates on leaf surface. The pupal period last for 100-131 days.
- There are two generations in a year.

Management

- Spray monocrotophos 36 WSC at 1.5 ml/litre of water.

5. Thrips *Scirtothrips bispinosus* Bagn. (Thripidae: Thysanoptera)

Damage

- Both nymphs and adults lacerate and suck the tender leaves.
- Due to the punctures caused by stylets the feeding site appear as brown spots or as continuos lines called "sand paper lines" In severe cases of infestation leaf growth is arrested, leaves become brittle, crinckled and corky and fall prematurely.

Bionomics

- S. dorsalis - This is known as Assam thrips, causes severe damage to tea bushes in North India.
- Its life cycle is completed in 13-17 days but the duration may vary in the different seasons. S. bispinosus -
- This is yellowish brown in colour which is found in large numbers in most tea growing areas of south India.

- The peak period for the population build up is between May and December.
- This life cycle is completed in 19 days.

1. White grub *Holotrichia conferta* S. (Melolonthidae : Coleoptera)

Damage

- The grub feeds on roots of the young seedlings.

• Distribution, hosts and natural enemies of pests of Coffee

Common name	Scientific name	Distribution	Hosts	Natural enemies
White stem borer	*Xylotrechits quadripes* Chevrolat	South India, Assam, Burma, Srilanka, Thailand, Philippines and Indonesia.	Coffee, Ixora *Olea dioica*	**Parasitoid** *Metapdma sp.*
Red borer	*Zeuzera cqffeae* Nietn	India, Malaysia	Cocoa, coffee	
Shot-hole borer	*Xylosandms compactus* Eichhoff	India, Papua, Madagascar, South-East Asia and New Guinea	coffee, tea, citrus, avocado, castor, rubber, cinchona etc.	
Coffee berry borer	*Hypothenemus hampei* Ferr.	Tropical Africa India, Srilanka, South East Asia Indonesia, Brazil New Guinea, Colombia, Surinam.	Coffee, hibiscus, Rubiaceae Leguminous plants	**Predators** Uganda Wasp - *Prorps nasuta* Waterston
Coffee green scale	*Coccus viridis* Green.	India, Ceylon, Burma, Bangladesh, Thailand, Malayia.	Coffee, citrus guava, mango and tea.	

Brown scale	Saisettia coffeae Wlk.	Cosmopolitan	Coffee, citrus, ea, guava and mango	**Parasitoids** *Aneristrus ceroplastae* How. *Coccophagus flavescens* How. *Coccophagus cowperi* Gir.
Striped mealy bug	*Ferrisia Virgata* Ckll.	Pan tropical, India, Srilanka, Pakistan, Burma, Bangladesh and Malaysia.	Coffee, cocoa, cotton, jute, citrus, beans, groundnut, cassava, sugarcane, sweet potato, guava, cashew and tomato	

TEA

1. Tea mosquito bug - *Helopeltis theivora* Waterhouse. *H .antonii* (Miridae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from young leaves, buds and tender shoots resulting dry spots on leaves and brownish patches in the tender shoots, buds and stem.
- In severe cases, the leaves curl up and shoot dry up.
- The attacked shoot may present die - back symptoms.

Bionomics

- The adult is a small, active elongated bug with black or olive green head.
- It has yellow and black thorax and yellow and greenish black abdomen.
- It thrusts the eggs in to the surface tissues of tender shoots, buds, mid ribs and petioles Eggs are elongated sausage shaped with two minute hairs on its operculum which project out of the eggs.
- The egg period is 5-7 days.
- The nymph is dirty yellow with long legs and antennae which resemble ants.
- They become full grown in 3 weeks under going five instars.
- Both nymphs and adults are active moving about on the bushes, flying swiftly in the early hours of the day.

Management

- Collect nymphs and adults with hand nets early in the morning or in the evening and destroy them.
- Spray the bushes with malathion 50 EC at 2 ml / litre of water.

2. Leaf hopper - *Empoasca flavescens* Fab. (Cicadellidae: Hemiptera)

Damage

- Both nymphs and adults desap the leaves resulting curling and crinkling of leaves.
- The margins of the leaves turn brownish and dry up causing the symptom "rim blight."

Bionomics

- It is a small yellowish green jassid.
- It lays eggs singly on the veins and midribs of leaves and on young stems.
- The egg period is 6-13 days.
- The nymphal period ranges from 8-12 days with five instars.
- The insect is found on the plants throughout the year.

3. Tea Aphid -*Toxoptera aurantii* Boyen. (Aphididae: Hemiptera)

Damage

- Colonies of dark brown to black aphid desap the tender stem, underside of young leaves and buds.
- The infested leaves curl and crinckle.

- Sooty mould develops on the leaves due to honeydew secretion of the aphid

4. Tea thrips -*Scirtothrips bispinosus* Bagn., *S.dorsalis* Hood and *Taeniothrips setiventris* Bagn. (Thripidae: Thysanoptera)

Damage

- Both nymphs and adults lacerate and suck the tender leaves.
- Due to the punctures caused by stylets the feeding site appear as brown spots or as continuos lines called "sand paper lines" In severe cases of infestation leaf growth is arrested, leaves become brittle, crinckled and corky and fall prematurely.

Bionomics

- ***S. dorsalis*** - This is known as Assam thrips, causes severe damage to tea bushes in North India. Its life cycle is completed in 13-17 days but the duration may vary in the different seasons.
- ***S. bispinosus*** -This is yellowish brown in colour which is found in large numbers in most tea growing areas of south India. The peak period for the population build up is between May and December. This life cycle is completed in 19 days.

5. Brown scale - *Saisettia coffeae* Wlk. (Coccidae: Hemiptera)

Damage

- Both nymphs and adults infest the leaves and tender shoots causing yellowing and drying of leaves.

Bionomics

- Adult is hemispherical and the body covered by a snuff coloured hard shield.
- Nymph is yellow or greenish brown in colour.

1. Looper - *Biston suppressaria* Guen. (Geometridae: Lepidoptera)

Damage

- The looper caterpillar causes severe defoliation

Bionomics

- The adult moth is greyish finely specked with black and yellow bands and spots along the other margins of wings.
- It lays eggs in groups of 200-600 on the trunk of shade trees and covered with buff coloured hairs.
- The egg period is 8-9 days.
- The larva is greyish brown resembling closely as that of tea twigs which become full grown in 24-36 days.
- It pupates in soil for 20-22 days.

2. Leaf roller - *Gracillaria theivora* Wism. (Gracillaridae: Lepidoptera)

Damage

- The second instar larva mines the tender leaf making serpentine tunnels for few days after which it reaches leaf margin.

- The fourth instar larva rolls the leaves from tip downwards.

Bionomics

- The purplish brown tiny moth lays eggs singly on the underside of leaves.
- The egg period is 2-3 days.
- The larva is yellowish.
- It pupates in a silken cocoon on the underside of the leaf for 9-13 days.

3. Bunch caterpillar - *Andraca bipunctata* Wlk. (Bombycidae: Lepidoptera)

Damage

- The caterpillar feeds on the surface tissues and later on leaf blades causing defoliation.
- It remain clustered in characteristic bunches on branches hence the name bunch caterpillar.

Bionomics

- The adult moth is brownish with dark wavy lines on the wings and two white spots distally on fore wings.
- It lays eggs in clusters of up to 120 eggs on the undersurface of leaves.
- Fecundity is about 500 eggs/female. The egg period is 10-11 days.
- The larva is smooth, greyish in colour with brown patches.
- It pupates on the ground among dried up leaves. The pupal period is about 16-29 days.

Management

- Collect and kill the caterpillar
- Spray malathion 50 EC at 2ml/lit of water.

4. Lobster caterpillar - *Neostauropus (= Stauropus) alternus* Wlk. (Notodontidae: Lepidoptera)

Damage

- The adult is brownish grey moth.
- The female moth lays eggs in small clusters on the undersurface of the leaves and hatch in 4-20 days.
- The grown up larva is about 40-45 mm, long with varying coloration of brown to black and is speckled, mottled or pubescent.
- The thoracic leg and abdominal claspers are elongated giving the larva the appearance of lobster when disturbed.
- It pupates between webbed up leaves in a cocoon.
- The pupal period is 10-23 days.

5. Flush worm - Cydia *(= Laspeyresia) leucostoma* Meyr. (Eucosmidae: Lepidoptera)

Damage

- The larva webs together the bud and feeds from inside on the surface tissues resulting the leaves become rough and discoloured.

Bionomics

- The adult moth is brownish with yellow and white streaks in fore wings.

- It lays eggs singly on under surface of leaves.
- The larva is green or brown in colour.
- The pupation takes place inside the leaf fold.

6. Tea tortrix - *Homona coffearia* Nietn. (Tortricidae: Lepidoptera)

Damage

- The caterpillar makes leaf nests by webbing the leaves.

Bionomics

- The adult moth is brownish yellow in colour.
- The fore wing has an oblique band and a few transverse wavy lines.
- It lays scale like eggs in clusters of 100-150 on the upper surface of leaves.
- The egg period is 6-8 days. The larva is greenish with black pro-thorax.
- The larval period is 3-4 weeks. It pupates within the leaf fold for 6-8 days.

1. Shot-hole borer - *Euvallacea forhicatus* Eichh. (Scolytidae: Lepidoptera)

Damage

- The grub tunnel in to the stem which interferes the flow of sap, weakening the stems.
- Presence of round shot holes in primary branches, mortality of buds, dieback in branches and circular or longitudinal tunnels inside the stem are the symptoms of attack.

Bionomics

- The adult xyleborus beetle is minute measuring 3-4 mm in length.
- It lays eggs at junction and opening of side branch and covers with a wad of damp saw dust.

2. Red borer - *Zeuzera coffeae* Nietn. (Cossidae: Lepidoptera)

Damage

- The red caterpillar bores into the stem and branches causing wilting of branches.
- Presence of bore, holes plugged with excreta at the base of the plant is the typical symptom of attack.

Bionomics

- The adult is white moth with black or steel blue spots in the wings.
- The larva is orange red and smooth.

1. White grub- *Holotrichia impressa* Burm. (Melolonthidae: Coleoptera)

Damage

- The grub feeds on roots causing drying of young plants.
- It also eats away the bark of stem below the soil surface.

Bionomics

- The adult beetle is redddish brown in colour.
- It lays eggs in soil. The grub is white, fleshy, 'C shaped. It pupates in an earthern cell.

- The life cycle occupies a year in the plains while at higher altitudes it may takes up to two years.

1. Red spider mite - *Oligonychus coffeae* Nietn. (Tetranyehidae: Acarina)

Damage

- It infests the upper surface of the older leaves making webbing on the leaf surface for shelter.
- When the infestation is higher the young leaves may also get attacked which turn brownish, dry up and fall.

Bionomics

- The adult mite is rounded and brick red in colour.
- It lays eggs singly on the surface of leaves mostly along the midrib and veins.
- Fecundity is about 137 eggs / female.
- The egg period is 4-6 days.
- The larval stage is followed by two nymphal stages.
- The larval nymphal period occupies 6-8 days.

2. Scarlet mite - *Brevipalpus californicus* Geij. (Tenuipalpidae : Acarina)

Damage

- The mite infest on the lower surface of the leaves causing yellowing of leaves.

- The bark on the leaf petiole of the affected shoot split, turn brown and dry up.

Bionomics

- The mite is flat, elongated and oval and scarlet in colour with black marks dorsally.
- It lays bright red eggs on the under surface of leaves.
- Female lays about 47 eggs during ovipositon period of 40 days.
- The egg period is 6-13 days.
- The life cycle is completed in 21-28 days.

3. Purple mite - *Calacarus carinatus* Green. (Eriophyidae: Acarina)

Damage

- The mite infests both sides of the leaves causing coppery brown or smoky discoloration of the leaves.

Bionomics

- The mite has a spindle shaped purple body with 5 longitudinal white waxy ridges dorsally.
- The life cycle is completed in 7-15 days.

4. Pink mite or orange mite - *Acaphytta theae* Keifer. (Eriophyidae: Acarina)

Damage

- It infests the both sides of leaves, petioles and tender stems.
- The affected leaf becomes discoloured and leathery, the veins showing a pink discoloration the bushes in general present a sickly appearance.

Management

- Spray methyl demeton 25 EC @ 1250 ml or dimethoate 30 EC @ 1500ml. / hectare.

Distribution, hosts and natural enemies of pests of Tea

Common name	Scientific name	Distribution	Hosts	Natural enemies
Tea mosquito bug	*Helopeltis iheivora* Water house	India, Srilanka, Vietnam, Indonesia	Tea, guava, grapevine, cashew, mahogany neem5 cacao, cinchona, pepper, tamarind and cinnamon apple	
Tea mite	*Brevipalpus phoenicis* Geij	India, Srilanka, Malaysia.	Tea, citrus, coffee, rubber, *Phoenix spp* Parthenium	Predatory mite *Typhlodromus pyri*
Yellow tea mite	*Polyphagotarsonemus latus* Banks	Cosmopolitan, Europe, U.S.A. Central America, Bangladesh, India, Malaysia, Srilanka, Philippines	Tea, cotton, jute, coffee, tomato, potato, chillies, rubber, mango, sesame, caster, bean, peppers, avacado and citrus	

Lecture No.24
Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Cocoa

1. Red borer - *Zeuzera caffeae* Nietn. (Cossidae: Lepidoptera)

Damage

- The caterpillar bores in to the stem of 3-4 year old plants resulting in wilting and drying of entire plants.
- The affected plants show bore holes on the stem and accumulating chewed fiber at the base of the plant.

