TEACHING MANUAL

ON

INSECT PESTS OF FRUITS, PLANTATION, MEDICINAL & AROMATIC CROPS

DR. SURESH KUMAR JAT

DEPARTMENT OF PLANT PROTECTION

AGRICULTURAL UNIVERSITY, KOTA

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Compiled and Edited by Dr. Suresh Kumar Jat, Assistant Professor, AU, Kota, Raj.

PPR-221: Insect Pests of Fruits, Plantation, Medicinal & Aromatic Crops 3(2+1)

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.

References:

No.	Name of the refence book	Authors
1	Agricultural pests of south Asia and their management	Atwal. A. S. and Dhaliwal G. S
2	Hand book of entomology for south India	Ayyar, T.V.R.
3	Integrated Pest Management Concept and Approaches	Dhaliwal, .G.S. and Ramesh Arora
4	Entomological Techniques in Horticultural Crops	Ranjit, P
5	Identification and management of horticulture pest	Ramnivas Sharma
6	Pest management and residual analysis in horticultural crop	Rachna and Benna kumara

Lecture Schedule

Theory

S. No.	Topic	Lectures
1.	Principles of applied entomology	1
2.	Economic classification of insects and ecology	1
3.	Pests – categories, causes for outbreak of pests-Pest – definition - insect pest management with reference to fruits, plantations, medicinal and aromatic crops	1
4.	Methods of pest control	1
5.	Pest surveillance and Methodology for Surveillance	1
6.	Biological control in pest management	1
7.	Insecticides, classification and their mode of action	1
8.	Pesticides applications methods.	1
Distribution, host range, bio-ecology, damage and integrated management of important insect and mite pests of following crops.		
9.	Mango, sapota	1
10.	Citrus	1
11.	Banana	1
12.	Guava	1
13.	Amla, jack fruit	1
14.	Grapevine	1
15.	Ber, pomegranate	1
16.	Fig, star gooseberry	1
17.	Wood apple, custard apple	1
18.	Jamun, pineappple, papaya, tamarind, Date palm, Litchi	1
19.	Apple, pear, peach, plum	1
20.	Coconut, oil palm, Areca nut	1

21.	Coffee, tea	2
22.	Cocoa	1
23.	Rubber, Cinchona	1
24.	Cashew nut	1
25.	Mint, betel vine, senna	1
26.	Neem, belladona	1
27.	Camphor, costus, crotalaria, datura, dioscorea, opium, *solanum khasianum* , tephrosia	1
28.	Important insect pests attacking stored fruits, plantations, medicinal and aromatic crops and their processed products	1
29.	Integrated management of storage insect pests	1
30.	Integrated pest management of rodent pests	1
31.	Toxicology- insecticide residue problems in fruit, plantation medicinal and aromatic crops and their tolerance limits	1

LECTURE-1: PRINCIPLES OF APPLIED ENTOMOLOGY

- **Economic entomology:** is the study of insects that are variously related to the welfare of mankind.
- **Applied Entomology** : A study of those insects which are variously related to the welfare of mankind (Positively or negatively) is referred as **Applied Entomology.**

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.

1. Without pollinating services of bees and other insect, we would have few vegetables, few fruits, no coffee, no tobacco and few flowers.
2. Insects provide us honey, beeswax, silk and many other useful products.
3. Many insects' species are parasites and predators and keep the crop pests under check.
4. Many of them control weeds.
5. Many of them act as scavengers and make the world little cleaner.
6. Insects are the sole or major item of food for many birds, fish and other animals (including man in some part of the world).
7. Some species have used in the treatment of certain diseases, in heredity, evolution, sociology etc.,
8. Insects have aesthetic value. Study of insects is a hobby for some people.

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

1. They attack various growing plants, feed on them, injure them and kill them or introduce disease into them.
2. They attack man's possessions-home, clothing; food grains and destroy them or contaminate them.
3. 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.

LECTURE: 2. ECONOMIC CLASSIFICATION OF INSECTS AND ECOLOGY

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: 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 are collected, grinding 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).

F. Insects as medicine: 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. The bee venom cures rheumatism and arthritis and is available for hypodermic injection.

G. Use of insect galls: Some of the galls are of medicinal value: the Aleppo gall of oak has astringent and tonic properties and dyeing wool and hair and ink has been used for about 25 centuries in Europe and West Asian Countries.

Other useful insects

1. Insects and pollination: The majority of higher plants are cross-pollinated. They depend on wind and insects for pollination.

2. Entomophagous 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.
- A classical example of successful control of an insect pest by a predator is the cottony cushion scale, *Icerya purchasi*, a serious pest of orchard in California, by a lady bird beetle (Vedalia beetle) *Rodolia cardinalis* introduced from Australia. Eg.Coccinellids, preying mantids.

3. Insect as weed killers: Many insects feed and destroy noxious weed plant, e.g.

- 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.
- *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. Eg.

- 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:

- Soil enriched by the excretions and dead bodies of insects.
- 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 number at low cost.

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), sap sucking (sucking pests e.g.aphids, thrips, leaf and planthoppers) etc.
- Injury by oviposition: e.g. Periodical cicadas cause wilting of twigs when the eggs are laid. Cowbug on many plants.
- Injury by disease transmission: More than 200 plant diseases are transmitted by insects. e.g. Banana bunchy top by Aphid.

2. Insects attacking stored products: Many insects damage stored produce by feeding, tunneling or contaminating them.

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).

Ecology and Pest Management:

Concept of ecology: The term oekologie (ecology) was coined in 1869 by the German biologist, Ernst Haeckel from the Greek oikos meaning "house" or "dwelling", and logos meaning "science" or "study". Thus, ecology is the "study of the household of nature".The term was first of all introduced by Reiter in 1868, but because the German biologist Ernst Haeckel (1869) first of all fully defined "the total relation of the animal of both its organic and its inorganic environment. In 1936, Taylor defined ecology as „ the science of all the relations of all organisms to all their environments. Charles Elton (1947) in his pioneer book animal Ecology defined ecology as „scientific natural history".

Ecological Aspects:

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

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.

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.

Existence and abundance of a species is determined by biotic and abiotic factors, besides the genetic makeup of the species.

Biotic factors: Living factors like competition, predators, parasitoids, etc.

Abiotic factors: Non living factors like temperature, RH, photoperiod, etc.

Acclimation: The temperature adaptation of an organism.

Acclimatization: The response of organism to temperature.

Cold hardiness: The ability of insect to withstand the lower temperature.

Thermal constant: The total heat energy required to complete a certain stage of development in the life cycle of a species.

Day degree: One degree of mean temperature lasting for one day (Mean temp- Lower development threshold).

Intra specific: Between the same species

Inter specific: Competition between the different species

Characteristics of a population: Density, natality, mortality, dispersal, dispersion, age distribution, population growth

- Density: Number of individuals per unit area or space occupied.
- Crude density: Number of individuals per unit of total space.
- Ecological density: Number of individuals per unit of habitat space i.e. space occupied by the population.
- Natality: Number of new individuals produced per unit time i.e. birth rate.
- Absolute natality/ physiological natality: Theoretical maximum number of individuals that can be produced under most ideal conditions.
- Ecological natality: Number of individuals that can be produced under specific environmental conditions.
- Mortality: Number of individuals dying in a given population in a given period of time.
- Minimum mortality: Mortality of individuals under most ideal or non limiting conditions. o Ecological mortality: Mortality of a population under specific environmental conditions.
- Numerical response (By increasing their number)
- Functional res ponse (By increasing the consumption).

Survivorship curves:

- Convex curve: High survival throughout most of the life span, until the near end of the life span. (common in mammals and social insects like honey bees)
- Concave curve: Mortality rate during early age is high followed by a period of much lower and relatively constant losses. (Found in parasites, grasshoppers, frogs, etc)
- Constant curve: This curve implies a constant rate of survival independent of age. Probably no population in reality posses a constant survival rate throughout the whole life, like butterflies.

Dispersal: The movement of individuals in to or out of the population

- Immigration: Movement in to the population.
- Emigration: M ovement out of the population.
- Migration: Mass movement of the entire population. Such movements are generally seasonal or periodical.

Role of dispersal in p opulation dynamics:

- Helps in shaping the population growth form by supplementing mortality and natality new o r unpopulated areas are colonized.
- Helps to introduce genetic variability through interchange between populations
- Leads to an increase in the range of species

Dispersion: Distribution of individuals within a population at a particular time.

Random (Poisson): Mean > Variance. Individuals are evenly spaced and tend to be as far apart from each other.

Uniform (+ve binomial): Mean = Variance. The probability of locating an individuals at a point in the populated area is equal for all the points.

Clumped (-ve binomial): Mean < Variance. The individuals of a population are found scattered in a group here and there eg. Bees

Age distribution: Relative proportion of individuals of different age groups of a population is called age distribution or age structure.

Population growth:

1. Exponential growth model:
   $N_t = N_0^{ermt}$
   Where N_t = Number of individuals at time t
   N_0 = Number of individuals at time zero
   e = base of natural log
   rm = Innate capacity of increase
   t = Time period

Population growth occurs due to the interplay of biotic potential and environmental resistance.

- **Biotic potential:** Inherent property of individual to reproduce and survive i.e. to increase in number.
- **Environmental resistance:** It is the sum total of environment‟s limiting factors that prevent the biotic potential from being realized.
- **Carrying capacity:** Capacity of environment or an ecosystem to support and sustain a level of population under an ideal set of conditions.