Bionomics

- Adult moth has dirty white bands and black or steel blue spots on the wings.
- The larva is orange red in colour.
- The full-grown larva is about 42 mm long.

Management

- Prune and destroy the affected branches.
- Spray carbaryl 50 WP 2 g / litre of water.

2. Fruit borer - *Dichocrocis* (=*Conogethus*) *punctiferalis* Guen. (Pyraustidae: Lepidoptera)

Damage

- The larva borers into the central core of the pseudostems resulting in the death of the central spindle causing charactersic “dead heart” symptom.

- In the case of capsules, the caterpillars bore into the immature capsules and feed on the seeds rendering them empty.
- The caterpillars occasionally tunnel into the panicle also.
- A characteristic indication for the presence of the larvae is the oozing out of excreted frass materials at the mouth of the bore hole, which are very conspicuous on the stem or pods.

Bionomics

- The adult is a medium sized brownish yellow coloured moth with a number of dark spots on the wings.
- It lays eggs on the top leaf axils of young pseudostem.
- The larva bore into the tender parts of the panicle, flower buds and immature capsules only, the later stage larva bore into the stem.
- The full grown larva is measuring 15-25 mm long and it pupates within the larval tunnel inside the pseudostems.
- The life cycle is completed within 25-40 days.

Management

- Collect and destroy the affected plant parts.
- Destroy the alternate host plants from the vicinity of the plantation
- Spray phosalone 3 ml/litre or Dimethoate 0.03 % /litre or quinolphos 4 ml/litre or fenthion 1.25ml / litre of water.

3. Stem girdler - *Sthenias grisator* Fab. (Cerambycidae:

Coleoptera)

Damage

- The grub bores into the bark and tunnels into the dry wood.
- The infestation resulted in wilting of branches and then the entire vine.
- The beetles have the habit of ringing the vines resulting in drying up of the regions beyond the cut.

Bionomics

- The adult beetle is greyish brown with white and brown irregular marking resembling the bark colour, elytra have an elliptical greyish median spot and an eye shaped patch measuring 24 mm long.
- The eggs are thrust in between barks and sapwood in clusters of 2-4 eggs by female beetle, which cuts branches slits under the bark of girdled branch.
- The egg period is 8 days. The hatched out grub feed inside the stem and completes its larval stage by 7-8 months.
- The total life cycle occupies more than a year.

Management

- Cut and burn the infested branches below the girdling point.
- Hand picks the beetles and destroys them which may help in migrating this longing horn beetle.
- Swab the trunk with carbaryl 50 WP 4 g / litre of water.

1. Brown looper - *Hyposidra talaca* Walk. (Geometridae: Lepidoptera)

Damage

- It is a looper caterpillar causing extensive defoliation.

Bionomics

- Adult moth is pink in colour.
- The eggs are laid in the leaves.
- Fecundity is about 250 eggs / female. EP: 4 days and LP: 19-24 days.
- The full grown larva is brown with orange coloured dots laterally.
- It pupates in fallen leaves.
- The life cycle is completed in 30-35 days.

2. Hairy caterpillar - *Argina syringa* Cl and *A. cribraria* (Hypsidae: Lepidoptera)

Damage

- They cause defoliation in early stages and bore in to capsules in the later stages

Bionomics

- *A. cribraria* - Adult is yellowish brown with black spots.
- Larva is hairy caterpillar with black transverse markings and white spots.
- *A. syringa* - Adult has reddish brown forewings with black spots.
- Larva is similar to that of *A. cribraria* but has reddish markings laterally.

3. Wooly bear - *Pericallia ricini* Fab. (Arctiidae: Lepidoptera)

Damage

- It causes defoliation

Bionomics

- See under brinjal and sweet potato.

4. Hairy caterpillar - *Diacrisa obliqua* Wlk. (Arctiidae: Lepidoptera)

Damage

- It causes defoliation

Bionomics

- See under brinjal and sweet potato.

5. Hairy caterpillar - *Metanastria hyrtaca* Cram. (Lasiocampidae: Lepidoptera)

Damage

- The hairy caterpillar feeds on leaves causing defoliation.

Bionomics

- The adult is stout grayish brown moth exhibiting sexual dimorphism.
- Male moth has pectinate antenna and chocolate brown patch in the middle of fore wings.

- Female moth is bigger in size with longer and broader wings having wavy transverse bands.
- The larva is nocturnal, cylindrical grayish brown, stout and hairy.

Management

- Kill the aggregating larvae on the bark using a torch of fire or with a bucketful of cowdung slurry during the day time in households.
- Spray fish oil rosin soap to kill the larva because of asphyxiation.
- Spray Dimethoate 0.03 % or carbaryl 0.1 % or malathion 0.1%.

6. Grey weevil - *Myllocerus subfasciatus* G.M., *M.discolor* Fab and *M.viruidu* Fab. (Curulionidae: Coleoptera.)

Damage

- Adult weevil cause notching of leaf margins.
- Grub feeds on roots resulting wilting of plants.

Bionomics

- *M. Subfasciatus* – Brownish weevil;
- *M. discolor* – Brown with white spot on elytra;
- *M.viridanus* – Small light green weevil.

Management

- Collect & destruct the adult weevils
- Apply carbofuran 3 G at 15 kg/hectare at 15 days after planting.

1. Mango hopper - *Idioscopus clypealis* (Cicadellidae: Hemiptera)

Damage

- Both nymphs and adults suck the sap from tender shoots and inflorescence resulting in withering and shedding of flower buds and flowers leads to wilting and drying of shoots and leaves. The flower stalks and leaves of infested trees become sticky due to the deposition of honey-dew secreted by the hoppers that encourages the growth of black sooty mould on foliage and other plant parts.
- The peak activity is confined during blossom and the loss ranges from 25 to 60 %. During the off - season, the hoppers congregate on newly developed shoots and suck the sap, results in malformation the leaves feeding on them. As a consequence, leaves become malformed and undersized. The hoppers take shelter in cracks and crevices on the barks during non-flowering season.

Bionomics

- Of these three species, *A. atkinsoni* is the largest one occurring right through the year and other two species have been observed to be mostly present during the blooming of the tree. The largest *A. atkinsoni* has two spots on scutellum while the smalll. clypealis has two spots on scutellum and dark spot on the vertex, while the least sized 1 . niveosparsus has three spots on scutellum.

- The adult hopper is light greenish-brown with black and yellow markings, wedge shaped with broad head measures 3-4 mm in length. It inserts the eggs singly into the plant tissues of young leaves, shoots, flower stalks and unopened flowers. A female lays about 200 eggs. The eggs hatch in 4-7 days. The nymph with red eyes appeared while yellowish green to greenish brown during the 5 instar occupying 8-13 days. The total life cycle from egg to adult takes 2-3 weeks for completion.

Management

- Grow less susceptible varieties *viz*., Banganapalli, Chinnarasam and Alphonsa.
- Avoid close planting, as the incidence is very severe in overcrowded and neglected orchards.
- Spray two rounds, of acephate 75 SP at 1 g /litre or phoasalone 35 EC at 1.5 ml / litre or carbaryl 50 WP at 42 g / litre of water, first round at the time of new flesh panicle emergence and 2nd at two weeks after the first spray.
- Spray wettable sulphur at 2 g / litre of water after spraying carbaryl to avoid mite resurgence
- Collect and destroy affected inflorescence or sticky inflorescence to minimize population build-up.

2. Scale - *Drosicha mangiferae* Gr. (Margarodidae: Hemiptera)

Damage

- Both nymphs and adults are found in clusters on tender shoots and desap the tissues resulting in drying of the shoots.

3. Aphid - *Toxoptera aurantii* Boyen. (Aphididae: Hemiptera)

Damage

- Both nymphs and adults infest flower stalks, tender leaves, buds and tender pods the infested flowers wilt and the leaves crinckle and fall.

4. Tea mosquito bug - *Helopeltis theivora* Sign. (Miridae: Hemiptera)

Damage

- The nymphs and adults feed on the young leaves, buds and tender shoots the tissues around the feeding punctures die and dry up due to toxic action of saliva injected.
- It results the water soaked lesions followed by brownish spots at the feeding site. Resin exudes from the feeding puncture. Blossom or inflorescence blight and die back symptoms appear.
- The terminal shoots are also dried.
- Shedding of flowers and nut also takes place.

Bionomics

- The adult is a reddish brown bug with red thorax and black and white abdomen.
- The eggs are inserted into the epidermis of tender shoots, axis of inflorescence, the buds and midribs.
- The eggs are sausage shaped, 2 mm long, slightly covered with a pair of breathing filaments which project out its operculum.
- The egg period is 5 to 7 days. Nymphal period is 15 days.
- The reddish brown and ant like nymphs undergoes five instars.
- The life cycle is completed in 22 days.
- This pest attacks guava, cocoa, pepper, cinchona, tamarind, mango, neem, cotton and avocado.

Management

- Spray Dimethoate 0.03 % /litre + urea 3% thrice. The first at the time of emergence of new flushes the second at floral formation and the third at fruit set.
- Remove dead wood and criss cross branches in cashew plantations atleast once in two to three years will help in effective spraying of insecticides against the pest.

Lecture No.25
Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Rubber and Cinchona

1. Bark caterpillar-*Aehterastic circulata* Meyr.(Hyponomeutidae: Lepidoptera)

Damage

- The caterpillar usually feeds on the dead bark.
- It becomes troublesome when it happens to feed on the renewing bark.

Bionomics

- The adult moth is small white and black spotted.
- It lays the eggs on the barks.
- The larva is small, bright red and flat.
- The larva feeds under a web on the bark.
- The larval duration is about 3 weeks.
- It pupates under a piece of bark in web for about 10 days.

2. Bark caterpillar- *Comocritis plena* Meyr. (Hyponomeutidae: Lepidoptera)

Damage

- The caterpillar constructs galleries on the bark and feeds on the bark surface.

3. Stem borer- *Batocera rufomaculata* Dejean. (Cerambycidae:Coleoptera)

Damage

- The grubs bore in to the branches causing drying of the branches.

Damage

- The grubs feed by tunneling through the bark of branches and main stem.
- The damage may also show itself by the shedding of leaves and drying of terminal shoots in early stage of attack.
- When the damage occurs at the main stem, the whole tree succumbs.

Bionomics

- The adult is a large longicorn beetle about 5 cm long and 1.6 cm broad and yellowish brown in colour.
- It has two pink dots and lateral spines on thorax.
- It lays eggs singly on the bark, or cracks and crevices on the tree trunk or branches hatch in about 1-2 weeks.
- The grub is stout with well-defined segmentation and yellow in colour.
- The grub makes *zig - zag* burrow beneath the bark.
- The grub feeds on the internal tissues and become full fed in about six months.
- It pupates inside the tunnel itself.
- The pupal period is. 19-36 days.

Management

13. Remove and destroy the dead trees and affected branches from the garden.
14. Swab trunk with carbaryl 20 g/1.
15. Use light trap 1 / ha to attract adult moths or beetles.
16. Locate bore holes, spike out grubs using a needle or iron wire.
17. Exclude the alternative host, silk cotton from mango orchards.
18. Grow less susceptible varieties *viz.*, Neelam, Humayudin, and Panchavarnam.
19. Swab coal tar + Kerosene (1 :2) on the basal part of the trunk up to 3 feet high after scraping the loose bark to prevent the female from egg laying.
20. Spike out the grub if the bore holes are located, and add insecticide emulsion (monocrotophos 0.1 % at 20 ml / hole) a fumigant tablets (3 g aluminium phosphide) or petrol and seal the holes with the mud.
21. Follow padding with monocrotophos 36 WSC 10 ml per tree soaked in absorbent cotton when the trees are not in bearing stage.
22. Apply carbofurean 3 - 5 g per hole and plug with mud after removing the grub by using needle.
23. Apply carbofuran granules in the soil at 75 g / tree basin.

1. Scale -*Aspidiotus destructor* Sign and *Saisettia nigra* NMetn.(Coccidae: Hemiptera)

Damage

- The scales infest the twigs and leaves causing dropping of leaves.

1. Basket worm -*Acanthopsyche snelleri* Heye. (Psychidae ; Lepsdoptera)

Damage

- The larva attacks newly tapped surface making small wound from which latex flows out freely.

2. Weevil- *Apoderus chrysochlorus* Wied. (Curculionidae: Coleoptera)

Damage

- The reddish brown adult weevil twists the leaf tips.

Lecture No.26

Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of Cashew

1. Cashew tree borer Plocaederus ferrugineus Linn. (Cerambycidae: Coleoptera)

Damage

- The grubs tunnel and feed inside the tree trunks and branches and damage cambial tissues and stop the flow of sap.
- It results in weakening and death of the plant.

Bionomics

- The adult beetle is reddish brown measuring 25-40 mm in length.
- It lays eggs in the cracks and crevices of the loose bark on the trunk.
- The eggs are ovoid or elliptical and dirty white in colour hatch in 4-6 days.
- The newly hatched grubs start feeding on soft tissues and bore in to the bark and make tunnels.
- The grub is off-white colour and the grown up grub measures 60-75 mm in length.
- The fully grown grub decends to root zone through tunnels.
- The grub stage last for 6-7 months.

- The pupal period last 60 days inside the cocoon.

Management

- Uproot and remove the dead trees from the plantation as they serve as source for multiplication of the borer.
- Avoid any injury or damage to the stem and exposed portion of the root.
- Apply coal tar and kerosene (1:2) on the trunk up to 1 metre height which prevent the beetles from egg laying.
- Detect the infestation in the early stage and swab the tree trunk with carbaryl 50 WP 0.1% suspension to save the tree.
- Adopt stem padding with cotton wool soaked in monocrotophos at 30 ml /tree gives good recovery.
- Follow the root feeding of monocrotophos 36 WSC 10 ml +10 ml of water kept in a polythene bag in two places (20 ml / tree) gives good protection to the trees.

2. Bark caterpillar-*Indarbela tetraonis* M. (Metarbelidae: Lepidoptera)

Damage

- The larva chews out the bark resulting zig-zag galleries and silken webbed masses comprising of chewed materials and excreta.

Bionomics

- Adult moth is pale brown with fore wings having brown spots and streaks and white hind wings. The larva is 40-45 mm long, stout and dirty brown in colour.

3. Apple borer- *Nephopteryx sp* (Phycitidae: Lepidoptera)

Damage

- The larva bores into the tender cashew apple and feeds on the internal tissues of false fruit.

Bionomics

- The adult moth is medium sized with dark fore wings and pale hind wings.

4. Apple and nut borer -*Thylocoptila paurosema* (Pyraustidae: Lepidoptera)

Damage

- The caterpillar borers into the tender apple and nut and feeds on them.

1. Shoot and blossom webber- *Macalia monocusalis* Wlk. (Pyraustidae: Lepidoptera)

Damage

- The larva webs together the tender leaves and inflorescence and feeds on the same.

2. Shoot tip and inflorescence caterpillar- *Hypatima* (= *Chelaria*) *haligramma* M. (Gelechiidae: Lepidoptera)

Damage

- The caterpillar webs together the terminal leaves and inflorescence and bores into the shoot tips.

3. Tea mosquito bug-*Helopeltis antonni* Sign. (Miridae: Hemiptera)

Damage

- The nymphs and adults feed on the young leaves, buds and tender shoots the tissues around the feeding punctures die and dry up due to toxic action of saliva injected.
- It results the water soaked lesions followed by brownish spots at the feeding site.
- Resin exudes from the feeding puncture.
- Blossom or inflorescence blight and die back symptoms appear.
- The terminal shoots are also dried.
- Shedding of flowers and nut also takes place.

Bionomics

- The adult is a reddish brown bug with red thorax and black and white abdomen.
- The eggs are inserted into the epidermis of tender shoots, axis of inflorescence, the buds and midribs.
- The eggs are sausage shaped, 2 mm long, slightly covered with a pair of breathing filaments which project out its operculum.
- The egg period is 5 to 7 days. Nymphal period is 15 days.

- The reddish brown and ant like nymphs undergoes five instars.
- The life cycle is completed in 22 days.
- This pest attacks guava, cocoa, pepper, cinchona, tamarind, mango, neem, cotton and avocado.

Management

- Spray Dimethoate 0.03 % /litre + urea 3% thrice. The first at the time of emergence of new flushes the second at floral formation and the third at fruit set.
- Remove dead wood and criss cross branches in cashew plantations atleast once in two to three years will help in effective spraying of insecticides against the pest.

1. Leaf miner- *Acrocercops syngramma* M. (Gracillaridae: Lepidoptera)

Damage

- The larva mines into the tender leaves causing whitish blotches.

Bionomics

- The adult is silvery greyish moth with fringes of hairs on the wing margins.
- The larva is reddish brown in colour.

2. Wild silk moth- *Cricula trifenestrata* H. (Saturnidae: Lepidoptera)

Damage

- It causes defoliation.

Bionomics

- The adult moth is reddish brown in colour, female moth has 3 clear hyaline spots, in fore wings and a smaller one in the center of hind wings. The caterpillar is stout, dark brown in colour. They pupate in golden yellow silken cocoon. The pupae are also reddish brown in colour and about 40mm long.

Management

- Spray quinolphos 25 EC 2 ml/litre of water.

3. Hairy caterpillar - *Metanastna hyrtaca* C, (Lasiocampidae: Lepidoptera)

Damage

- The hairy caterpillar feeds on leaves causing defoliation.

Bionomics

- The adult is stout grayish brown moth exhibiting sexual dimorphism. Male moth has pectinate antenna and chocolate brown patch in the middle of fore wings. Female moth is bigger in size with longer and broader wings having wavy transverse bands. The larva is nocturnal, cylindrical grayish brown, stout and hairy.

Management

- Kill the aggregating larvae on the bark using a torch of fire or with a bucketful of cow dung slurry during the day time in households.
- Spray fish oil rosin soap to kill the larva because of asphyxiation.
- Spray dimethoate 0.03% or carbaryl 0.1 % or malathion 0.1%.

4. Slug caterpillar - *Parasa lepida* Cramer. (Cochlididae: Lepidoptera)

Damage

- The caterpillar feeds on the leaves gregariously in the beginning, subsequently they disperse.
- It causes severe defoliation.

Bionomics

- The adult moth is stout with wing expanse of 4.0 cm and having green wings fringed with brown patches.
- The eggs are laid in batches of 10-15 on the under surface of leaves.
- The eggs are ovals flat scale- like in shape.
- The fecundity is on an average 167 eggs / female. The egg period is 7 days.
- The caterpillar is fleshy, slug-like with yellowish green body bearing a greenish blue stripe dorsally and yellowish green stripes laterally.

- The larval period is 5-6 weeks undergoes seven instars.
- It pupates in a hard shield - like greyish cocoon on the tree trunks for 4-5 weeks.

Management

- Set up light traps to monitor and kill the adult moths.
- Spray the crown with carbaryl 0.1 % (or) dichlorovos 0.02 % or malathion 0.05 % solution.
- In severe cases, root feeding of monocrotophos as explained earlier under leaf eating caterpillar may be taken up with safety precautions.
- Collect all the stages of pests viz. eggs on tree trunks, leaves, larvae during migration stage, pupae in soil and leaf sheath and adult moth during emergence and destruction.
- Organise mass collection campaign involving farmers, school children and college students.
- Spray dichlorovos @ 2 ml / litre using specially designed tractor mounted tall tree sprayer.
- Dust methyl parathion or endosulfan dust @ 1 kg / tree using power operated bellowed crane duster to reach tall trees.
- Encourage the predatory birds to pick up the larval stages.

5. Leaf twisting weevil - *Apoderus tranquebaricus* Fab. (Curculionidae: Coleoptera)

Damage

- The adult weevil has the habit of cutting and twisting the mango leaves into shapely thimble like rolls which remain attached to the parent leaves.
- The grub feeds on the leaf tissue within the leaf roll.

Bionomics

- The adult weevil is medium sized, reddish brown with a long snout.
- Eggs are laid in each leaf roll.
- The grub pupates within the leaf roll.

Management

- Spray insecticides like monocrotophos at 1.25 ml or Dimethoate 0.03 % / litre of water to check the spread of infestation.

6. Looper - *Oenospila flavifuscata* W, (Geometridae: Lepidoptera)

Damage

- The larva infests the leaf margins cause defoliation.

1. Red banded thrips - *Solenothrips rubocinctus* G. (Thripidae: Thysanoptera)

Damage

- Both nymphs and adults infest the leaves and cause crinkling discolouration and leaf drop.

2. Thrips - *Rhipiphorothrips crueniatus* Hood. (Thripidae: Thysanoptera)

Damage

- Both nymphs and adults lacerate the leaves and suck the sap.
- The infested leaves shows silvery white patches on leaves with excreta.

3. Flower thrips - *Scirtothrips dorsalis* (Thripidae: Thysanoptera)

Damage

- Both nymphs and adults lacerate the tender tissues and suck the exuding sap.
- The infested leaves begin to curl downwards from the margin towards the mid rib.
- Heavily infested trees exhibits sickly and faded appearance, which can be recognized even from distance.

Bionomics

- The adult is minute measuring 1 mm in length.
- It is yellowish brown insect, with fringed wings. It reproduces parthenogenetically.
- The fecundity is 30-50 eggs per female.
- It lays eggs on the lower surface of leaves by inserting them singly in the tissues along the mid rib of tender leaves.
- The eggs are reniform and hyaline when laid but turn pale yellow just before hatching.
- The egg period is about 4-6 days.

- The nymphs are pale yellow and wingless.
- They moult 2-3 times passing through 3-4 instars in 12-18 days according to the prevailing temperature.
- Full grown nymphs undergo two resting stages called pre-pupa and pupa.
- The pupal period lasts for 6-10 days.

Management

- Sprays water twice or thrice during thrips out break helps to reduce its population load appreciably.
- Spray monocrotophos 36 WSC 1.5 ml or endsulfan 35 EC 2ml/ml or quinalphos 25 EC 2.0 ml / litre of water.

Lecture No. 27
Pest Management in Mint, betel vine, senna

MINT

1. Lace wing bug - *Cochlochila bullita* (Tingidae: Hemiptera)

Damage

- The nymphs and adults desap from the under surface of leaves.
- The infested leaves turn brown and gradually dry up.
- The stunted plant growth and presence of chlorotic spot on the leaf surface are the symptom of attack.

Bionomics

- The adult bug is yellow in colour.
- The nymph is small, long flat and black in colour.

1. Cut worm - *Agrotis segetum* Dams and Schifffer Muller. (Noctuidae: Lepidoptera)

Damage

- The caterpillar cuts the seedling at the ground level and eats tender parts.

Bionomics

- The adult noctuid moth is pale whitish brown in colour.
- The fore wings are yellowish brown with waxy lines and marginal series of specks.

2. Semilooper - *Plusia orichalcea* Fab. (Noctuidae: Lepidoptera)

Damage

- The caterpillar cuts the edges of lamina, folds it over the leaf and feed from within the leaf roll causing defoliation.

Bionomics

- The adult is stout dark brown with shiny fore wings.
- The larva is green the body having black warts and hump on its anal segment.

Lecture No.29

Pest Management in Long pepper, medicinal yam, Aswagandha, Sarpagandha, Opium poppy and geranium

OPIUM POPPY

1. Root weevil - *Sternocarus fuliginosus* (Curculionidae: Coleoptera)

Damage

- Grubs feed on roots.

Management

- Apply lindane 1.3 D 25 kg/ha on soil at planting is it available in market.

2. Cutworm-*Agrotis suffusa* (Noctuidae: Lepidoptera)

Damage

- Larva cuts younger plants at the base above ground level. Larva remains concealed in cracks in the ground and become active at night.

Bionomics

- Larva is dark with red coloured head.

3. Green peach aphid - Myzus persicae (Aphididae: Hemiptera)

- Both nymphs and adults suck sap from leaves. Body colour of apterous form is yellowish green and rarely reddish.

4.Gram pod borer - *Helicoverpa armigera* (Noctuidae:

Lepidoptera)

Damage

- Larva feeds on flower heads and seeds. Adult is a medium sized mom with 'V' shaped speck and dull black border on hind wing.
- Full-grown larva is greenish with dark brown grey lines along sides of body.
- Spherical, yellowish white eggs are laid singly on buds and flowers.

Bionomics

- Larval period lasts for 15 to 20 days. It pupates in the soil and pupal period is 10 to 15 days.

Management

- Hand pick and destroy larvae.
- Use pheromone traps to attract and kill adult moths.
- Spray dimethoate 0.03 % /l.

Lecture No.30

Important insect pests attacking stored fruits and plantations

I. **Internal feeders**

1. Rice weevil - *Sitophilus oyzae* Linn. *S. zeamais*, *S. granarius* (Curculionidae : Coleoptera)

Nature of damage

- Both grubs and adults cause damage to grains.
- Adult weevil cuts circular holes of 1.5 mm. dia on grains.
- During heavy infestation heating takes place which is known as dry heating.
- The grub feeds internal content of the grain.
- It attacks the grains of rice, wheat, sorghum, barley, maize before harvest and in store.

Bionomics

- The adult weevil is small in size of 3 mm reddish brown or chocolate to almost black colour having characteristic beak or snout.
- The antenna is elbowed and slightly clubbed.
- The elytra have 4 yellow spots. The female makes a cavity on the grain and deposits white translucent eggs singly and covers it with gelatinous fluid.
- The fecundity of weevil is 150-250 eggs per female.

- The grub is white, apodous with yellowish brown head, which feeds inside the grain.
- The larval duration is about 20 days.
- It pupates inside grain itself for 3-6 days.
- The adult longevity is 3-5 months.
- The life cycle occupies 26 days at 30°C and 75% relative humidity.

2. Lesser grain borer - *Rhyzopertha dominica* Fab.(Bostrychidae: Coleoptera)

Nature of damage

- Both grubs and adults make irregular holes of 1 mm diameter on the grain and feeds on the internal content of it.
- The grain or kernels are reduced to mere powder. It attacks paddy, rice, wheat and maize.

Bionomics

- The adult beetle is dark brown measuring about 3 mm in length.
- The head is deflexed downwards with a pair of antenna having serrated and three segmented club.
- There is a prominent constriction between prothorax and elytra.
- .It lays eggs singly or in clusters on the surface of cereal grains. A single female lays eggs up to 550.
- The grub is white, apodous with brown head.
- It develops within the grain or kernel and feeds on starchy material.

- It pupates inside the grain after 3rd instar.
- The total life cycle is completed in 25 days under optimum conditions.