2. Logisic growth model:
   dN/dt = rN (K-N)/K
   dN/dt – Rate of population growth
   r – Intrinsic rate of increase
   N – Population number
   K – Carrying capacity

FACTORS INFLUE NCING PEST POPULATIONS:

1. Abiotic factors (Temperature, humidity, light etc)
2. Biotic factors (Food, predators, parasitoids, pathogens)

Different effects of temperature are:

i. Indirect effect of temperature
ii. Lethal influence of high temperature
iii. Effect of fluctuating temperature
iv. Temperature and development
v. Temperature and fecundity
vi. Temperature and dispersal

Different effects of moisture are:

i. Effect of moisture on development and fecundity
ii. Effect of moisture on insect coloration
iii. Moisture balancing and conserving device in insect
iv. Effect of extremes of moisture conditions
v. Humidity and survival
vi. Interaction of temperature and humidity

Influence of light on different movement of insects are:

i. Phototaxis: the bodily movement of a motile organism in response to light, either towards the source of light (positive phototaxis) or away from it (negative phototaxis)
ii. Phototropism: move towards the light
iii. Photo periodism: A response by an organism to the duration or turn of light and dark periods.
iv. Effect of alternating light and darkness on insect
v. Bioluminescence

Wind and air current:

Water currents:

Edaphic factors:

Biotic factors:

Intra specific interactions

a. Aggregation of individuals of the same species
b. Concurrence
c. Cannibalism: Feeding on other individuals of the same species. Eg. *Helicoverpa armigera*
d. Association of sexes
e. Parental care

f. Social life

Inter specific interactions

a. Symbiosis: One or both are benefited (Commensalism, Cooperation, Mutualism, Competition, Parasitism, Predatism)
b. Antagonism: At least one should be harmed
c. Neutrality: Neither harmed or benefited

Insect plant relationship

a. Non preference for oviposition, shelter or food
b. Antibiosis
c. Tolerant

Food in relation to insect: Quantity and quality of food.

LECTURE: 3. PESTS – CATEGORIES, CAUSES FOR OUTBREAK OF PESTS-PEST

PEST - Derived from French word 'Peste' and Latin term 'Pestis' meaning plague or contagious disease - Pest is any animal which is noxious, destructive or troublesome to man or his interests. Pests are organisms which impose burdens on human population by causing (i) Injury to crop plants, forests and ornamentals (ii) Annoyance, injury and death to humans and domesticated animals (iii) Destruction or value depreciation of stored products. -

CATEGORIES OF PESTS

Based on occurrence: following are pest categories

Regular pest: Frequently occurs on crop - Close association e.g. Brinjal fruit borer

Occasional pest: Infrequently occurs, no close association e.g. Caseworm on rice, Mango stem borer

Seasonal pest: Occurs during a particular season every year e.g. Mango hoppers

Persistent pests: Occurs on the crop throughout the year and is difficult to control e.g. mealy bug on guava

Sporadic pests: Pest occurs in isolated localities during some period. e.g. Coconut slug caterpillar

Based on level of infestation

Pest epidemic: Sudden outbreak of a pest in a severe form in a region at a particular time e.g. BPH in Tanjore, RHC in Madurai, Pollachi

Endemic pest: Occurrence of the pest in a low level in few pockets, regularly and confined to particular area e.g. Mango hoppers in Periyakulam

Parameters of insect population levels

General equilibrium position (GEP): The average density of a population over a long period of time, around which the pest population over a long period of time, around which the pest population tends to fluctuate due to biotic and abiotic factors and in the absence of permanent environmental changes.

Economic threshold level (ETL) : Population density at which control measure should be implemented to prevent an increasing pest population from reaching the ETL.

Economic injury level (EIL): The lowest population density that will cause economic damage

Damage boundary (DB): The lowest level of damage which can be measured. ETL is always less than EIL. Provides sufficient time for control measures.

PEST CATEGORIES ACCORDING TO EIL, GEP AND DB

(i) Key pest

- Most severe and damaging pests
- GEP lies above EIL always
- Spray temporarily bring population below EIL
- The environment must be changed to bring GEP below EIL e.g. Cotton bollworm, Diamond backmoth

(ii) Major pest

- GEP lies very close to EIL or coincides with EIL
- Economic damage can be prevented by timely and repeated sprays e.g. Cotton jassid, Rice stem borer

(iii) Minor pest/Occasional pest

- GEP is below the EIL usually
- Rarely they cross EIL
- Can be controlled by spraying e.g. Cotton stainers, Rice hispa, Ash weevils

(iv) Sporadic pests

- GEP generally below EIL
- Sometimes it crosses EIL and cause severe loss in some places/periods e.g. Sugarcane pyrilla, White grub, Hairy caterpillar

(v) Potential pests

- They are not pests at present
- GEP always less than EIL
- If environment changed may cause economic loss e.g. *S. litura* is potentia pest in North India

CAUSES OF PEST OUTBREAK

Activity of human beings which upsets the biotic balance of ecosystem is the prime cause for pest outbreak. The following are some human interventions - Reason for outbreak

i. **Deforestation or bringing forest area under cultivation:** The destruction of forest over wide areas for cultivation affects several of the weather conditions in that locality and thus set conditions favourable for some insects to develop enormously and assume pest status.

ii. **Destruction of natural enemies:** The natural enemies, predators and parasitoids, keep the insect under check. Destruction of these either by man or other agencies tends to increase the population of insects in an area.

iii. **Intensive and Extensive cultivation Monoculture** (Intensive) leads to multiplication of pests.

iv. **Introduction of new varieties and crops.** Varieties with favourable physiological and morphological factors cause multiplication of insects.

v. **Improved agronomic practices and increased N fertilizer:** High leaf folder incidence on rice closer planting.

vi. **Introduction of new pest in new environment:** Pest multiplies due to absence of natural enemies in new area Apple wooly aphid *Eriosoma lanigerum* multiplied fast due to absence of *Aphelinus mali* (Parasite)

vii. **Accidental introduction of pests from foreign countries (through air/sea ports) e.g.**

a Cottony cushion scale *Icerya purchasi* on wattle tree

b. Wooly aphid - *Eriosoma lanigerum* on apple

c. Psyllid - *Heteropsylla cubana* on subabul, Spiralling whitefly - *Adeyrodichus dispersus* on most of horticultural crops

viii. **Large scale storage of food grains:** Serve as reservoir for stored grain pests.

xi. Resurgence of sucking pests: Synthetic pyrethroids - Whitefly in cotton

x. Biotypes of pest species: Development of biotype of pest species which are able to attack resistant cultivars, results in breakdown of resistance. Eg. Whitefly biotype

Resurgence: Tremendous increase in pest population brought about by insecticides despite good initial reduction in pest population at the time of treatment.

Deltamethrin, Quinalphos, Phorate - Resurgence of BPH in rice

Synthetic pyrethroids - Whitefly in cotton

Carbofuran - Leaf folder in rice

LECTURE: 4. METHODS OF PEST CONTROL AND IPM

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:

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

ECOLOGICAL BASES OF PEST MANAGEMENT:

CONCEPTS OF IPM:

- Avoidance of economic damage with minimum affects on the environment
- IPM (Term coined by Geir and Clark, 1961): IPM 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 as compatible manner as possible and maintains the pest populations at level below those causing economic injury (FAO, 1972).
- Economic Injury Level [Term coined by Stern *et al*, 1959 (EIL)]: It is the minimum pest population which causes the economic damage.
- Economic damage (ED): The damage caused by the pest to a crop which justifies the cost of control or in other words it is the damage equal to the cost of control.

- Economic Threshold Level [Term coined by Stern *et al*, 1959 (ETL)]: It is the pest population where control measures should be initiated to prevent the pest population in reaching the EIL.

Basic necessities in IPM:

- Measurement of pest population intensity.
- Determining the influence of natural enemies on the pest population
- Crop loss assessment by the pest
- Monitoring of pest population for decision making.

COMPONENTS OF IPM:

1. **Monitoring:** Use of different techniques for monitoring of insects.
2. **Resistant varieties**
3. **Cultural control**
    a. Tillage
    b. Planting and harvesting time
    c. Sanitation and Plant diversity
    d. Trap cropping
    e. Crop rotation
    f. Nutrient and water management
4. **Physical control**
    a. Hot and cold treatment for fruit fly
    b. Light trapping for nocturnal insects
5. **Mechanical control**
    a. Hand picking : Large size insects or their stages.
    b. Exclusion by screens and barriers eg. Against fruit sucking moth and Anar butterfly
    c. Clipping and pruning : for bark eating caterpillar
    d. Trapping
        - Light trap for nocturnal insect
        - Bait trap for household, fruit sucking moth, fruit fly etc
        - Pheromone trap for same sex
        - Malaise trap for beetles, moth etc
        - Suction trap for sucking pest
        - Window trap for flying insect
        - Water trap for BPH
        - Sticky trap for sucking pest
        - Pitfall trap for soil dwelling insect

6. **Legal control**
    - Legislation for foreign quarantine to prevent the introduction of new pests from abroad.

- Legislation for domestic quarantine to prevent the spread of established pests within country or a particular state.
- Legislation for notified campaigns of control against pests.
- Legislation to prevent the adulteration and mishandling of insecticides or other devices used for the control of pests.