3. Cigarette or tobacco beetle -*Lasioderma serricorne* Fb.(Anobiidae: Coleoptera)

Nature of damage

- Both grubs and adults bore into tobacco products *viz.*, cigarettes, cheroots and chewing tobacco.
- Presence of circular pin head sized bore holes on processed tobacco is the typical symptom of attack.
- It also attacks the grain of wheat, peanut, cocoa, bean, cotton seed etc.

Bionomics

- Adult light brown round beetle with its thorax and head bent downwards and this presents a strongly humped appearance to the insect.
- The elytra have minute hairs on them.
- Antenna is of uniform thickness.
- The creamy white oval eggs are laid on the surface of stored material and the incubation period is 9 - 14 days.
- The larval and pupal periods range respectively from 17 - 29 days and 2-8 days.

- Grub whitish hairy grub feed on stored tobacco, ginger, turmeric and chillies.

4. Drug store beetle - *Stegobium paniceum* Linn. (Anobiidae: Coleoptera)

Nature of damage

- Circular pinhead sized bore hole on turmeric, coriander, ginger, dry vegetable and animal matter.

Bionomics

- Adult reddish brown small beetle has striated elytra and measures 3mm long.
- Antenna is clubbed.
- It lays the eggs in batches of 10 - 40.
- Grub is not hairy but is pale white, fleshy with the abdomen terminating in two dark horny points.
- LP: 10 - 20 and PPL 8-12 days.

5. Pulse beetle - *Callosobruchus theobromae* Linn.(Bruchidae:

Coleoptera)

Nature of damage

- Grub alone eats away the entire seed content make a cavity.
- Adult beetles are harmless and do not feed on stored produce at all.
- The infestation starts in the field itself from where the infestation is carried over to godown and pulse seed with round exit holes and cigar like eggs consented of them.
- It attacks all whole pulses, bean and gram.

Bionomics

- Adult is brownish grey coloured with characteristic elevated ivory like spots near the middle of the dorsal side.
- Elytra do not cover the abdomen fully.
- It lays 80 - 100 eggs singly and glued on the surface of pod in the field or on grain in stores.
- The egg period is about 5 days.
- The grub is fleshy, white, creamy in colour which moulds four times.
- Grub bores into the pod or grain.
- The larval period lasts for 30-50 days.
- It pupates in a pupal cell prepared beneath the seed coat.
- Pupal period last for 4 days in summer and two weeks in winter. The life cycle is completed in 23 days at 300C and 70% relative humidity.

6. Tamarind beetle - *Pachymeres gonagra* Fb. (Bruchidae:

Coleoptera)

Nature of damage

- Circular holes on fruits of tamarind both in tree and storage.

Bionomics

- Adult small grey coloured beetle.

7. Angoumois grain moth - *Sitotroga cerealella* Olivier (Gelechiidae: Lepidoptera)

Nature of damage

- The larva bores into the grain and feeds on the internal content of it.
- Exit holes of 1 mm diameter with or without a trap door on the damaged grain are typical symptoms of attack.
- It attacks paddy, maize, sorghum, barley and wheat before harvest and in store.

Bionomics

- The adult moth has pale fore wings and uniformly grey pointed wings with fringe of hairs.
- It lays about 100 white eggs singly in stores or fields on the surface of damp grains.
- The egg period is 4-30 days.
- The larva is white in colour with yellow head measuring 5 mm in length.
- It undergoes four instars.

- It feeds in side and remain in a single grain only.
- It over winters in pupal stage.
- It spins a cocoon and pupates for 7 days

II. External feeders

1. Red flour beetle - *Tribolium castaneum* Herbst.(Tenebrionidae: Coleoptera)

Nature of damage

- Both grubs and adults feed on milled products.
- Adult beetles are readily observed even in moderately infested stored foods.
- They construct tunnels as they move through flour and other granular food products.
- In addition they release gaseous quinones to the medium which may produce a readily identifiable acid odor in heavy infestations.
- It attacks broken grains or mechanically damaged grains and milled products.

Bionomics

- The beetle is small, oblong, flat, brown in colour measuring 3-4mm in length.
- In *T. confusium* the compound eyes are completely notched and antennae are not gradualy thickened in the latter where as in *T. castaneum* not notch is not complete and antennae have a clear 3 segmented club.

- It lays 400-500 eggs in stored grain at random for several months.
- The eggs are white and cylindrical.
- The egg period is 5-12 days.
- The grub is white worm like having two spine like appendages at the last abdominal segment.
- The larval period is 3-12 weeks.
- The pupal stage lasts for 5-9 days.
- The life cycle is completed in 3-4 weeks at 35-57°C at 70% relative humidity.

2. Indian meal moth - *Plodia interpunctella* Huebn (Phycitidae: Lepidoptera)

Nature of damage

- The larvae feed on the grain and contaminate with excrement, webbing, dead individuals and cocoons.
- It attacks maize cereals, dry fruits groundnuts and cereal products.

Bionomics

- The adult moth has brown fore wins with white band.
- It lays greyish white coloured eggs on the surface of grain.
- The fecundity of this insect is 39-275 eggs per female.
- The egg period is 2-17 days.
- The larva is dirty white in colour.
- The larval period is 30-35 days.

- It pupates in silken cocoons for 10 days.
- The life cycle is completed in about 5-6 weeks.

3. Fig moth - *Ephestia cautella* Walk. (Phycitidae: Lepidoptera)

Nature of damage

- The larva mainly feeds on germ portion leaving the rest of the kernel undamaged.
- It forms webs on the surface of commodity or on the bags by silk and silk strands.
- It attacks wheat, rice, maize, sorghum, groundnut and spices.

Bionomics

- The small moth has dirty white to grayish wings with indistinct black bands about 4 mm from the head.
- It lays 200 - 250 eggs on grains exposed at the sampling tube spots in jute bags.
- The caterpillar is grayish white, hairy with dark brown head with 2 dark areas on the first segment behind the head.
- It pupates in a silken cocoon at the junction of two overlapping edges of stalked bags.
- The adult longevity is 14 days.
- The entire cycle is completed in 25 days.

4. Rice moth - *Corcyra cephalonica* Staint. (Galleriidae: Lepidoptera)

Nature of damage:

- The larva feeds on the grains and pollutes them with frass, moult and dense webbings.
- It attacks rice, sorghum, other millets whole cereals, deals, processed products of cereals, pulses oilseeds, nuts, dry fruits and milled spices.

Bionomics:

- Adult moth has pale yellowish green fore wings and grey white hind wings.
- It lays small, oval, elliptical eggs on walls, bags or on grain.
- The egg period is 3-5 days.
- The larva is creamy with prothoracic shield.
- The grown up larva is fleshy, 12 mm in size.
- It pupates in a silken cocoon sticking on to gunny bags.
- The pupal period is 10 days.

5. Khapra beetle - *Trogoderma granarium* Everts. (Dermestidae: Coleoptera)

Nature of damage

- It chews up the seed coat in an irregular manner on all cereals and reduces the grain into frass.
- It attacks wheat, maize sorghum, rice, pulses, oilseeds and their cakes.

Bionomics

- Adult beetle is reddish brown measuring 4-6 mm in length.

- The male beetles are smaller than females in size.
- It lays about 80-125 eggs.
- The yellowish brown grubs are clothed with long hairs.
- The grubs are active, move and feed freely.
- It pupates on the surface of the grain in bulk and overlapping edges of bags.
- The pupal period last for 5-8 days.

Lecture No. 31

Secondary pests and scavengers of stored product

1. Saw toothed grain beetle - *Oryzaephilus surinamensis* Linn.(Cucujidae: Coleoptera)

Nature of damage

- It feeds on grains, dried fruits etc. by scarving of grain surface or burrowing holes in them.
- It attacks rice, wheat, maize, cereal products, oil seeds and dry fruits.

Bionomics

- It is slender, dark brown, narrow, flattened beetle having a row of saw like sharp teeth on each side of the prothorax.
- The antenna is clubbed and elytra cover abdomen completely.
- It lays 300 whitish eggs loosely in cracks of storage receptacles of godown.
- The eggs period is 3-17 days.
- The larva is sender, pale cream in colour with no slightly darken patches on each segment.
- The larval period is 14-20 days.
- It pupates in a protective cocoon like covering with sticky secretion.
- The pupal period is 7-21 days.

2. Long headed flour beetle - *Latheticus oryzae* Water house.(Tenebrionidae: Coleoptera)

Nature of damage

- Both grubs and adults beetles feed on the milled products.
- It occurs as secondary infestation in stored grain.
- It attacks cereal flour, packaged food, rice and rice products.

Bionomics

- The beetle is light brown in colour with elongated body, measuring 2-3 mm in length and resembles *Tribolium castaneum*.
- It lays 400 white eggs singly on grain and seams of the bags.
- The incubation period is 7-12 days.
- The grub is small, white active which feeds voraciously.
- The larval period is 15-80 days.
- It pupates for 5-10 days.
- Life cycle is completed in 25 days at 35° C and 70% relative humidity.

3. Flat grain beetle - *Cryptolestes minutus* Olivier.(Cucujidae: Coleoptera)

Damage

- Both grubs and adults feed on broken grains or on milled products.
- In case of heavy infestation it cause heating in grain and flour.
- It attacks rice, maize, wheat with excessive broken, different flours, groundnut particularly with high moistures and mouldy grain.

Bionomics

- It is smallest amount the stored grain insect pests.
- It is light to dark reddish brown beetle measuring 1.5 mm to 2.0 mm.
- It lays white eggs loosely in flour, grain or crevices.
- The egg period is 5 days.
- The larva is cigar like, yellowish white with two reddish brown spots at anal segment.
- The larval period is 21 days.
- It pupates in a gelatinous cocoon.
- The life cycle is completed in 42 days.

4. Grain lice - *Liposcelis divinitorius* Muli. (Psocoptera)

Damage

- They are scavengers affecting only germ portion in heavy infestation.
- .It thrives on insect fragments and broken grains.
- It attacks all starchy material.

Bionomics

- It is pale grey or yellowish white coloured, small, pin head sized louse with filiform antenna.
- It lays about 7-60 eggs.
- The metamorphosis is incomplete.

5. Grain mite - *Acarus siro* Linn. (Acarina)

Damage

- It feeds on the surface of the grains.
- It attacks cereal grains, flour and other eatables.

Bionomics

- It is pale straw to dark reddish brown mite.
- It lays about 100 eggs.
- The eggs are hatched into 6 legged larvae which mould into nymphs.
- There are 1-3 instars.
- The life cycle is completed in 9-12 days at 23°C and 70% relative humidity.

Lecture No. 32

Integrated Management of Stored Produce Pests

Control methods

- The control methods of stored produce pests can be categorized into preventive and curative measures.

A. Preventive measures

- Brush the cracks, crevices and corners to remove all debris in the godown.
- Clean and maintain the threshing floor / yard free from insect infection and away from the vicinity of villages.
- Clean the machines like harvester and thresher before their use.
- Made the trucks, trolleys or bullock carts free from infestation.
- Clean the godowns/storage structures before storing the newly harvested crop to eliminate various bio stages of pest hiding.
- Provide a metal sheet upto a height of 25 cm at the bottom of the wood in doors to arrest the entry of rats.
- Fix up wire meshes to windows, ventilators, gutters, drains etc. to prevent entry of rats, birds and squirrels.
- Remove and destroy dirt, rubbish, sweepings and webbings etc. from the stores.
- Close all the rat burrows found in godown with a mixture of broken glass pieces and mud and plastered with mud / cement.

- Plaster the cracks, crevices, holes found on walls, and floors with mud or cement and white wash the stores before storing of grains.
- Provide dunnage leaving gangway or alleyway of 0.75 to 1 m all around to maintain good storage condition.
- Store the food grains in rat and moisture proof storage structures.
- Disinfest the storage structures receptacles by spraying malathion 50 EC @ 3 lit 100 m before their use.

B. Curative measures

i. Ecological methods

- Manipulate the ecological factors like temperature, moisture content, and oxygen through design and construction of storage structures/godown and storage to create ecological conditions unfavorable for attack by insects.
- Temperature above 42oC and below 15oC retards reproduction and development of insect while prolonged temperature above 45oC and below 10oC may kill the insects.
- Dry the produce to have moisture content below 10% to prevent the buildup of pests.
- Kill the pests bio stages horboured in the storage bags, bins etc. by drying in the sun light.
- Store the grains at around 10% moisture content to escape from the insects attack.
- Manipulate and reduce oxygen level by 1% to increase the CO_2 level automatically, which will be lethal to all the stages of insects.

ii. Physical methods

- Provide a super heating system by infrared heaters in the floor mills and food processing plant to obtain effective control of pests since mostly the stored produce insects' die at 55-60oC in 10-20 minutes.
- Modify the storage atmosphere to generate low oxygen (2.4% and to develop high carbon dioxide (9.0 - 9.5) by adding CO2 to controls the insects.

Seed purpose

- Mix 1 kg of activated kaolin (or) lindane 1.3 D (or) Malathion 5 D for every 100 kg of seed and store / pack in gunny or polythene lined bags.

Grain purpose

- Mix 1 kg activated kaolin for every 100 kg of grain and store. To protect the pulse grains, mix activated kaolin at the above dosage or any one of the edible oils at 1 kg for every 100 kg of grin or mix 1 kg of neem seed kernel for every 100 kg of cereal or pulse and store.
- Do not mix synthetic insecticides with grains meant for consumption.

iii. Cultural methods

- Split and store pulses to escape from the attack by pulse beetle since it prefers to attack whole pulses and not split ones.

- Store the food grains in airtight sealed structures to prevent the infestation by insects.

iv. Mechanical methods

- Sieve and remove all broken grains to eliminate the condition which favour storage pests.
- Stitch all torn out bags before filling the grains.

v. Chemical methods

- Treat the walls, dunnage materials and ceilings of empty godown with Malathion 50 EC 10 ml / 1 (or) DDVP 76 WSC 7 ml / 1 at 31 spray solution / 10 sq.m.
- Treat the alleways and gangways with Malathion 50 EC 10 ml / 1 or DDVP 76 WSC 7 ml / 1 (1 litre of spray fluid / 270 M3).
- Spray Malathion 50 EC 10 ml / 1 @ 3 1 of spray fluid / 100 M2 over the bags.
- Do not spray the insecticides directly on food grains.
- Use knock down chemicals like lindane smoke generator or fumigant strips pyrethrum spray to kill the flying insects and insects on surfaces, cracks and crevices.
- Use seed protectants like pyrethrum dust, carbaryl dust to mix with grains meant for seed purpose only.
- Decide the need for shed fumigation based on the intensity of infestation.

- Check the black polythene sheets or rubberized aluminum covers for holes and get them ready for fumigation.
- Use EDB ampoules (available in different sizes of 3 ml, 6 ml, 10 ml, 15 ml and 30 ml) at 3 ml / quintal. At for wheat the pulses and 5 ml / quintal for rice and paddy (Do not recommend EDB for fumigation of flour oil seeds and moist grains).
- Use EDCT (available in tin containers of 500 ml, 1 liter and 5 litres) at 30-40 litres / 100 cubic meter in large-scale storage and 55 ml/quintal in small-scale storage.
- Use fumigants like Ethylene dibromide (EDB), Ethylene dichloride carbon tetra chloride (EDCT), Aluminium phosphide (ALP) to control stored produce pests effectively.
- Apply Aluminium phosphide (available in 0.6 g and 3 gram tablets) @ 2 tablets (3 gram each) per tonne of food grains lot with help of an applicator.
- Choose the fumigant and work out the requirement based on the following guidelines.
- 3 tablets of aluminum phosphide 3 g each per tonne of grain (For cover fumigation)
- 21 tablets of aluminium phosphide 3 g each for 28 cubic meters (For shed fumigation)
- Period of fumigation is 5 days.

- Mixclay or red earth with water and make it into a paste form and keep it ready for plastering all round the fumigation cover or keep ready sand snakes (For cover fumigation).
- Place the required number of aluminium phosphide tablets in between the bags in different layer.
- Cover the bags immediately with fumigation cover.
- Plaster the edges of cover all round with wet red earth or clay plaster or weigh down with sand sankes to make leak proof.
- Keep the bags for a period of 5 - 7 days under fumigation based on fumigant chosen.
- Remove the mud plaster after specified fumigation periods and lift cover in the corner to allow the residual gas to escape.
- Lift the cover after few hours to allow aeration.

General precautions

- Read the label carefully and follow the instructions given by manufactures
- Keep the pesticides in labelled containers only
- Store pesticides under lock and key beyond the reach of children
- Do not store insecticides near food stuff and store them in cool places
- Never use empty containers for any other purposes except for insecticides
- Destroy and dump the waste containers
- Wash hands with soap and water after using pesticides
- Do not use moth for cleaning nozzles etc. of sprayers.

- Avoid swallowing, inhalation, or contact with skin as far as possible.
- Keep first air box ready along with universal antidote.
- Activated charcoal 2 parts + tannic acid 1 part + magnesium oxide 1 part (Dose: 15 grams in half tumblers of water).
- Consult a doctor in case of signs of illness eg. giddiness, nausea, head ache, blurred vision, vomiting, depression, respiratory problem and inform about the pesticide the patient had handled.

Lecture No. 33

Integrated pest management of rodent pests

Introduction

- Integrated pest management is a system which in the context of the associated environment and the population dynamics of the pest species, utilize all suitable techniques and methods in a compatible way and maintains pest populations at levels below the economics injury level. Rodent control is a problem of applied ecology factors into management polity. The primary aim is to reduce damage, rather than to kill the pest. However, most often this is achieved by use of a lethal chemical. However, if lethal control is followed by rapid immigration then the damage reduction may be short lived. Thus it is important to take account of spatial dynamics of the pest. Simple ecological theory treats a population as a group of organisms in one place at one time, the number of which change through time according to the number of births, deaths, immigrants and emigrants.
- Although rodents have potentiality for fast breeding, the geometrical progression is countered by various limiting factors operated by nature. Implantation failure, intra uterine mortality, maternal cannibalism and postnatal mortality due to social strife etc. limit their number. However, the higher carrying capacity of crop fields result in maintaining more number of rodents resulting in significant crop losses.

- A number of vegetables, groundnut, pulses, sugarcane, cotton boll finger millet, sesame and tender coconuts in the field and also stored grains in ware house and store rooms are damaged by rats and nice. Rats are among the most destructive pests of paddy in field causing about 5 - 10% damage.
- It has been estimated that there are about 2500 million rats in our country. Five species of rats and three species of mice are important pests of cultivated crops in the field in Tamil Nadu.
- They are as follows.

6. Mole rat or lesser bandicoot or field rat - *Bandicota bengalensis*
7. Bandicoot rat - *Bandicota indica*
8. Grass rat - *Millardia meltada*
9. Gerbil rat - *Tatera indica*
10. Common house rat - *Rattus rattus rufescens*
11. Indian field mouse - *Mus booduga*
12. Brown ring mouse - *Mus platythrix*
13. House mouse - *Mus musculus*

1. Mole rat - *Bandicota bengalensis* Gray. (Muridae: Rodentia)

Nature of damage

- The rat enters the paddy nursery and nibbles the seeds.
- After transplantation the seedlings are cut.
- In short stage it cuts the tillers and the affected area is seen as circular patches in a field.
- The rat revisits the same area next night and spread the damage.

- It cuts ear heads and carries to its burrow and in a burrow up to 2 kg of hoarded grain can be noticed.
- It also feeds on pulses, grasses and grains.

Bionomics

- The rat lives in burrows made in the sides of bunds channel bunds and in waste lands adjoining the fields.
- Mole rat is robust, dark brown to black with a short, stumpy truncated and pig like face.
- Tail has scaly rings, normally smaller but sometimes equal to head and body.
- The adults weigh 300 grams.
- It breeds round the year with 5-8 litters year. Life span is approximately 7-8 months.
- It is expert in digging burrows, excellent swimmer and aggressive fighter.

2. Bandicoot rat - *Bandicota indica* Bechstein. (Muridae: Rodentia)

Nature of damage

- It weakens the foundation of walls, river bunds, railway tracts by making bug burrows.
- It cuts the tillers / leaves in the rice field and reduce the yield drastically.
- It hoards grain in burrows. It feeds on grain in burrows.
- It feeds on grain, animal products, meat etc. in stores.

Bionomics

- It is the largest rat in size with a ferocious look and brownish to black in colour head is broad, truncated, pointed with long black whiskers.
- Eyes are small with white eye borrows and ears are short, rounded opaque and nude.
- Fur is thick coarse with spines.
- It weighs about 800 - 1000 grams.
- The tail is equal to the length of body but not uniformly tapering Droppings are scattered and spindle shaped.

3. Grass rat - *Millardia meltada* Gray. (Muridae: Rodentia)

- Body small and slender, dark brownish grey above and pale grey below with soft fur.
- Head and body is about 13 cm long and tail 10 cm long.
- The burrows of the grass rat are similar to that of the mole rat excepting that they are smaller in length and diameter and that usually more than one adult rat occupies a single burrow.
- It attacks rice in all stages and feeds upon young germinating grains.
- It damages green cotton bolls in black cotton soils.

4. Gerbil rat - *Tatera indica* Hrdwicke. (Muridae: Rodentia)

- It is reddish grey in colour with white under side and it equals the common house rat in size with about 18 cm long head and body and a hairy tail little longer than the head and body.

- It generally feeds on grams, grass, roots and fruits.

5. Common house rat- *Rattus rattus rufescens* Linn. (Muridae: Rodentia)

Nature of damage

- It feeds upon all kinds of vegetable and animal food.
- Its damage is great in ware house and storage godowns on vegetable grains and preserved food materials.
- It is responsible for plague.

Bionomics

- It is brownish grey with dark under surface.
- It has small eyes, large sparsely hairy ears and pointed snout.
- The tail is uniformly dark coloured and is equal to the size of body plus head.
- It weighs about 150-200 gram.
- The droppings are banana shaped and found scattered.
- It has 5-7 litters per year, each having 6-14 young ones after gestation period of about 25 days.
- The life span is 1 year in field and 2 years in laboratory condition.
- It lives in roots of houses and underground burrows.

6. Indian field mouse - *Mus booduga* Gray. (Muridae: Rodentia)

- It is about 5 to 8 cm long with 5 cm long tail.
- It is brown in colour with a white belly.

- It burrows in field bunds causing extensive damage to bunds and wastage of water.
- It produces 3 to 9 young ones per litter.
- It cuts and removes grains from rice crop.
- It feeds on gram and grain.

7. Brown ring mouse - *Mus platythrix* (Muridae: Rodentia)

- Body-small, fur crisp and tends to be spiny grayer basally, browner terminally, above dark brown to pale brown, under part with a clear line of demarcation along the sides.
- Tail stout averaging below 90% of the length of the body.
- It feeds on grains and grasses.

8. House mouse - *Mus musculus* Linn. (Muridae: Rodentia)

Nature of damage

- It feeds on cereals, cereal products, vegetables, meat, fat, carbohydrates etc.
- It also damage wooden furnitures, paper clothes, rubber and leather goods etc.
- It consumes 3-4 grams per day.

Bionomics

- Adult is dark brown to sandy brown rat with short hairs, undersurface light grey.

- It weighs about 23-35 grams.
- Tail is longer than head and body and dropping are scattered and spindle shaped.
- There are 8 litters per year with gestation period of 19 days.

9. Brown rat of ship rat - *Rattus norvegius* Birken (Muridae : Rodentia)

Nature of damage

- It feeds on gains damages bags, cartons and pollutes gain with excreta, dropping and hairs.

Bionomics

- Adult is soft skinned brownish grey rat with whitish belly.
- It weighs about 200-300 grams.
- The snout is wide and blunt.
- The tail is shorter than head and body.
- There are 6-14 liters per year with a litter size of 5-7 young ones.
- The gestation period is 4 weeks.
- The life span is one year.

Integrated Rodent Management

- The following integrated approaches can be adopted for the management of rodents both in field and storage.

1) Cultural methods

2) mechanical methods

3) biological methods and

4) chemical methods.

I. Field

1. Cultural methods

- Dig burrows and kill rats at the beginning of crop season while rectifying bunds for cultivation and plan to have narrow bunds in the field, which are adequate for the rats to construct furrows.
- Avoid keeping hay stakes near the fields as they provide excellent harborage for rats.
- Plough the field deeply up to 18" to unearth rat burrows and to expose the rats to enemies like cats and kites before the sowing operation.
- Flood the field with water to suffocate and kill the rats.
- Organise campaigns to dig out rat burrows and kill them soon after the harvest.

2. Mechanical methods

- Kill the solitary rats by sticks and brooms
- Set up indigenous local trap like bow traps at 20-25 per acre.

3. Biological methods

- Keep up the trained dogs to prey upon rats or even dig out rats from burrows by smelling.
- Conserve snakes and mangooses to reduce the rat populations.
- Set up owl perches in the paddy field to reduce rate damage.

4. Chemical Methods

a. Single dose poison

- Use acute or single dose poision bait at 1 part Zinc phosphide with 49 parts popped corn / rich / dry fish.

b. Multi dose poison

- Use ready to feed anticoagulant like warfarin 0.5% cakes to cause blood haemorrhage in rats.
- Prepare dry bait by mixing flour (ie. cereals or millets) 450 g (4 tea cupful) any edible oil 10 g (2 teaspoonful) sugar or jaggery 15 g (3 teaspoonful) and anticoagulant, warfarin 0.5% 25 g (5 teaspoonful) for effective rat control.
- Prepare water-soluble bait by mixing 1 part anticoagulant and 19 parts of water (2.5 grams of anticoagulant dissolved in 475 ml of water).
- Use ready to use second generation anticoagulant namely bromodiolone at 125 grams (1 teacupful).
- Before providing poison bait keep the plain or non poisoned bait for 2-3 days as a pre bait to make the rats used to the food provided.

c. Fumigation

- Control the rats by fumigating the burrows with aluminium phosphide tablets during the process of baiting with rodenticides.
- Plug the entry holes of all rat burrows and locate the burrows which have the entrance opened by the rats and inset two tablets each of 0.5 or 0.6 g aluminium phosphide per burrow.

II. Storage

- Construct the pucca masonry cement concrete storage structures on plinth of 75 cm high without steps or ladder.
- Plaster the walls and floors of godowns with cement.
- Provide a metal sheet up to height of 25 cm at the bottom of the wooden doors and fit the wire meshes to windows, ventilators, gutters, and drains to prevent the entry of rats, birds and squirrels.
- Plug the rat holes and plaster with glass pieces and cement.
- Provide automatic door closures in houses to prevent the entry of rat.
- Prepare and keep dry bait and water bait with rodenticide as detailed above.
- Keep the bait with multi dose or chronic anticoagulant in small cups on the rat runs, dark places etc. where rat frequently move.
- Replace consumed bait daily, collect the rats which begin dying after 5 or 6 days and bury them.