7. Biological control

- Predators: Lady bird beetles, syrphid flies, lace wings, etc. against sucking pests
- Parasitoids:*Trichogramma spp* (Egg Parasitoid), *Apanteles spp, Bracon sp*, etc
- Bacteria: *Bacillus thuringiensis* against caterpillars, grubs
- Viruses: NP Vs and GVs have been successfully used against caterpillars
- Fungi:
  - *Beauveria bassiana:* Against beetles and caterpillars
  - *Metarrhizium anisopliae*: Against beetles and caterpillars
  - *Nomuraea rileyi:* Against caterpillars
  - *Verticillium lecanii*: Against sucking pests
  - *Paecelomyces sp:* Against sucking pests

8. Botanical control

- A pesticide produced by and extracted from plants and use against pest management called Botanical control

- Neem oil at 2% and neem seed kernel extract (NSKE) at 5% with liquid soap 0.05% have been proven effective against pests.
- 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.
- Nicotine, Pyrethrum, etc

9. Chemical control

The new generation insecticides are grouped into

- Neonicotinoids / Nitroquanidines: Imidacloprid, Acetamiprid, Thiamethoxam
- Synthetic pyrethroids: Lamda cyhalothrin, Beta cyfluthrin
- Insect growth regulators: Diflubenzuron, Teflubenzuron, Fluenoxuron, Nuvaluron. These insecticides are effective chewing insects and defoliators
- Organic insecticides: Spinosad, Abamectin, Cartap hydrochloride. Spinosad is extracted from actinomycetes *Saccharopolyspora spinomosa*. The insecticide formulation contains two components as spinosyn A+D. It is a contact and stomach poison targeted against Defoliators and Chewing insects. Abamectin is extracted from bacteria, Streptomyces avermectilis. This insecticide is having contact and translaminar action and it is used as an Acaricide in ornamentals
- Organophosphates: Malathion, Profenofos, Quinalphos, Dimethoate
- Carbamates: Thiocarb, Carbosulfan

- Insecticide combinations**:**

10. Semiochemicals

a. Allelochemical: Allomone, Kairomone, Synomone
b. Pheromone: Sex, Aggregation, Trail, Alarm pheromone

11. Other components
    a. Genetic control : Male sterile techniques

Advantages of IPM:

- It provides sustainable control of the pest and also adds to sustainable crop productivity.
- It is economically viable and is affordable by marginal farmers.
- It is environmentally safe.
- Less health hazards.
- Social and political stability
- Quality produce with minimum pesticide residues and hence will enhance the export of agricultural commodities
- Delay the development of resistance

LECTURE-5: PEST SURVEILLANCE AND METHODOLOGY FOR SURVEILLANCE

Survey and Sampling

- Survey: Survey is a planned activity to collect some data.
- Surveillance: When survey of the same area/ plot or locality is carried out at regular intervals to record some observation or to ascertain the changes in the subject of study, it is called as surveillance.

Objectives of survey and surveillance:

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

- Detect species of pest or pathogen present
- Assess levels of population / damage / infection
- Study the influence of weather and seasonal parameters on pests and diseases.
- Know new species of pests and diseases.
- Monitor the behaviour of pests under changing cropping pattern / new varieties.
- Find out natural enemy population
- Watch the behaviour of pests under changing cropping pattern/new varieties
- Assess resistance/susceptibility/break-down of resistance in crops to pests and diseases.
- Monitor build-up of resistance in pests and pathogens to pesticides
- Mark endemic areas/pest calendar
- Apply timely plant protection measures on need-basis,
- Reduce cost of cultivation
- Avoid contamination to eco-system, and
- To forewarn farmers

Types of survey:

Qualitative: To identify the different insect species present over an area or their density whether abundant, common, rare, in traces, etc

Quantitative: To estimate the exact number of one or more species of insects in time and space.

Sampling insect populations:

- In quantitative survey a count of insects is required.
- Due to large number and/or secretive nature it is not possible or even desirable to count each and every individual in a population.
- Hence more efficient method is by sampling.
- Randomization and the choice of sampling unit are the fundamentals of sampling.
- The total number of samples to be taken depends upon the degree of precision required

Sampling unit: Sampling unit is a portion of the habitat from which insect counts are to be made e.g. a plant, branch, leaves or fruiting bodies, a clump, a micro plot of 1 m2, etc.

Sample: A group of sampling units from which an estimate is made.

Sampling technique: It is the method used to collect information form a single sampling unit.

Sampling programme: Sampling programme is the procedure that employs the sampling technique to obtain sample and make a density estimate. These are following type:

Extensive programmes:

- Conducted over a large area to determine information like species distribution, status of injurious insect stages.
- Usually a single insect stage is sampled.
- Only one or few samples are taken per season.
- Only moderate levels of precision are required and emphasis on low cost.

Intensive programmes:

- Conducted as part of research in population ecology.
- Here sampling is done frequently, in a small area
- All or most stages in the life cycle are sampled
- High degree of precision in sought

Pest Forecasting: Forecasting is the prediction of the type of fluctuation which will ensue. The forecasting is mainly of two kinds:

1. **Short term forecasting:** It covers a particular season or one or two successive season.
2. **Long term forecasting:** It covers large area and based mainly on the possible effects of weather on the insect abundance or by extrapolating from the present population density into the future

Diapause: Diapause is a suspension of development that can occur at the embryonic (Silkworm), larval (Caterpillar), pupal (Cabbage butterfly) or adult stage (White grub) depending on the species. Daipause is of two type:

a. **Facultative diapauses:** Some members of a generation enter diapause resulting in two or more generation in a year.
b. **Obligatory diapauses:** Every individual in every generation enter diapauses resulting in only one generation in a year.

Common Sampling Techniques:

- In situ count
- Knock down (By jarring, by chemicals, by heating)
- Netting
    - Sweep netting for flying insect
    - Vacuum netting for sucking pest
    - Aerial netting for fast flying insect
- Trapping
    - Light trap for nocturnal insect
    - Bait trap for household, fruit sucking moth, fruit fly etc
    - Pheromone trap for same sex
    - Malaise trap for beetles, moth etc
    - Suction trap for sucking pest
    - Window trap for flying insect
    - Water trap for BPH
    - Sticky trap for sucking pest
    - Pitfall trap for soil dwelling insect
- Mark, release and recapture technique
- Sequential sampling

Population estimates:

Absolute estimates:

- Absolute estimates (number per ground surface area e.g. per hectare or acre or 1 m2)
- Population intensity (per habitat unit e.g. leaf, plant, etc)
- Basic population estimates (intermediate between above two e.g. per 5 cm of stem)

Relative estimates: (don‟t give definite number per unit area).

Population indices: (insects themselves are not counted but their products).

Criteria of estimates:

- The estimates must be evaluated for:
- Fidelity: accuracy with which estimates follow the actual number in the population.
- Precision: It is the reproducibility of the results and measures the degree of error

- Cost: Cost is very important. Any estimates having great fidelity and precision will be of no use until and unless it is cost effective.

Parameters of sampling programme:

- ✓ Insect stage to be sampled
- ✓ Number of sampling units
- ✓ Time of sample
- ✓ Pattern of sampling
- ✓ Types of sampling

Number of samples:

$N = [(t \times s)/ (d \times m)]^2$

Where N = no. of sampling units required,

t = student „t" value

s = standard deviation

d = precision (RV) expressed as decimal

m = mean density

Pattern of sampling: Random, diagonal, double diagonal, zigzag diamond, „W" pattern, micro plot, „U" pattern etc.

- Types of sampling:
- Random sampling
- Stratified random sampling
- Systematic sampling
- Sequential sampling

Important Definition:

Allomone: A chemical substance, produced or acquired by an organism, which, when it contacts an individual of another species in the natural context, evokes in the receiver a behavioural or physiological reaction adaptively favourable 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.

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.

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.

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.

LECTURE: 6. BIOLOGICAL CONTROL IN PEST MANAGEMENT

The term biological control was coined by Smith in 1919 and microbial word was first derived by Stainhaus in 1949.

The steps involved in biological control are:

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

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.

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.*

5. Based on the stage of host insect attacked

I. **Egg parasitoid:** *Trichogramma chilonis:* Eggs of sugarcane internode borer, cotton bollworm, rice leaf folder.

II. **Egg-Larval parasitoid:** *Chelonus blackburni* eggs of cotton spotted bollworm.

III. **Larval parasitoid:** *Bracon hebetor* larvae of coconut black headed caterpillar

IV. **Larval – Pupal parasitoid:** *Isotima javensis* pre – pupal parasite of top shoot borer of sugarcane.

V. **Pupal parasitoid:** Brachymeria nephantidis Pupae of coconut black headed caterpillar.

VI. **Nymphal and adult parasitoid:** *Aphelinus mali* on apple wooly aphids

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.

Insect predators: A predator is a free living organism throughout its life, it kills the prey, usually larger than the prey and requires more than one prey to complete its development.

- Coccinellids (Coleoptera): e.g. *Coccinella septempunctata, Hippodamia variegata, cheilomenes sexmacula*, etc. against aphids, bugs
- Syrphids (Diptera): e.g. *Episyrphus balteatus, Metasyrphus corrollae, Scaeva pyrastri, Ischiodon scutalaris, Metasyrphus conferator*, etc. against aphids
- Chrysopids (Neuroptera): e.g. *Chrysoperla zastrowi sillemi, Mallada sp* against caterpillars, bugs
- Predatory bugs (Heteroptera): e.g. *Anthocoris minki, Orius* spp, *Blaptostethes pallescens sp* against caterpillars
- Preying mantids (Dictyoptera): e.g. *Statilia maculate sp* against caterpillars

- Predatory wasps (Hymenoptera): e.g. *Vespa* spp *sp* against caterpillars

Microbial control: Microorganisms which cause diseases in host insects are known as insect pathogens. Utilisation of insect pathogen and their products in the suppression of insect pests is known as microbial control (eg) virus, bacteria, fungi, protozoa, rickettsiae and nematodes.

a. Insect viruses:

Nuclear polyhedrosis virus (NPV): Occluded singly or in groups in polyhedral inclusion bodies. Site of multiplication is in cell nucleus of epidermis, fat body, blood cells and trachea. Symtom is Wipfelkrankheit or top disease (eg) NPV of *Spodoptera* and NPV of *Helicoverpa armigera*.