- Use also water soluble bait by mixing 25 g water soluble coagulant in 475 ml of water and keep them in shallow cups or plates in a number of places inside the godown for the rats to drink the poisoned liquid and get killed.
- Discontinue the baiting or remove all the baited food and destroy as soon as the rat population is controlled.

1.1. Factors for rodent incidence

- Climate affects the food supply in nature. Based on this the rodents exhibit unimodal or bimodal peaks in breeding activity often coinciding with the crop maturity periods. Bimodal pattern of breeding is observed in *Bandicota bengalensis, Millardia meltada, Funambulus pennant, Tatera indica* and *Meriones hurrianae*. However, wherever single cropping is practiced unimodal pattern is reported for these species in the country.
- Harbourage or cover is an important parameter that limits the rodent infestation. Weeds afford both shelter and food to the rodents. Bunds with more volume have more weeds, thereby more rodent infestation. Similarly, denser fields with more tiller density afford cover and energy, which enhance reproductive activity of rodents. Wider spacing and even maintenance of alleys in rice fields prevent rodent damage. Cover / shelter in storage of commodities is one of the major factors influencing the rodent population.
- Rodents are highly mobile and form limited social structures based on a hierarchy. These home ranges depend on food reserves, cover, and presence of other individuals of it or other species. Home ranges change

with altered resources. Rodents emigrate from their ecosystems once the food source is removed/shifted. This is particularly important since rat control is done in some places at harvest time. They also immigrate very fast. Sustained trapping and poisoning which may reduce 80-90% of rodent infestation often fail to prevent the damage because of constant immigration from untrapped and unpoisoned areas nearby. In cereal crops booting stage attracts rodents, which on arrival settle in the field and start breeding due to abundant availability of quality food. This is one of the factors to planning timing the rodent control operations. Pre seasonal rat control operations are vogue in some of the States. Such control may have limited result due to this dispersal behavior. Further the compensatory capacity of the cereal crops before booting stage also makes it imperative to take up rat control operations at late tillering stage.

1.2. Monitoring rodent incidence

- Since the aim is primarily for damage reduction, but not individual rat killing, there is a necessity of monitoring the situation in different ecosystems through either their damage or through their levels of infestation. The control decision may be taken depending on the monitoring surveys. Limited work undertaken on monitoring indicated that damage index of 15% of rodent affected hills or 2% tiller damage may be taken as threshold value.
- Looking at National perspective it is recommended that efforts for periodic monitoring of rodent infestation in crop fields at tehsil levels be made

based on the number of active burrows per hectare (25 burrows per hectare: low intensity, 25 to 50 burrows/ha: medium intensity and more than 50 burrows/ha : severe intensity).

1.3. Rodent management measures

- Different methods exist in controlling rodents. However, each method has its own limitation. The methods that are in vogue and limiting factors are given below.
- Role of predators/Biological control
- Snake and owls have been the natural predators for field rodents. Bird perches are used for attracting owl perching in the nights to facilitate hunting the colonizing rats. The perches should be used at tillering stage of the crops to tackling immigrating rodents. However, if these perches are continued in later stages, granivorous birds may cause damage to the panicles. Since most of the predators of rodents are general feeders, they often tend to feed on food other than rodents. Cats in residential premises are one of the examples. Declined rodent population after harvest of the crops also makes the predators to leave the area. There is also sometimes a possibility of predation triggering increase in rodent populations after partial removal of the rodents.
- Attempts were also made with parasites and pathogens to bring successful rodent control. However, the efforts are so far not fruitful since they also equally affect human populations. Attempts are in progress to use immuno contraception through viral vectors (VVIC) among rodents. This

combination of induction of sterility by activating body immune response through a viral vector appears to be promising in modern rodent management. Laboratory results are quite promising. However, the trials are at infancy stage only.

Physical methods

- Trap Barrier System (TBS) is being tried in different countries employing fences to the rice farming and fixing traps at different intervals. Trap crop is also is added to attract rats to immigrate by growing a small patch of the crop on the periphery. However, looking at the cost of fencing and land holdings, it may not be appropriate in Indian conditions to use this method, although the preliminary studies yielded significant results. However, in North-eastern States this method can be followed in jhum cultivation. Non lethal electric fencing as a barrier method were found to be cost effective and has limited extension value.

Ultrasound and electromagnetic devices

- The sense of hearing among rodents is above 20kHz thus extending well into ultrasonic range. Ultrasound devices are being used as deterrents to rodent immigration. However no convincing evidence was found them as effective against rodents. Similarly little scientific support was found for use of electromagnetic devices.

Chemical repellents

- There is no effective chemical repellent available that is not also toxic. Although pheromones appear to be promising, lot of scientific work is required to identify, isolate and bring out the pheromones for extension purpose.

Trapping

- Trapping is one of the oldest methods of animal control. A variety of traps can be used against rodents-live or snap. The efficacy of trapping, whether live or snap trap, depends on operational conditions of the trap, number of traps set, type of bait, place and time of placement. Scientific literature has seldom proved trapping as effective method against rodents as a measure of reducing their numbers. However, they can be employed in controlling localized infestations effectively. Tanjor kitties, bamboo Palmyra traps are highly effective for localized infestations. They help in maintaining rodent numbers at a low level once they have been reduced by other methods.

Use of rodenticides

- Generally rodenticides are used for mass scale rodent control campaigns. Application of rodenticides and environmental manipulation should be considered as complimentary to each other rather than alternative approaches. Amalgamating various methods as above results in reduction in rodent damage in different situations.

1.4. Suggested control measures

- The suggested control practices under different situations for rodents for large scale treatments are given below:

1.4.1. In field conditions

Day 1

- Make a survey in the area to locate rodent burrows on the bunds and no mans lands around the fields. Identify the live rodent burrows, through the presence of soil plugs and faecal pellets.
- Prepare poison bait of Bromadiolone at 0.005% a.i. in cereal base. Keep the bait approximately 15 g. wrapped in paper packet inside the burrows. No pre baiting is required while using this anticoagulant.

[or]

- Acute rodenticide like zinc phosphide may be used when infestations are high.Keep pre bait of approximately 20 g. broken grain of staple food with little amount of vegetable oil.

Day 4

- Prepare zinc phosphide poison bait at 2.5% using broken grain of staple food with vegetable oil as binding medium.
- Keep bait deep inside burrows.

Day 5

- Close all rodent burrows.

- Locate dead rodents and bury them. Normally most of the rodents die inside the burrows. Hence, mostly dead rodents cannot be seen. Dear rats may not be taken as a criterion to evaluate success of any rodenticide.

Day 6:

- Treat the residual burrows with bromadiolone based on the situation.
- Place 1 piece of Bromadiolone wax block (16.6 g.) or 15-20 g. of loose Bromadiolone bait (0.005% *a.i.* Bromadiolone mixed in bait material) in packets in all the reopened burrows. With Bromadiolone, rodents die between 3-10 days after the placement of bait material.

In rodent endemic areas or when the rodent problem is quite serious, fumigant like aluminium phosphide may be used to treat all the residual rodent burrows in the field conditions. At each time of fumigation enblock treatment should be followed. Fumigation by individual farmers at different times should not be encouraged. Residual burrows are the reopened burrows after closure of the burrow entrances with mud one day prior to the observations. The following procedure may be followed while using aluminium phosphide fumigation.

- Cover the nose and mouth with a cotton cloth.
- Cover hands with gloves / polythene cover.
- Take a tube/pipe
- Take two Aluminium phosphide pellets.
- Insert the tube deep inside the rodent burrow.
- Leave the Aluminium phosphide pellets inside the tube.

- Remove the tube/pipe and close the burrow.
- Fumigation should be done under the technical guidance and strict supervision of officials from the State Department of Agriculture.

1.4.2. In Residential Premises / storage situations

- Inspection of the residential premises for rodent infestation is to be performed as a first step. The procedure of the inspection is as follows.

1. Observe the following around the premises and mark them on the layout of the area.

    - Rodent burrows
    - Drainage canals
    - Holes at the base of compound wall
    - Garbage dumps

2. Observe the following on the building / premises and mark them.

    - Branches of trees overhung on the premises
    - Wires from poles to the premises
    - Holes in the walls
    - Drainage pipes

3. Observe for rodent "signs" inside the premises, room wise and mark them.

    - Faecal pellets adjoining walls or corners
    - Rat holes, if any, active/inactive

- Rat/mouse paw markings
- Rat runways
- Rat smears on beams, wiring etc.
- Base of the doors for space
- Windows/ventilators connecting any wiring or on roof
- Drainage

Special care should be taken while inspecting storage areas. Based on the layout marked the following actions may be initiated based on the severity/intensity of the problem;

Hygiene and Sanitation

- Proper cleanliness of the premises.
- Left over foods and empty food tins should be kept in dustbin with tightly fitted lids.
- Remove piles of rubbish, timber and bricks near the godowns/houses.

Rodent proofing

- Use modern rodent proof storage structure or improve the existing ones.
- Fix wire meshes (24 gauge) to all windows, ventilators, gutters and drains
- Fix 25 cm. metal sheet lining or rubber sheet at the bottom of the doors
- Close the rodent burrows with concrete and cement.
- Remove the branches of the trees over hung on the godowns.

Poison baiting

- **Step 1.** Select the rooms where infestation is reported
- **Step 2.** Fix 10 tracking points using fine powder at 10 x 10 cm.on the runway of rodents or at the areas frequented by them.
- **Step 3.** Observe the 10 tracks next day for rodent activity.
- **Step 4.** Coumatetralyl which is available as 0.75% Concentrate Powder may be used at 0.0375% in cereal baits in houses and in storage by mixing 1 part of the poison with 19 parts of the bait. Vegetable oil should be used as binding medium. Bromadiolone baiting can also be used at 0.005% in the baits. The poison bait (about 100g) should be placed in suitable bait stations (discarded tins, earthen pots etc.) @ 2-5 bait stations in the premises based on level of infestation. The poison bait should be maintained for 5-7 days with replenishment if required. Bromadiolone may also be used at 0.005% a.i. in baits distributed at number of places preferably in bait containers/stations.
- **Step 5.** Repeat step 2 on 15th day
- **Step 6.** Observe the tracking points for rodent activity
- **Step 7.** Calculate the control success

$$\text{Control Success} = \frac{A-B}{A} \times 100$$

Where

'A' is pre-control infestation (per cent tracks touched) level and 'B' is post-control infestation level.

Note: Keep vitamin K1 as stand by for meeting any exigency of accidental poisoning.

2. Application Techniques

The chemical control of rodent infestation is most commonly accomplished by the use of poisoned baits. Hence, selection of acceptable baits and their placement is an important element in a successful rodent control.

- Bait materials most commonly used for the control of rodents are crushed cereals followed by nuts, fruits or vegetables. Cereal-type baits have found the widest use because rodents generally prefer them; they are most easily mixed with poisons; and because of their low moisture content they also tend to keep well, both in the store and in the field.
- The baits should be laid in the late evening, since rodents are mostly nocturnal.
- Open baiting i.e. placing the baits in open places should not be resorted. In houses/godowns, the baits should be exposed in protected bait containers as far as possible on the runways of rodents.
- Baits should be exposed in protected bait containers, which provide a secure place where rodents can become accustomed to feed; their use also helps to prevent other animals from gaining access to poison bait.
- The position of bait containers should not be changed
- While using bromadiolone small quantities of the poison bait (10-20 g.) should be laid at all the places frequented by the rodents. The application may be repeated on 8th day to tackle residual population.

- While using coumatetralyl poison, bait of approximately 100 g. be kept at 2 or 3 places frequented by the rodents in the residential premises. The poison bait should be maintained for 5-7 days with replenishment, if required.
- Precaution while using rodenticide baits:
- Know-how of the operation should be told to the public always in local language followed by demonstrations by departments concerned.
- Baits should always be placed late in the evening, as most of the rodents are active during night.
- Keep poisons away from the reach of children, pet animals, drugs and food.
- Smoking, eating and drinking should be totally avoided while handling the poison.
- Containers of the poisons should be opened in a well-ventilated room. Unused baits, containers and dead rodents should be buried deep.
- Ensure that the antidotes of poisons are available with the doctor for use in case of any accidental ingestion of poison.
- Acute poison bait is generally better accepted and an improved kill obtained by laying prebait for a few days before hand. The bait laid should be the same as that used later in the poison treatment.
- Acute poison baits should be exposed for more than one day.

3. Prevent Rodent Management

- Rodents require food and shelter for their survival in crop fields or in storage.

- If any of these two factors are altered or eliminated, they will leave the place.

3.1. Crop fields

- Hygiene practices in the fields are often referred to a habitat manipulation. It simply means that the habitat the living area of rodents is managed or altered so that it is less acceptable rodents. The main principal in habitat manipulation is to reduce the shelter to the rodents to the maximum extent possible. Following measures may be followed.