Cytoplasmic polyhedrosis virus (CPV): Spherical virions are occluded singly in polyhedral inclusion bodies. Site of multiplication is .cytoplasm of midgut epithelium.

LACTURE 7: INSECTICIDES, CLASSIFICATION AND THEIR MODE OF ACTION

Classification of pesticides based on target organisms

- Insecticides eg. malathion
- Rodenticides eg. Zinc phosphide
- Acaricides eg. Spiromecifen
- Avicides eg. anthraquinone
- Molluscides eg. metaldehyde
- Nematicides eg. Carbofuran
- Fungicides eg. Copper oxychloride, mancozeb
- Bactericides eg. Streptomycin sulphate, aureomycin
- Herbicides eg. 2,4-D, butachlor

Classification based on mode of entry

Stomach poison: Those insecticides which enter the body of the target insect through its food. Eg. Bt

Contact poison: Those insecticides which enter the body of the target insect by penetrating through their cuticle or through spiracles. Eg. Malathion

Fumigants: Those insecticides which enter in gaseous state into the body of the insect through the spiracles. Eg Almunium phosphide

Systemic Poison: Toxicant that are capable of absorption into plant sap or animal blood and lethal to insect feeding on or within the treated host. Eg. Imidacloprid

Classification based on mode of action:

Physical poison: Poison which kill the insect by exerting a physical effect. Eg. heavy oils

Protoplasmic poison: The toxicants which kill the insect by destruction of cellular protoplasm of the mid gut epithelium. Eg. Arsenic compounds

Respiratory poison: Poison which block the cellular respiration and render the respiratory enzymes inactive. Eg. HCN

Nerve poison: Poison which affect the nervous system and render the insect to behave abnormally leading to death. Eg. organophosphate, carbamate insecticides.

Classification based on chemical nature:

- Inorganic compound:
- Organic compound
- Synthatic organic compounds
- New group of insecticides

LECTURE 8: PESTICIDES APPLICATIONS 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.

2. Spraying: Spraying is normally carried out by mixing EC (or) WP formulations in water.

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

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.

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.) 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.

6. Sett treatment: Treat the sugarcane setts in 0.05% malathion for 15 minutes to protect them from scales.

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 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 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

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, soil mealy bug.

12. Capsule 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 litura:*** 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:** Castor 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.

Lecture-9: Insect Pests of Mango and Sapota

Major insect pests of Mango

S. No.	Common Name	Scientific Name	Order	Family
1.	Mango Hopper	*Idioscopus niveosparsus, I.clypealis and Amritodes atkinsoni*	Hemiptera	Cicadellidae
2.	Mango mealybug	*Drosicha mangifarae*	Hemiptera	Pseudococcidae
3.	Mango stem borer	*Batocera rufomaculata*	Coleoptera	Cerambycidae
4.	Mango stone/nut weevil	*Sternochetus mangifarae*	Coleoptera	Curculionidae
5.	Mango fruit fly	*Bactrocera dorsalis*	Diptera	Tephritidae
6.	Mango bud mite	*Aceria mangifarae*	Acari	Eriophydae
7.	Flower gall midge	*Procystiphora mangiferaae, Erosomyia indica, Dasyneura amaramanjarae*	Diptera	Cecidomyiidae
Minor insect pests of mango				
1.	Flower webber	*Autoba versicolor*	Lepidoptera	Noctuidae
2.	Shoot webber	*Orthaga exvinacea*	Lepidoptera	Pyralidae
3.	Bark caterpillar	*Indarbela tetraonis, L.quadrinotata*	Lepidoptera	Metarbelidae
4.	Red tree ant	*Oecophylla smaragdina*	Hymenoptera	Formicidae
5.	Aphid	*Toxoptera aurantii*	Hemiptera	Aphididae

1. Mango hopper

a. **Scientific Name**- *Idioscopus niveosparsus, I. clypealis and Amritodes atkinsoni*

b. **Order**- Hemiptera

c. **Family**- Cicadellidae

b. **Distribution:** The mango hopper is widely distributed in India, Indonesia, Malasiya etc.

c. **Host:** Only mango, monophagous nature

d. **Identification:** The adult of *Idioscopus niveosparsus* is slightly smaller with three spots on the scutellum and prominent white band across its light brown wings. *I.*

Clypealis is the smallest with two spot on the scutellum and dark spot on the vertex and is light brown in colour. *Amritodes atkinsoni* is the largest and light brown having two spots on the scutellum.

e. **Nature of damage:** The nymph and adult cause damage. Injury to the inflorescence and young shoots is caused by egg laying and feeding. 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. As the wind blows, young fruits and dried inflorescence fall to the ground. 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.

f. **Life cycle:** The pest active throughout the year except May- June and October-January, only the adult undergo dormancy. When the inflorescence appears the female lay on an average 200 eggs singly embedded in plant tissue. The eggs hatch in 4-7 days and newly emerge nymph commence feeding on the inflorescence. The nymph are mature when fruit has set. The nymph then migrate to the stem and young leaves and become full grown in three stages, in 8-13 days. The full fed nymph gives rise to winged adult. The life cycle is completed in 15-19 days and only two generation are completed in a year.

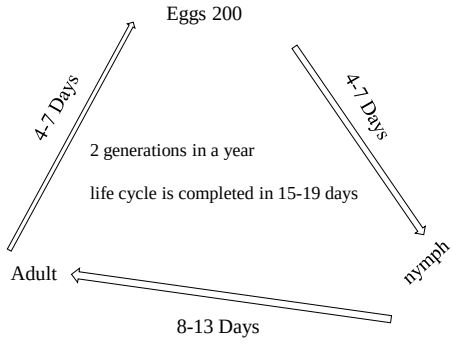

Fig. Life Cycle of Mango hopper

Management:

- Don't grown high density planting as it provide favourable habitat for hopper.
- Grow less susceptible varieties viz., Banganapalli, Chinnarasam and Alphonsa.
- Judicious use of nitrogenous fertilizer.
- Don't give regular irrigation
- Avoid waterlogged condition
- Collect and destroy affected inflorescence or sticky inflorescence to minimize population build-up
- Timely pruning is done during winter to have better light interception.
- Spray of NSKE @ 5.0 % is also effective. .
- The pest can also be controlled by spraying of two spray, acephate 75 SP at 1 g /litre or phoasalone 35 EC at 1.5 ml / litre or carbaryl 50 WP at 2 g / litre of water, first

spray at the time of new flesh panicle emergence and second at two weeks after the first spray.

2. Mango mealy bug

Scientific Name- *Drosicha mangifarae*
Order- Hemiptera
Family- Pseudococcidae
Distribution: The mango bug is widely distributed in India, Indonesia, Malasiya, Sri- lanka, China, Formosa, Pakistan etc. In India it is mainly found in Bihar, Delhi, Maharastra, UP, MP, Punjab and Assam.
Host: Jack-fruit, banyan, guava, papaya, citrus spp, jamun, mango, peach,fig etc.
Identification: The female is wingless which are oval, flattened and have body covered with a white mealy powder whereas male have one pair of black wings and crimson red. Nymph is also wingless.
Nature of damage: The nymph and female adults causes damage. The nymph sucks plant juice, causing tender shoots and flowers to dry up. The young fruits also become juiceless and drop off. Nymphs secrete honey dew which attracts fungus due to which black spot may be seen on the twigs, fruits and shoots.
Life cycle: The females and male adults develop differently. In case of female three developmental stages, egg, nymph and adult while in case of male, egg, nymph, pupa and adult are found. The pest is active from December to May and spends rest of the year in the egg stage. The female lay eggs 300-400 in April- May in soil up to 15 cm within silken purses. They hatch at the end of December or in January and in a given locality continue to hatch. The duration of the first stage is December to middle February, second stage February to middle March and third stage is middle March to April. After the emergence of adult mating take place at a time when the female are not fully developed. The male of mealy bug undergo for pupation in soil only and the pupal period last 3 weeks. The female mature after 15-35 days and lay eggs for 4-7 weeks during April –May. *Drosicha mangiferae* is univoltine and has a total lifecycle of 9-11 months.

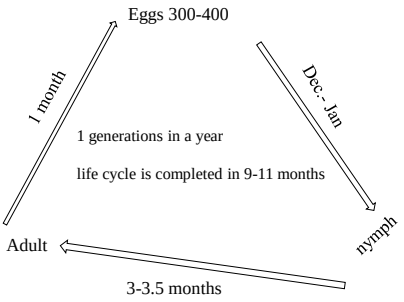

Fig. Life Cycle of Mango mealy bug female

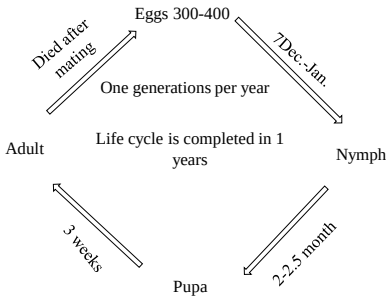

Fig. Life Cycle of Mango mealy bug male

Management:

- Clean the orchard from weeds which act as additional host for nymphal stage..
- Deep summer ploughing exposes eggs to natural enemies and high sun heat.
- Racking around the trunk expose eggs and pupae.
- Judicious use of nitrogenous fertilizer.
- Don't give regular irrigation
- Avoid waterlogged condition
- Collect and destroy affected inflorescence or sticky inflorescence to minimize population build-up
- Timely pruning is done during winter to have better light interception.
- Nymph should be prevented from crawling up the trees by applying 15-20 cm wide sticky bands with alkaline sheets around the trunk about one meter above the ground level during second week of December.
- The nymphs are parasitized by *phygadeuon spp*. and grub of *Rodolia fumida* are predaceous.
- Release *Cryptolaemas montrouzieri* @ 10 beetles per tree
- Spray of NSKE @ 5.0 % is also effective. .
- The pest can also be controlled by spraying of two spray, acephate 75 SP at 1 g /litre or phoasalone 35 EC at 1.5 ml / litre or carbaryl 50 WP at 2 g / litre of water.