2. Weed removal
3. Maintenance of small bunds
4. Rouging planting etc.

Lecture No.34

Toxicology- insecticide residue problems in fruit, plantation medicinal and aromatic crops and their tolerance limits

Insecticide residues

- Pesticides are normally applied at only very low rates typically 1-2 kg ha^{-1}. Even so small amounts may be found on or in the treated crop on harvest. These traces, expressed as parts per million (ppm) of active ingredients and, breakdown products are generally known as 'residues'. Residues are the left out chemical and their metabolite present in the environment or treated surface plant, grain, animal, over a period of time after the application of insecticides. The footstuff may get contaminated by pesticides in the following ways.
    1. Through deliberate application of pesticide on plants.
    2. Through drift during application of pesticide on plant.
    3. Pesticide residues may occur on crops gown in soil to which the pesticides were previously applied.
    4. Pesticide residue may occur on animal products (milk, egg, meat) as result of contamination of animal feed with pesticide.
- Compatibility of pesticides: For higher crop production, simultaneous application of insecticides, fungicides, fertilizer etc is made in a single cropping season. There are often advantages of spraying two or more pesticides simultaneously. The main reason for combination of pesticides is saving time, equipments wear and cost of application. But there are also problems associated with this practice like physical incompatibility (agglomeration, phase separation etc) chemical incompatibility

(degradation of native ingredient, change in PH) and biological incompatibility (reduction in bio-efficacy of one by other, phytotoxcityy.) Hence it is advised to consider the following before combination of pesticide is restore. Do not mix two insecticides, as they will hasten the development of resistant in pests. Do not mix incompatible pesticides. Do not mix the pesticides as a matter of routine.

Impact of pesticides on agroecosystem

- **I. Abiotic environment:** Include soil, air and water. 1) Soil: Source of contamination. Direct application; Fall out from plants, Rain. 2) Air: Source of contamination; Drift during conventional and aerial application; Volatilization; Thermal decomposition; Evaporation with water vapour. 3) Water: Source of contamination; Direct treatment; Surface run off; Aerial spraying; Precipitation Effect: biomagnifications, reduction of o2content, toxic to fishes.
- **II.Plants**:1) Presence of residual amount – health hazard 2) Damage because of phytotoxicity 3) Changes in the vegetative development – Etiolation by heribicide
- **III. Animals**: 1) Domestic animals: Source, Forage treatment; Direct application Effect; Chronic poisoning; storage in fat reserves. 2) Wild life: Trophic transfer of pesticides through food chain kill wild life (eg) Egg shell thinning led non vitality of bird eggs through D.D.T. poisoning. 3) Natural enemies: Elimination of parasitoid and predators upset the biotic balance. Effect: I) Pest resurgence: Recovery of pest population following

the application of insecticides to levels higher than before treatment. (eg) BPH resurgence after quinalphos application. II)Secondary pest outbreak; increase in the population of non-target insect to damaging levels followed by the application of pesticides due to the elimination of natural enemies of minor pests or potential pests (eg) Red spider mite outbreak in apple followed by the application of organo chlorines. III) Pollinators: Pesticide applications during blooming kill honey bees and other pollinators.

- **IV. Man**: a)Operational hazards: Manufacture – Distribution – Application – Post – application, b)Accidental and intentional poisoning, c)Indirect hazards through food chain – Handigodu syndrome, d) Disease: carcinogenic, Mutagenic and Teratogenic effects.

- **V. Food**: Residues in human food – Reason; Use of persistent chemicals; spraying crops nearing harvest; Excessive and improper use of pesticides.
- **VI. Target insect**: Development of resistance to insecticides in insects. Excessive use exerts a high selection pressure in selecting resistant strains; (eg) Mosquito resistance in DDT; Synthetic pyrethroid resistance in cotton bollworms and diamond black moth.

  Insecticide resistance insect: The resistance is the development of an ability in a strain of insects to tolerate doses of insecticides which prove lethal to the majority of individuals in a normal population of the same species.

  Resurgence of insect pests: The tremendous increase in the pest population brought about by the insecticides, in spite of a good initial at the time of treatment is called as “resurgence” or “flare black’.

Impact of global warming on pests

What is global worming?

- Sun Earth reflects some solar energy as infrared radiation.

  Green house gases.

  Infra red radiation from earth reflected back to earth by green house gases.

  This increases the temperature of earth and lower atmosphere. This is called global warming or greenhouse effect

Solar radiation falls on earth surface. Earth absorbs and gets heated up. EARTH

- Warmth from sun heats the surface of the earth
- Earth absorbs most of the energy but reflects back some energy in the form of infra red radiation.
- Greenhouse gases (e.g.CO_2,Methane, CFC (Chloro Fluoro Carbon), Nitrous oxide) present in atmosphere traps the infrared radiation and reflects back to earth.
- This reflected energy falls on earth and also lower atmosphere and keeps it warmer (Heats the earth’s surface).

- This is called global warming or green house effect.

Effect of global warming on world and agriculture

- Increase in overall temperature on earth (e.g.) Earth's surface temperature has increased 1.4°F in Ist one century (Forecast:5°F rise in next century).
- Change in climate tremendously.
- Melting of ice in Polar region.
- Increase in sea level and submerging of coastal areas.
- Flooding and intense down pours.
- Drought in warmer regions.

Impact of global warming on pest status

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

Sources of green house gases

Developed countries	:	Emission from Automobiles and factories contain CFCs
Developing countries	:	Deforestation causes rise in **CO_2** level **Methane gas** from paddy fields and livestock. **Nitrous oxide** from 'N' based fertilizer.

- The rapid growth of chemical industry in India, while helped in the progress due to increased production, also contributed to the pollution of the environment, following their extensive use.

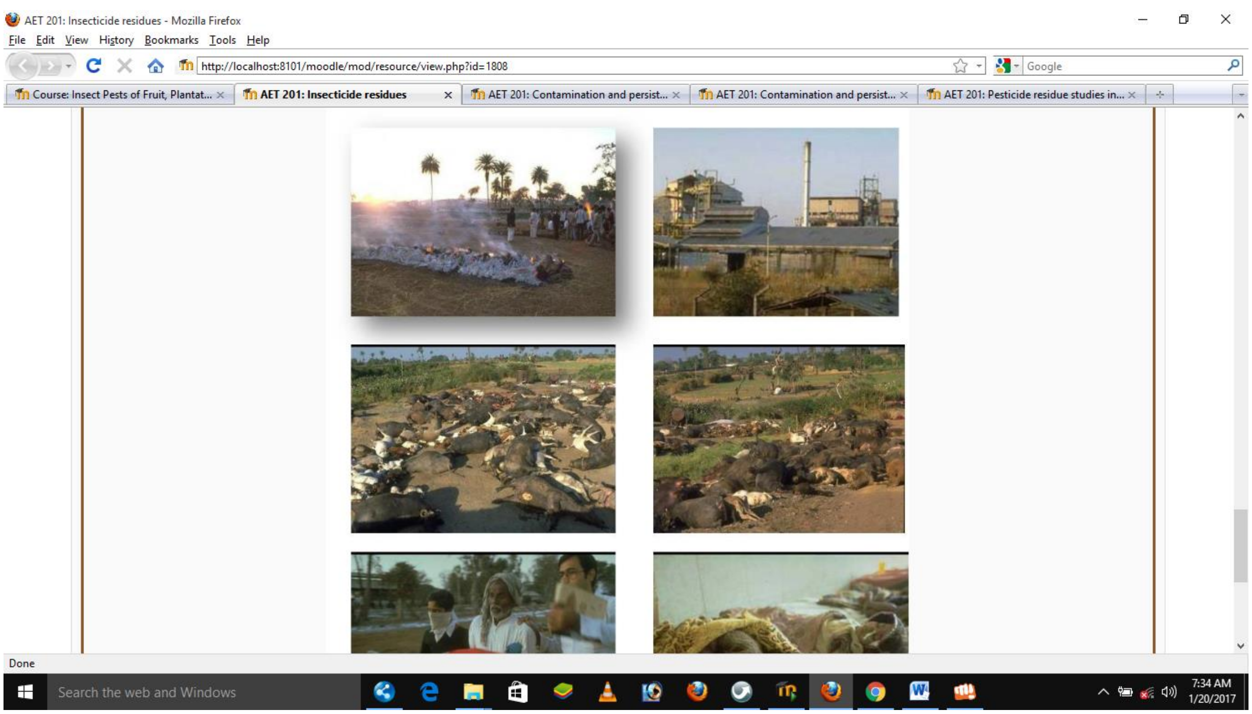
- Agriculture and horticulture sector uses two main groups of chemicals *viz.*, fertilizers and pesticides to combat the increasing demand of foodgrains, fruits and vegetables by increasing the production and preventing the losses.
- Pesticide chemicals have decidedly been proved to control the heavy losses of crops in field and during storage due to various pests to the extent of Rs.140000 crores annually.
- However, pesticide consumption in India is still insignificant as compared to developed countries It is because the importance of their use has not reached to the common fanner.
- Further, these chemicals are costly too. Therefore, only progressive farmers are currently using under irrigated conditions of crop production. Apart from agriculture use, the pesticide use in health programme for control of vectors of various diseases has also achieved significance.

Among the various pesticides, used in the country, insecticides constitute 75%, fungicides 15%, weedicides 6% and others 4%.

- To date, 144 chemicals are registered with Govt. of India that come under the category of pesticides possessing insecticidal, fungicidal, nematicidal, weedicidal and molluscicidal properties. The major classes of synthetic pesticides employed today include: organochlorines, organophosphates, organocarbamates, synthetic pyrethroids, thiocarbamate, nitrochloroalkyl thiocyclohexane dithiocarboxymide substitutes, alkyl halides, hydroxy coumarine derivatives, metal phosphides, phenoxy acetic acid derivatives, bipyridium derivatives, triazine derivatives, substituted anihilides, dinitroalkyl tolydines, antibiotics and gibberallins.
- The use pattern of various pesticides increasing sharply year by year with the growing awareness among farmers about the utility of pesticides in maximising their benefits.
- Their bad effects become more relevant as the hazards caused by them start from manufacturing state itself and continue upto the post application stage. The harmful effects of pesticides are well known. Human-beings are exposed to pesticides by following ways:—

34. Intentional : Suicide
35. Accidental : Careless handling
36. Occupational : In production plants, application in agriculture and public health
37. Contaminated food, : Residues resulting at post application stage air and water

- The post-application stage hazards concern the common man, as they come from pesticide residues persisting on food following their use in plant protection resulting in the contamination of food chain.
- Pesticide residues are essentially the ramanents of a pesticide as any substance or mixture of substances that can be found in or on crop, food, soil, water, etc., resulting from the use of pesticide chemicals for the control of pest infestation and includes metabolic and degradation products along.



Contamination and persistence of pesticide residues in fruits

- Application of pesticides is associated with fruit cultivation so intensely that today it has become impossible to get economic yield without their use. At times, their use close to harvest as well as post-harvest applications result in the build-up of pesticide residues in bioconcentrations which on consumption may cause toxic hazards. Among the common fruits being consumed, mango, grape, guava, banana, citrus, apple, plum and sapota were monitored across the country for the extent of contamination and persistence of pesticide residues with various pesticides. It is surprising to find that majority of the market basket fruit samples were found contaminated with the residues of toxic and hard to degrade chlorinated hydrocarbon insecticides like DDT and BHC

- **Mango** fruits from Parbhani markets recorded 24.1% contamination with DDT at average residues of 0.045 ppm ranging between traces -0.09 ppm and HCH at 1.145 ranging between 0.04 and 2.25 ppm. Over 95.6% mango fruits from Delhi-Ghaziabad markets were found contaminated with 0.74 ppm DDT (traces -1.48 ppm) and 0.95 ppm BHC (0.02 -1.05 ppm) residues while monitoring of mango fruits in Kanpur, Lucknow and Allahabad markets showed no detectable contamination with pesticide residues.
- Periodic monitoring of **grape** berries from the markets of Hyderabad during 1972 and 1975 recorded 81.8% samples contaminated with 1.2 ppm malathion (0.40 -2.00 ppm) residues, 100% with 3.00 ppm BHC (tr - 6.00 ppm) residues, and 49% with 0.125 ppm DDT. 0.04 ppm endrin and traces of Lindane. It was recorded 23.3% berry samples at Ludhiana market contaminated with 1.00 ppm methyl parathion (traces.-2.00 ppm), 0.75 ppm DDT (0.50 - 1.00 ppm), traces of lindane and 0.75 ppm malathion

(0.50 -1.00 ppm) levels. Over 56.6% samples of grape berries at Parbhani market were found contaminated by Jadhav, (1986) with 1.815 ppm DDT (0.08 - 3.67 ppm) and 0.640 ppm BHC (0.05-1.23 ppm) while 100% samples were reported contaminated from the markets of Lucknow, Kanpur and Allahabad with DDT and HCH residues at 0.004 ppm (0.001-0.006 ppm DDT) and 0.004 ppm (0.002-0.006 BHC) levels.

- Similarly, **guava fruits** from Parbhani recorded 21.6% samples contaminated with 0.08 ppm DDT (0.05 - 0.11 ppm) and 0.53 ppm BHC (0.04 -1.02 ppm) residues whereas, 84.6% samples from Delhi-Ghaziabad markets were found contaminated with 1.58 ppm DDT (0.04-3.13 ppm) and 0.68 ppm BHC (0.01—1.36 ppm) levels. A high level of contamination to the tune of 70% samples of guava fruits from Lucknow, Kanpur and Allahabad was detected by with 0.003 ppm DDT (0.001-0.005 ppm) and 0.003 ppm BHC (0.001-0.005 ppm) residues Banana fingers at Delhi were found to be 85.6% contaminated with residues of 0.095 ppm DDT (traces-1.10 ppm) and 1.62 ppm BHC (0.02-1.05 ppm).
- Over 90.9% **sweet lemon** fruits in Delhi-Ghaziabad markets were found containing DDT residues at 0.02 ppm level (traces -0.04 ppm) and BHC at 0.15 ppm level (0.01-0.30 ppm).
- A moderate contamination of 23.8% **sapota** samples from Parbhani market were found contaminated with 0.55 ppm DDT (traces-1.10 ppm) and 0.075 ppm BHC (0.05-0.10 ppm) whereas 100% plum samples from Delhi-Ghaziabad markets were found contaminated (Anon, 1987) with 0.82 ppm DDT (0.01-1.63 ppm) and 0.61 ppm BHC (0.02-1.20 ppm).