3. Mango stem borer

Scientific Name- *Batocera rufomaculata*
Order- Coleoptera
Family- Cerambycidae
Distribution: The stem borer is distributed throughout the mango growing areas.
Host: Jack-fruit, fig, citrus spp, jamun, mango etc.
Identification: Full grown larva is a stout, yellowish, white fleshy grub, 6 cm length. The adults are longicorn beetles, well built, large and pale greyish and 5 cm in length. The beetle is long legs and antennae and a dirty white band from head to tip of the body on each side.
Nature of damage: The grub causes damage. The grubs feed by tunnelling 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.
Life cycle: The life cycle is prolonged and the adult generally appear during the monsoon. The female laid 150 eggs singly under the loose bark in a wounded or diseased portion. The eggs hatch in about 1-2 weeks and winter is passed in the grub stage. The grub feeds on the internal tissues and become full fed in about 10-11 months. The full grown larvae then hollow out a cell for pupation and pupal period lasts about one month. The life cycle may be completed in 1-2 years and only one generation is complete in a year.

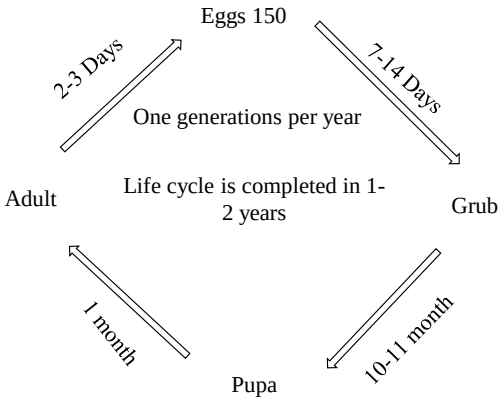

Fig. Life Cycle of Mango stem borer

Management:

- Cut and destroy the dead trees and affected branches from the orchard.
- Use light trap @ 4 / ha to attract adult moths or beetles.
- Identify bore holes and spike out grubs using a needle or iron wire and add insecticide emulsion (monocrotophos @ 20 ml / hole) a fumigant tablets (3 g Aluminium phosphide) or petrol and close the holes with the mud.
- Remove the alternative host from mango orchards.
- 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.
- Follow padding with monocrotophos 36 WSC 10 ml per tree soaked in absorbent cotton when the trees are not in bearing stage.
- Apply carbofuran 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.
- Swab trunk with carbaryl 20 g/1.

4. Mango nut/stone weevil

Scientific Name- *Sternochetus mangifarae*
Order- Coleoptera
Family- Curculionidae
Distribution: The nut weevil is distributed throughout the mango growing areas.
Host: Mango
Identification: The grub is apodous, fleshy, light brown with dark head. The adult is stout, ovoid, dark brown, about 6 mm long with snout.

Nature of damage: The injury caused by the larvae feeding in pulp but certain number of fruits spoiled when the weevil make an exit through ripe fruits. The grub tunnel in a zig - zag manner through the pulp endocarp and the seed coat and they finally reach the cotyledons and destroy them by feeding. The adults who emerge from the pupae also feed on the developing seed and this may hasten the maturity of infested fruits. Due to the hidden nature of damage this pest is quarantine important and USA banned import of mangoes from India.

Life cycle: The weevil are inactive from July-August and active as soon as the formation of mango fruits take place. The female lays eggs singly on the marble sized fruits by scooping out the surface tissue and cover over with a transparent secretion. On a single fruit up to 15 eggs may be laid in a day. The egg hatch within 7 days and newly emerge grub feed inside the fruits. The larval period lasts about 20-30 days and pupates inside the nut along the concave side. The pupal period is 7 days. The total life cycle occupies 40-50 days but the emerging adults become inactive (hibernation) and resume breeding only in the next season. Thus, there seems to be a single generation in a year.

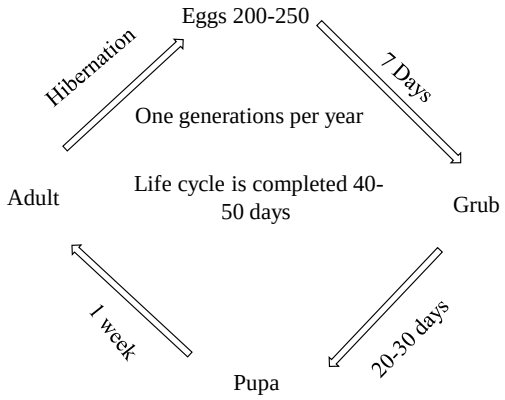

Fig. Life Cycle of Mango nut weevil

Management:

- Collect and destroy the fallen fruits, which contain 85 % of the weevil
- Raking of soil below the tree in October/November and March can manage partially.
- 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.

5. Mango fruit fly or oriental fruit fly:

Scientific Name- *Bactrocera dorsalis*

Order- Diptera

Family- Tephritidae

Distribution: The mango fruit fly is widely distributed in India, Indonesia, Malasiya, Sri-lanka, China, Formosa, Pakistan etc. In India it is mainly found in Bihar, Rajasthan, Delhi, Maharastra, UP, MP, Punjab and Assam.

Host: Mango, guava, peach, apricot, cherry, pear, chiku, ber, citrus and other plants.

Identification: The maggot is legless, 8-9 mm long, yellowish- white colour with dark brown head. The adult is stout, measure 14 mm across the wings and 7 mm in body length. It is brown and transparent wings with yellow legs and dark rust red and black pattern on the thorax.

Nature of damage: Damage caused by maggot only. The maggot feed on pulp and convert the pulp into a bad smelling, discoloured semi liquid mass making the fruit unfit for human consumption. The infested fruit drop and start rotting from inside and on complete rotting of the fruits, the damaged fruit develop yellow spots with black centers through which liquid oozes out on pressing.

Life cycle: The pest is active during the summer months and passes the winter as a hibernating pupa in the soil during November to March. The adult flies emerge in April and shift seasonal fruits and vegetables. Later on, they shift to mango. The flies are most active at 25-30 degree temperature and they become inactive below 20 degree Celsius. After mating the flies are 10-15 days old, they lay 2-15 eggs at a time in groups in the soft skin of fruits. The female lays, on an average 150-200 eggs in a month. The eggs hatch in 2-3 days spring, 1-2 days in summer and 10 days during winter. The maggots full grown in 1-4 weeks through three stages and move into the soil and pupate 8-13 cm below the surface. The pupal period is 1-7 weeks and the life cycle is completed in 2-13 weeks and many generation are completed in a year.

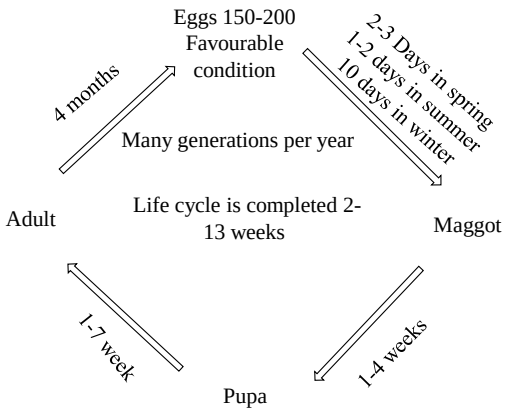

Fig. Life Cycle of Mango fruit fly

Management:

- Avoid infestation by early harvesting of mature fruits
- Plough the interspaces to expose and kill the pupae during the winter season.
- Collect and destroy the fallen fruits twice in a week
- Monitor the fruit fly by set up fly trap using methyl eugenol. Prepare solution, taking methyl eugenol 1 ml/ 1 litre of water + 1 ml of malathion.

- Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am and collect and destroy the adult flies.
- Conserve parasitoids like *Optius compensates* and *Spalangia philippinensis*.
- Spray 1.25 litre of malathion 50 EC + 12.5 kg gur/ jiggery in 1250 lit. Water per hectare and repeat spray 10 days interval if infestation continues.
- After harvest, dip the fruits in 5 % sodium chloride solution for one hour to kill the eggs.

Major insect pests of Sapota

S. No.	Common Name	Scientific Name	Order	Family
1.	Sapota leaf webber	*Nephopteryx eugrapllylla*	Lepidoptera	Pyralidae
2.	Bud worm	*Anarsia epotias*	Lepidoptera	Gelechiidae
3.	Sapota seed borer	*Trymalitis margaritas*	Lepidoptera	Tortricidae
Minor insect pests of Sapota				
1.	Fruit fly	*Bactrocera dorsalis* Bend. *B. zonatus* Saund.,*B. tau* and *B. correctus* Beezzi.	Diptera	Tephritidae
2.	Hairy caterpillar	*Metanastria hyrtaca*	Lepidoptera	Lasiocampidae
3.	Aphid	*Toxoptera aurantii*	Hemiptera	Aphididae

1. **Sapota leaf webber**

Scientific Name- *Nephopteryx eugrapllylla*

Order- Lepidoptera

Family- Pyralidae

Distribution: The pest is found throughout India.

Host: chiku, tobacco and other plants.

Identification: The adult moth is greyish with fore wings having brown or black spots and hind wing semi hyaline. The larva are 25 mm long, slender in body shape, and is pinkish with a few longitudinal lines on the dorsal surface.

Nature of damage: Damage caused by caterpillar. The larvae clump the leaves together and feed on matter of leaves, often on buds and flowers and sometimes on the tender fruits as well. 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. The larvae bore into the buds which wither and then they move on to the next buds.

Life cycle: The pest is found throughout the year but the activity increases with the appearance of new shoots and buds. The maximum activity of pest is seen during June-July. With the onset of spring season, the female start laying 374 eggs, pale yellow, oval shaped eggs singly or in groups of 2 -3 on leaves and buds of young shoots. The eggs hatch in 2-11 days. The full fed larva developed 2-8 weeks and undergoes pupation in the leaf webs and is completed in 1-4 weeks. The life cycle is completed in 26-90 days and 7-9 generations are completed in a year.

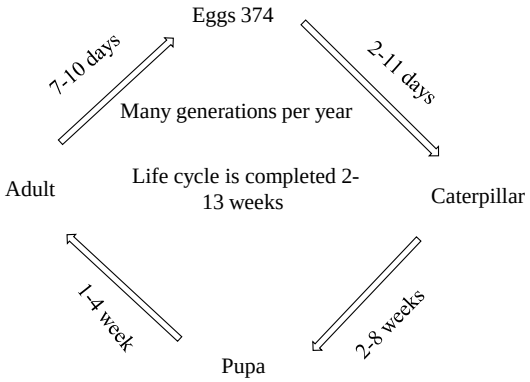

Fig. Life Cycle of Sapota leaf webber

Management:

- Removal and destruction of infested leaves and affected fruits.
- Collect and destroy the fallen fruits twice in a week
- Use light trap @ 1/ha to monitor activity
- Spray NSKE @ 5% along with sticking agent.
- Conserve natural enemies.
- Spray two times of carbary .01% 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. Sapota Seed borer

Scientific Name- *Trymalitis margaritas*

Order- Lepidoptera

Family- Tortricidae

Distribution: The pest is found throughout India.

Host: Sapota, mango, guava, jamun, tobacco and other plants.

Identification: The first instar larvae were very minute, white in colour with pinkish tinge, without distinctly segmented and hairless body. Fully developed larvae were pinkish in colour. 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. d wings were cream coloured with thick hairs at the margins.

Nature of damage: Damage caused by caterpillar. Sapota seed borer is an invasive pest that might have been accidentally introduced in India from Sri Lanka a decade back. The larvae bore immature fruits, tunnelling them and feed, it is difficult to distinguish between infested and uninfested fruits prior to the emergence of larvae.

Life cycle: The female lays up to 270 eggs. The eggs hatch in 10-11 days and larva bore into the fruit and feed them. The larva full grown in 12 days and the full grown larva come out of the seed, starts folding the leaf with silken thread to form a cocoon and pupate inside. The pupal period lasts for 10-15 days. The adult male lived for 3 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 to 45 days.

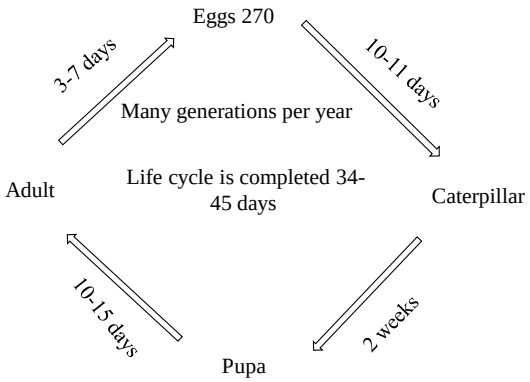

Fig. Life Cycle of Sapota lseed borer

Management:

- Removal and destruction of infested leaves and affected fruits.
- 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
- Sprays of Deltamethrin 2.8 EC at 1 ml/l and Bt at 1 ml/ l at fortnightly interval will bring down the seed borer infestation.

Lecture 10: Insect pests of Citrus

Major insect pests of Citrus

S. No.	Common Name	Scientific Name	Order	Family
1.	Citrus Psylla	*Diaphorina citri*	Hemiptera	Psyllidae
2.	Citrus whitefly	*Dialeurodes citri*	Hemiptera	Aleyrodidae
3.	Citrus blackfly	*Aleurocanthus woglumi*	Hemiptera	Aleyrodidae
4.	Citrus mealybug	*Pseudococcus filamentosus*	Hemiptera	Pseudococcidae
5.	Citrus caterpillar/butterfly	*Papilio demoleus*	Lepidoptera	Papilionidae
6.	Citrus leafminer	*Phyllocnistis citrella*	Lepidoptera	Phyllocnistidae
7.	Bark eating caterpillar	*Indarbela quadrinotata*	Lepidoptera	Metarbelidae
8.	Fruit sucking moth	*Eudocima maternal, E. fullonica, E. conjuncta*	Lepidoptera	Noctuidae
9.	Citrus Aphid	*Toxoptera citricidus, T. Aurantii*	Hemiptera	Aphididae
10.	Citrus mite	*Oligonychus citri*	Acari	Tetranychidae
Minor insect pests of Citrus				
1.	Citrus blossom midge	*Dasineura citri*	Diptera	Cecidomyiidae
2.	Citrus borer	*Chloridolum alcamene*	Coleoptera	Cerambycidae

1. **Citrus Psylla**

Scientific Name- *Diaphorina citri*

Order- Hemiptera

Family- Psyllidae

Distribution: India, China, Formosa, Japan, Myanmar, Sri- Lanka, East Indies and New Guinea.

Host: All species of Rutaceae.

Identification: The nymphs are flat, louse like, orange yellow. The adult is small, the tail end of body being turned upwards. The body is brown with head with lighter brown and pointed, wings are membranous, semi-transparent with a brown band in apical half of the fore wings.

Nature of damage: Only the nymphs are damaging stage. They suck sap of the fresh tender parts of the plant. The vitality of plants deteriorates, and the young leaves and twigs stop further growing. The leaf buds, flower buds and leaves may wilt and die. The nymphs secrete honey dew on which a black fungus develops, adversely affecting photosynthesis and also produce toxic substance resulting fruits remain undersized. This insect is also responsible for spreading the citrus greening disease.

Life cycle: The pest is found throughout the year but the activity is prolonged in winter as adult. They resume breeding in February- March and lay, on an average 500 almond shaped stalked eggs, singly or in groups of two or three arranged in straight line on the tender leaves and shoots. The eggs hatch in 10-20 days in winter and 4-6 days in summer. There are five nymphal stages and the development is completed in 10-11 days in summer and 1 month in winter. When the nymphs are full grown, they migrate to the lower surface of leaves where they change into adults. The adult copulate 4-8 days after emergence. The female live 190 days in winter and 12-26 days in the summer. In summer the life cycle is completed in 14-17 days. There are 8-9 overlapping generation in a year.

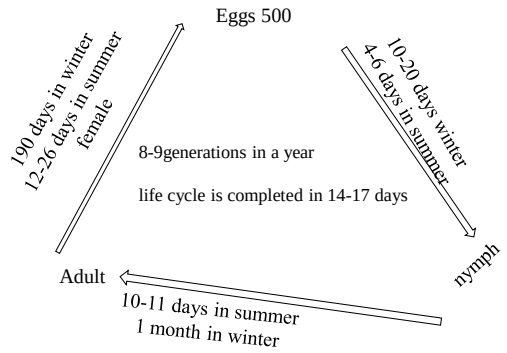

Fig. Life Cycle of Citrus Psylla

Management:

- Removal and destruction of infested leaves and affected fruits.
- Collect and destroy the fallen fruits, flower buds, leaf buds twice in a week
- Erect sticky trap for monitoring.
- Spray NSKE @ 5% along with sticking agent.
- Conserve natural enemies like *Tetrastichus radiates*, *Coccinella Spp*, *Chrysoperla carnea*.
- Spray thiamethoxam 25 WG @ 400g or imidacloprid 17.8 SL @ 500 ml or diamethoate 30 EC @ 3.125 Lit in 1250 litre water per hectare during March and again in the first week of September.

2. **Citrus whitefly**

Scientific Name- *Dialeurodes citri*

Order- Hemiptera

Family- Aleyrodidae

Distribution: India, China, Formosa, America, Vietnam, Pakistan

Host: All species of Rutaceae, persimmon, dharek, guava, pear, mango etc.

Identification: Adult is minute, male being smaller than female having six jointed antennae and the last segment ending in a sharp point. Eyes are transparent, red and kidney shaped. Both the wings and body are completely covered with a white waxy powder. The nymphs is pale yellow, with purple eyes and body fringed with bristles.

Nature of damage: The nymph and adult causing damage. It sucks the cell sap from leaves which curl over and fall off. The nymphs secrete honey dew on which a black fungus develops, adversely affecting photosynthesis.

Life cycle: In February, the adult emerge from pupae and the female lay eggs 200 singly on the underside of soft young leaves which may last from 7-10 days. The hatch within 10-20 days and the young nymph, on emergence, crawls about for a few hours and start suck cell sap of the tender parts. A nymph is full fed in 25-71 days and then change into a pupa. The pupal stage is longer in summer and winter, when it lasts 114-159 days. The life cycle is completed 5-6 months and there are probably 2 generation in a year.