- **Apple** fruit samples from Delhi Ghaziabad markets (Anon; 1987) were found to be 90% contaminated with 0.92 ppm DDT (0.01-1.80) and 1.62 ppm BHC (traces -3.24 ppm). Equally contaminated apple fruits to the extent of 100% were detected in with 0.004 ppm DDT (0.001-0.007 ppm) and 0.002 ppm BHC (0.001-0.004 ppm). Dube and Nath (1991) reported 85% apple fruit samples of Solan markets contaminated with residues of thio-carbamate fungicide at an average of 4.50 ppm residues (1.00 -8.00 ppm).
- The screening of various fruit samples from the markets of different cities in India for the contamination and persistence of pesticide residues works out an average of 59.4% ranging between 23.5-100% contaminated samples containing residues of persistent and toxic insecticides like DDT and BHC in most of the cases.
- There was wide variation in the contamination of different fruits like 41.8% mango, 57.6% grape, 47.6% guava, 85.6% banana, 90.9% sweet lemon, 23.5% sapota, 100% plum and 87.6% apple samples were found contaminated across the country.
- The detection of residues of DDT and BHC in most of the fruit samples appears to be the result of post-harvest application during storage or transport as they are not being recommended for pest control in fruit crops any more.

Contamination and persistence of pesticide residues in vegetables

- Pesticide residues in vegetables result mainly due to frequent and repeated applications necessitated because of heavy pest infestation all through the crop growth stages to fruiting due to intensive crop cultivation cutting across the cropping seasons. The persistence of pesticide residues in vegetables is more important and of great concern because they are consumed afresh and directly without much processing or storage and consumption of such vegetables loaded with excess toxic residues can cause both acute and chronic toxicity effects as the build-up of residues is not even subjected to degradation and aging. The analysis of market samples of various vegetables viz., okra, cabbage, cauliflower, potato, tomato, brinjal, chillies, beans, gourds, onion, carrot and leafy vegetables across the country showed wide spread contamination with the residues of various insecticides sometimes in excess of prescribed maximum residue limits, that may danger the consumer's health
- Over 20% vegetable samples comprising of various vegetables from Pantnagar market were reported contaminated with average residues of 0.72 ppm DDT. Higher contamination to the extent of 44.6% of vegetable samples from Hyderabad was recorded with 0.25 ppm DDT and 0.25 ppm BHC while Verma (1989) reported the contamination of vegetable samples from Hissar to the extent of 33.7% with 0.76 ppm DDT, 3.45 ppm BHC and 0.81 ppm endosulfan residues.
- **Potato and Starchy Vegetables** —DDT, aldrin, endrin and chlordane residues were detected in 60% of potato samples to the extent of 3.25, traces and 3.00 ppm, respectively, however, in 1972 the contamination

level being only 10% with 0.15 ppm DDT and 0.15 ppm BHC residues. Periodical monitoring in 1975 detected DDT, BHC, aldrin, dieldrin, endrin, heptachlor and lindane residues at trace levels only in 60% potato samples from the same markets reported 100 % samples of potato contaminated with DDT at residue range of 0.1-169.0 ppm and 0.12-8.00 ppm, respectively. The qualitative contamination analysis of potato showed 48 samples contaminated with DDT, BHC, endrin,endosulfan and lindane residues. Noronha (1978) reported 43.4% potato samples from Bombay markets contaminated with DDT (3.67ppm), lindane (3.90 ppm), dieldrin (0.80 ppm) and endrin (1.80 ppm) residues. All the potato samples of Ludhiana markets were found containing DDT, BHC and aldrin residues at'the concentration levels of 0.008, 0.006 and 0.001 ppm respecitvely. About 50% samples from Parbhani markets were found loaded with 1.92 ppm DDT and 1.06 ppm BHC residues. The contamination level of 0.685 ppm DDT, 0.004 ppm BHC, 0.010 ppm heptachlor and 0.012 ppm aldrin residues in 100% potato samples of Delhi markets. Similarly, 100% samples from Kanpur, Lucknow and Allahabad were found contaminated with 0.001 ppm BHC residues.

- **Tomato**—Contamination level of 60% samples of tomato from Hyderabad and Ludhiana markets with DDT residues at 0.05 and 0.08 ppm residues was reported. Contamination of 40% tomato samples with 2.16 ppm DDT and 1.65 ppm lindane from markets. Cent per cent contamination in tomato fruits with 0.195 ppm DDT, 2.55 ppm BHC and 0.75 ppm endosulfan residues A lower level of 22% contamination with malathion and organophosphate insecticides in the range of 2.64-5.88 ppm was detected and 10% with BHC (0.002-0.007 ppm). Recently, carbon disulphide residues resulting from thiocarbamate treatments were detected on tomato fruits marketed at Solan in the range of 1-8 ppm contaminating 85% tomato fruits.

- **Brinjal**—the contamination of 71.4% brinjal samples was detected. with 0.2 ppm DDT, 1.1 ppm heptachlor and traces of endrin residues, 40% brinjal samples in markets were found to possess 100% contaminated brinjal fruits with DDT (0.01-1.00 ppm) and BHC (0.10-56.0 ppm). Persistence of DDT, BHC, endrin and endosulfan residues in 38.5% samples were found.BHC residues in the range of 4.3-4.4 ppm were found in 100% samples of brinjal.
- **Chilli**—wide spread contamination of 0.6 ppm endosulfan in 100% chilli samples was recorded. However, only 23% samples in markets were found containing 2.48 ppm carbaryl and 5.04 ppm organophosphate residues.
- **Cabbage**—Cabbage samples from Hyderabad (Lakshminarayana and Menon, 1969) were cent per cent contaminated with DDT (tr-0.20 ppm) and endrin (tr-0.10 ppm) residues. Samples from Delhi market (Agnihotri et al., 1974) showed wide variation in residue build-up of tr - 5.00 ppm DDT and tr - 56.2 ppm BHC. It was recorded contamination in 50% samples with 0.04 ppm DDT and 0.005 ppm BHC. Delhi markets possessed contamination of low magnitude with 0.070 ppm DDT, 0.004 ppm HCH, 0.004 ppm heptachlor and 0.024 ppm aldrin residues. Similarly, samples from Kanpur, Lucknow and Allahabad contained only

0.025 ppm DDT and 0.012 ppm BHC though contamination was in 100% samples. Organophosphate insecticide residues were detected only in 6% samples from to the extent of 3.60 ppm.

- **Cauliflower**—A wide variation in the magnitude of contamination of 100% cauliflower samples from Delhi markets was recorded. Residues of a number of insecticides 0.06 ppm BHC, 0.89 ppm lindane, 0.52 ppm aldrin, 1.75 ppm dieldrin and 0.45 ppm heptachlor were detected. Ludhiana markets recorded as high as 100% contamination with 0.013 ppm DDT and 0.007 ppm BHC, while, it was detected 0.017 ppm DDT, 0.001 ppm BHC and 0.002 ppm heptachlor residues in cauliflower samples.
- **Knol-khol** samples of Hissar markets were found contaminated with 1.80 - 1.90 ppm residues.
- **Bhendi**—DDT and endrin residues to the extent of 0.60 and 0.20 ppm, respectively were detected on 50% bhindi fruit samples. Insecticides like DDT, BHC, endrin, endosulfan and lindane were detected in 42.6% samples of Hyderabad-Secunderabad. BHC residues in the range of 2.10-6.00 ppm and 0.20-0.50 ppm DDT were detected from Hissar markets in most of the bhindi fruit samples. 100% contamination in samples from Ludhiana with 0.050 ppm DDT and 0.007 ppm BHC. Contamination level of 64.5% was reported.. About 50% samples were found contaminated with 5.52 ppm malathion, 0.70 ppm carbaryl and 5.10 ppm residues of different organophosphate insecticides.

- **Root vegetables**—Contamination level of over 87.5% in carrot samples was detected by with 0.35 ppm DDT, 1.05 ppm lindane, 0.50 ppm aldrin and traces of dieldrin. Dahia and The persistence of 0.90 ppm BHC residues from Hissar. Ludhiana markets were found to contain 0.015 ppm /DDT, 0.005 ppm HCH and 0.070 ppm aldrin residues in 100% carrot samples.
- Radish sample from Ludhiana markets were found to possess 0.05 ppm DDT residues in 80% samples while sample from Delhi contained 0.092 ppm DDT, 0.009 ppm HCH, 0.020 ppm heptachlor and 0.006 ppm aldrin residues

  Onion—Residue persistence of 0.040 ppm DDT, 0.260 ppm HCH, 0.015 ppm heptachlor and 0.015 ppm aldrin on 100% onion samples of Delhi market was detected.
- **Beans and greenpea**—Wide spread contamination of bean samples was detected with 0.40 ppm DDT. Residues of malathion (5.50 - 6.00 ppm) and other organophosphate insecticides (2.76 - 3.24 ppm) were found in 50% bean samples
- Gourds—Bittergourd samples recorded about 70% samples contaminated with 0.65 ppm endodulfan and 1.25 ppm BHC residues. Delhi market samples contained 0.01 ppm DDT, 0.001 ppm BHC, 0.002 ppm heptachlor and 0.001 ppm aldrin residues. Bottlegourd samples from Hissar markets were found to contain 4.35 ppm endosulfan residues. Smooth gourd samples of Delhi markets were found to contain 0.093 ppm

DDT, 0.045 ppm HCH, 0.002 ppm heptachlor and 0.008 ppm aldrin residues.

- **Leafy vegetables**—DDT residues in 41.2% leafy vegetables of Hyderabad were found to contain 0.15 ppm residues.
  Mustard leaf samples were 100% contaminated with tr -2.50 ppm DDT and 0.20 - 0.25 ppm BHC residues
  Radish tops were also found equally contaminated with 0.05 -1.00 ppm DDT and 0.30 - 50.0 ppm BHC in the samples from Delhi markets.
- **Coriander** leaves were reported to be contaminated with 0.008 ppm DDT, 0.007 ppm HCH, 0.001 ppm heptachlor and 0.016 ppm aldrin residues.
- **Coccinia** samples of Hyderabad-Secunderabad markets were found to possess traces of DDT and BHC residues. Colocasia samples of Delhi were found possess 0.024 ppm DDT, 0.002 ppm HCH, 0.001 ppm heptachlor and 0.004 pm aldrin residues.
- The pesticide residue contamination in vegetable produce after harvest and ready to consume, ranged between 33.3 to 100% in market samples across the country. On an average, potato samples registered contamination to the extent of 45.6%; tomato 49.5%; brinjal 47.3%; chilli 61.6%; cabbage 42.0%; cauliflower 61.8%; Knol-Khol; 100% Bhindi 58.0%; root vegetables 97%; onion 33.3%; beans and green peas 71.9%; gourds 91.8% and leafy vegetables 86.6% with residues of various pesticides, mainly being from chlorinated hydrocarbon insecticides like DDT, BHC, aldrin, dieldrin, heptachlor and endosulfan.

- Among other groups of insecticides only carbaryl, malathion and other organophosphates were detected.

  The prevalence of the residues of various hard to degrade insecticides like DDT and HCH in samples monitored in recent years reflect the source of residues from post-harvest use by dipping the vegetables in pesticide solutions presumably to keep vegetable fresh looking and during transport. These practices are unauthorised and injudicious use of toxic pesticides.

Pesticide residue studies in fruits and vegetables for safety constants

- Extensive studies have been carried out under different agroclimatic conditions of India over a period of time on the persistence and dissipation of pesticide residues mainly from insecticide group on various fruit and vegetable crops following the supervised field trials based on recommended plant protection schedules involving the applications of emulsifiable concentrates, water dispersible powders, dust and granular formulations of various pesticides.
- While foliar applications effected surface residues, the soil granular applications resulted in plant uptake by fruit and vegetable crops. The periodic analysis of residues brought about the rate of residue decay (half life) as an index of persistence pattern, that is governed by various factors and hence required to study across the climatic zones of the country.

- This data in turn helped in working out safe waiting periods (Tol), the period in days required for residues to reduce to safe levels, based on prescribed maximum residue limits. The waiting period requirements varied from pesticide to pesticide and crop to crop, being dependent on persistence of pesticide residues as the degradation of residues is governed by chemical nature of pesticide, type of formulation, type of crop, , application rates and frequency, cropping season and climatic conditions.
- The studies revealed the variable pattern of residues of various insecticides and accordingly required waiting periods of 15-21 days on citrus fruits, as against 7-10 days on mango, grape, guava, papaya, ber and banana from foliar applications of insecticides. While waiting periods of 2-3 days for endosulfan, malathion, carbaryl, 3-7 days for dichlorvos, phosalone, dimethoate, fenthion, methyl parathion, monocrotophos, phosphamidon and 7-10 days for fenitrothion, quinalphos, chlorpyriphos and synthetic pyrethroids insecticides have been recommended on variety of vegetables belonging to malvaceae, solanaceae, cucurbitaceae, cruciferae, leguminaceae, root, bulb and leafy groups.
- The soil granular applications of insecticides, like phorate, aldicarb and carbofuran, etc., required 50-60 days time for degradation of their residues translocated into plant system to safe limits.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