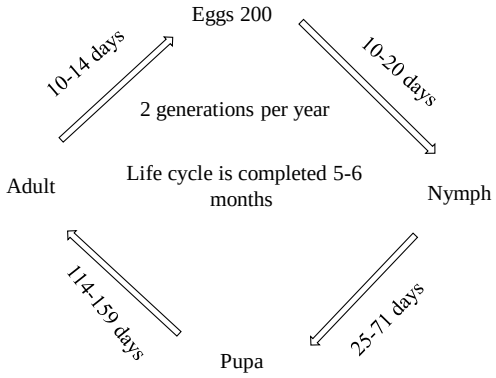

Fig. Life Cycle of Citrus whitefly

Management:

- Removal and destruction of infested shoots and affected leaves.
- Avoid close planting, water logging or damp condition or any other stress condition.
- Collect and destroy the fallen fruits, flower buds, leaf buds.
- Excessive irrigation and application of nitrogen and synthetic pyrethroid should be avoided.
- Erect sticky trap for monitoring.
- Spray NSKE @ 5% along with sticking agent.

- Conserve natural enemies like *Encarsia spp*, *Brumoides suturalis*, *Chrysoperla carnea*, *Aleurothrips spp*.
- Spray thiamethoxam 25 WG @ 400g or imidacloprid 17.8 SL @ 500 ml or diamethoate 30 EC @ 3.125 Lit in 1250 litre water per hectare during April and again in August.

3. **Citrus caterpillar/butterfly**

Scientific Name- *papilio demoleus*

Order- Lepidoptera

Family- Papilionidae

Distribution: Africa, greater part of Asia, Formosa and Japan.

Host: All species of Rutaceae.

Identification: The first instar larvae look like bird dropping, the full grown larvae is yellowish green, has a horn like structure on the dorsal side of the last abdominal segment. The adult head and thorax are black; its wings are dull black with yellow markings and hind wings having tail like prolongation on anal margin. The antennae are black and have club like at their ends.

Nature of damage: The caterpillar causing damage which feeds on the leaves from the margin inwards to the midrib. The larvae cuts leaves irregularly in the nursery. The leaves of young plants are completely eaten up. Heavily attacked plants bear no fruits.

Life cycle: The butterflies appear in March and lay eggs 75-120 singly or sometime in groups of 2 to 5 on the surface of the leaf. They hatch in 3-4 days during summer and in 5-8 days during winter. The young larva emerges by cutting round hole through the egg shell which forms the first food of the larva. This scavenging habit persists throughout life and the larvae eat their own exuviae after each moulting. The larval stage lasts 8-16 days in summer and about 28 days during winter. When full grown, the larvae have to pupate on the plant. The pupal stage lasts about 8 days in summer and 56-98 days in winter due to hibernation. A male lives for 3-4 days whereas a female lives for about 7 days. The life cycle is completed 20-117 days depending on environmental condition and 3-4 generation are completed in a year.

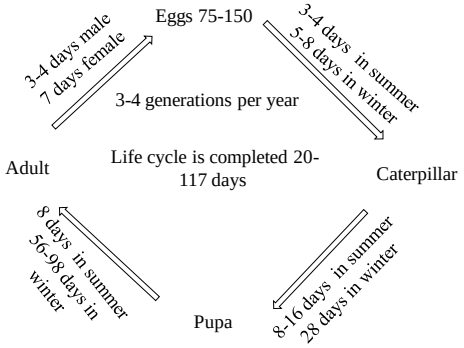

Fig. Life Cycle of Citrus caterpillar/butterfly

Management:

- Hand picking of large size larva in nurseries and orchard and destroy them.
- Avoid close planting, water logging or damp condition or any other stress condition.
- Removal of alternate host
- Spray NSKE @ 5% along with sticking agent.
- Spraying the entomopathogen bacterial like Bt@ 2 g per litre water
- Conserve natural enemies like *Trichogramma spp. Brachymeria sp.*
- Spray indoxacarb 14.5 SC or Fame 48 SC or emamectin benzoate @ 0.4 ml/g per litre of water. First spray during April after fruit set and second in October.

4. **Citrus leaf miner**

Scientific Name- *Phyllocnistis citrella*

Order- Lepidoptera

Family- Phyllocnistidae

Distribution: This insect is widely distributed in the Orient, northern Australia, India and is to be a serious pest of nurseries in Tamil Nadu, MP, Assam, UP, Punjab.

Host: All species of Rutaceae, pomelo, willow, cinnamon and *Loranthus* spp.

Identification: The full grown larva measure 5.1 mm long, pale yellow or pale green with light brown. The adult is tiny, fore wings with brown stripes and black spots along the tips. The hind wings are white and both pairs fringed with hairs.

Nature of damage: The caterpillar causes damage by making zig-zag silvery mines between epidermis of leaves. Due to high mining by the pest, leaf suffer badly, get deformed and irregularly curled up and finally it dries up and fall off. On the older leaves, brownish patches are formed which serve as foci of infection for citrus canker. In case of nursery plants and large trees, photosynthesis is adversely affected due to which an appreciable reduction occur in yield.

Life cycle: The eggs are usually laid singly on underside of the leaves and tender shoots. Hatching period varies from 2-10 days. The newly hatched larva is legless which enters the leaf tissue and begins to feed inside it and mines the leaf lamina. The larval period lasts 5-30 days. The full grown larva come out and pupate near the margin of leaf which rolls up to provide a sort of cover over the pupa. The pupal period varies from 5-25 days. The life cycle is completed in 12-55 days and several overlapping generations are produced in a year.

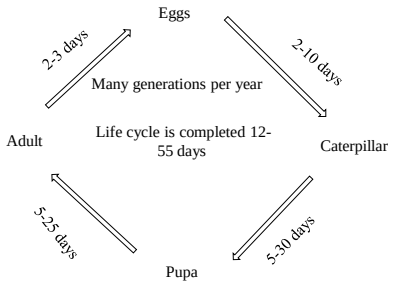

Fig. Life Cycle of Citrus leaf miner

Management:

- Avoid close planting, water logging or damp condition or any other stress condition.
- The orchard should be kept free of wild citrus hedges, which serve as breeding places of the pest.
- Collecting and burning the mined leaves.
- Spray NSKE @ 5% along with sticking agent.
- Spraying the entomopathogen bacterial like Bt@ 2 g per litre water
- Conserve natural enemies like *Trichogramma spp. Brachymeria sp.*
- Spray thiamethoxam 25 WG @ 400g or imidacloprid 17.8 SL @ 500 ml or diamethoate 30 EC @ 3.125 Lit or profenophos @ 3 lit. in 1250 litre water per hectare during April- May and again in August- September.

5. Bark eating caterpillar

Scientific Name- *Indarbela quadrinitata*

Order- Lepidoptera

Family- Metarbelidae

Distribution: This insect is widely distributed in Myanmar, Bangladesh, Pakistan, America, China, , India and is to be a serious pest in Tamil Nadu, MP, Assam, UP, Punjab.

Host: Citrus, mango, Guava, Jamun, Loquat, Mulberry, Anar, Ber, Drumstick, Litchi, Amla, Rose etc.

Identification: The newly emerge larvae are dirty brown while later on have pale brown bodies with dark brown head. The moth are pale brown with rufous head and thorax. The fore wings are pale rufous with dark rufous bands and hind wings are fuscous.

Nature of damage: The caterpillar causes damage. Thick, ribbon like, silken webs are seen running on bark of the main stem and larvae also make hole on tree one larvae or pupa occupying each hole. In severe infestation may result in the death of the attacked stem but not of the main trunk.

Life cycle: The adult become active with commence of summer season in which the females start laying up to 2000 eggs in clusters of 15-25 eggs each under the loose bark of trees continuous throughout the summer. The eggs hatch in 8-10 days and the newly emerge larvae

nibble at the bark and after 2-3 days bore inside. The larvae take as many as 9-11 months to complete development. When full grown they make a hole into the wood and pupate inside. The pupal stage lasts 20-28 day. The life cycle is completed in one year and only one generation is produced in a year.

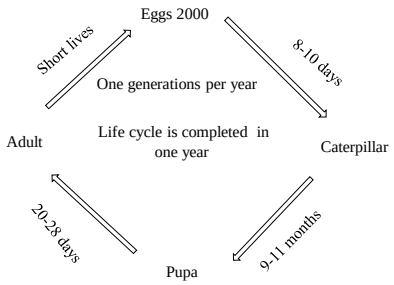

Fig. Life Cycle of bark eating caterpillar

Management:

- Avoid close planting, water logging or damp condition or any other stress condition.
- Clean cultivation is done to prevent infestation..
- Kill the caterpillars by inserting an iron spike into the holes
- Swab Coal tar + Kerosene @ 1:2 or Carbaryl 50 WP 20 g / lit of water on the basal portion of the trunk up to 3 feet height
- If infestations are severe then apply the copper oxychloride paste on the trunk of the tree
- Apply carbofuran 3G 5 g per hole and plug with mud
- Treat all alternate host plants in the vicinity of the orchards.

6. Fruit sucking moth

Scientific Name- *Eudocima maternal, E. fullonica, E. conjuncta, E ancilla*

Order- Lepidoptera

Family- Noctuidae

Distribution: This insect is widely distributed in Myanmar, Bangladesh, Pakistan, America, China, , India and is to be a serious pest in Tamil Nadu, MP, Assam, UP, Punjab.

Host: Citrus, mango, grape and apple.

Identification: The moth of *E. conjuncta* is faint orange brown, its fore wings are dark grey and the hind wings are orange red having two black curved patches. The fore wings in *Eudocima maternal* are pale greenish grey with palish white markings and the hind wings are orange brown having marginal dark bands mixed with white spots. The larvae are semilooper, distinct eye spots on the head, yellow or red lateral spots and a dorsal hump on the last segment of the body. The full grown larva is 5-6 cm length and when disturbed it assumes a characteristics posture by curving round the head and raising the hind part of its body.

Nature of damage: The adult of this moth cause damage only. With the help of strong piercing mouth parts, the moth puncture the fruits for sucking juice and puncture site the microbial infections take place with the result brownish mouth of a puncture become pale and later on whole fruit turn yellow. The infected fruits drop off immature stage.

Life cycle: The moths are lay eggs on a number of wild plants and weeds like Tinospora, Cocculus etc which are often found near the orchards. They hatch in about two weeks and a larva passes through five instars in four weeks. When full grown, its make a pupal case by webbing together pieces of leaves and soil particles. The pupal stage is lasts about 2 weeks. The life cycle is completed 7-8 weeks and only 2 generations are completed in a year but third generation pupae hibernate in winter.

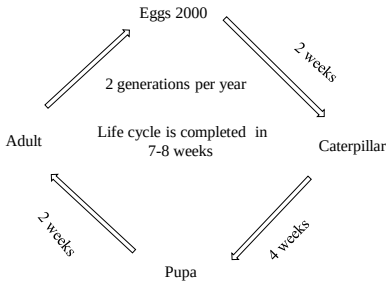

Fig. Life Cycle of fruit sucking moth

Management:

- Destruction of alternate host plants in the vicinity of the orchard like *Tinospora cardifolia* and *coccules pendules.*
- Dispose off fallen fruits which attract the moth.
- Bagging of fruits with polythene bag is done but very laborious.
- Creating smoke in the orchard during evening may keep away the moth.
- Trap crop – growing tomato crop in orchards to attract the adult moth
- Erect light trap @ 1 per hectare.
- Spray NSKE @ 5%
- Spray Carbaryl 50 WP @ 2.5 kg in 1250 litre of water per hectare at the time of maturity of fruits.
- Bait poison containing, gur 1 kg + vinegar 60 g + lead arsenate 60 g + water 10 litre. Apply one bottle per ten trees containing bait solution should be tied to the plants when the fruit are in unripe condition.
- Treat all alternate host plants in the vicinity of the orchards.

7. **Citrus Aphid**

Scientific Name- *Toxoptera citricidus*, *T aurantii*

Order- Hemiptera

Family- Aphididae

Distribution: South America, central America, South and Southeast Asia

Host: All species of Rutaceae and Rosaceae

Identification: The adult wingless forms of *Toxoptera citricidus* are shiny black and nymphs are dark reddish brown.

Nature of damage: The nymphs and adult cause damage. Both are suck the cell sap from young leaves and tender twigs and the affected leaves in severe cases curl up and get deformed. The growth of young shoots is adversely affected resulting into stunted growth. They secrete honey dew on which a black fungus develops, adversely affecting photosynthesis. This insect is also responsible for spreading the citrus tristeza virus.

Life cycle: The pest is found throughout the year but the activity is preferred in the spring and autumn. Each female can produce 5-68 nymphs parthenogenetically for a period of 7 to 21 days. Winged colonizing adults called stem mothers give birth directly to nymphs with no egg stage and no mating required. The nymphs take 1-6 weeks to complete five instar. The adult live for 5-25 days. The life cycle is completed in 1-6 weeks and there are 9 generation in a year.

Management:

- Removal and destruction of infested leaves and affected fruits.
- Erect yellow sticky trap for monitoring.
- Spray NSKE @ 5% along with sticking agent.
- Conserve natural enemies like *Tetrastichus radiates, Coccinella Spp, Chrysoperla carnea.*
- Spray thiamethoxam 25 WG @ 400g or imidacloprid 17.8 SL @ 500 ml or diamethoate 30 EC @ 3.125 Lit in 1250 litre water per hectare during March and again in the first week of September.

7. **Citrus mite**

Scientific Name- *Oligonychus citri*

Order- Acari

Family- Tetranychidae

Distribution: USA, Indonesia, Phillipines, Isreal, Irak, Iran, UAR, Sri-Lanka and India.

Host: sweet orange, lemon, grape fruit and sour lime.

Identification: The adult is small, plump and orange with thick deep brown patches on the dorsal side of its body and body covered with bristles, have four pairs of legs. The nymph is light yellowish brown and have three pairs of legs.

Nature of damage: The nymphs and adult cause damage. Both are suck the cell sap from young leaves and tender fruits and green bark and the affected leaves in severe cases curl down and get deformed and speckled appearance. On leaves, citrus red mite feeding results in a pale stippling visible primarily on the upper surface of the leaf. In severe infestations, the stippling enlarges to dry necrotic areas (commonly called mesophyll collapse). High numbers can also cause fruit sunburn if hot weather is occurring.

Life cycle: The pest is found throughout the year but slower in winter. The mite are most active in summer and lay 50 eggs arranged singly along large vein on the underside of the leaves. They hatch in about 7 days. The eggs laid by unmated female, develop into only male whereas those from mated female, develop into both male and female. The first instar larva have three pairs of legs and it moult into a protonymph within 3-4 days having four pairs of legs. Its develop into duetonymph after 3-4 days. It full fed in 4-5 days and transforms into an aduly mite. The female mites live for about 10 days and life cycle in summer is completed in 17-20 days and passes through several overlapping generation in a year.

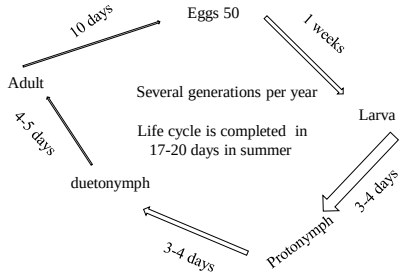

Fig. Life Cycle of citrus mite

Management:

- Predaceous mites, predaceous insects, and a virus are important in regulating citrus red mite numbers. The most important natural enemy is the predaceous mite *(Euseius tularensis*).
- Good irrigation reduces red mite outbreaks
- Spray of acequinocyl (Kanemite), fenbutatin oxide (Vendex), hexythiazox (Onager), oil, pyridaben (Nexter), spirodiclofen (Envidor), and fenpyroximate (Fujimite).

Lecture 11: Insect pests of Banana

Major insect pests of Banana

S. No.	Common Name	Scientific Name	Order	Family
1.	Banana stem borer	*Odoiporus longicollis*	Coleoptera	Curculionidae
2.	Banana weevil	*Cosmopolites sordidus*	Coleoptera	Curculionidae
Minor insect pests of Banana				
1.	Banana Aphid **Vector of bunchy top disease or katte disease**	*Pentalonia nigronervosa*	Hemiptera	Aphididae
2.	Banana rust thrips	*Chaetanephothrips signipennis*	Thysanoptera	Thripidae
3.	Banana lace wing bug	*Stephenitis typicus*	Hemiptera	Tingidae
4.	Banana scale moth	*Nacoleia octasema*	Lepidoptera	Pyralidae

1. Banana stem borer

Scientific Name- *Odoiporus longicollis*
Order- Coleoptera
Family- Curculionidae
Distribution: This insect is widely distributed in North East India.
Host: Banana.
Identification: Grub is apodous, yellowish with reddish head. Adult is robust, reddish brown and black weevil.
Nature of damage: Both grub and adult causing damage. Grubs bore into rhizome and make tunnels within it. Adult also tunnel within the stem and tunnelled part decomposes and pseudo stem wilts. Exudation of plant sap-initial symptom and blackened mass comes out from the bore hole.
Life cycle: The weevil is lay eggs in small furrow in the rhizome or within leaf sheaths just above the ground level. The eggs hatch in 3-5 days in summer and 5-8 days in winter. The larva bores into pseudostem making tunnels within and cutting holes on its outer surface. The larval period last 26 days in summer and 68 days in winter through five larval instars. The pupal period lasts 20-25 days in summer and 5-7 weeks in winter. The adult lives for a period of upto two years.

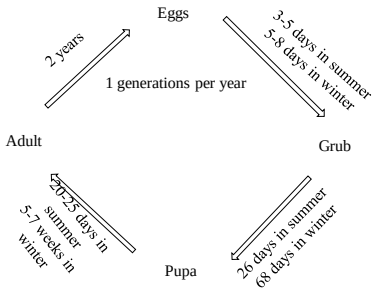

Fig. Life Cycle of Banana stem borer

Management:

- 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
- Do not dump infested materials into manure pit
- Uproot and burn the infested plants.
- Use longitudinally split pseudostem trap @ 65/ha
- Spray 2.5 kg of Carbaryl 50 WP in 1250 litre of water per hectare.

2. Banana weevil

Scientific Name- *Cosmopolites sordidus*
Order- Coleoptera
Family- Curculionidae
Distribution: This insect is widely distributed in India, South East Asia, Australia, Hawaii, Island, Tropical and South Africa and Tropical America.
Host: Banana.
Identification: Grub is apodous, yellowish white with red head. The newly emerged weevil is red brown
Nature of damage: Both grub and adult causing damage. Grubs bore into the rhizome and cause death of the plant. The seedlings are killed as a result of the borer attack when the larvae approach the growing point.
Life cycle: The weevil make a small hole in the corm, lays a single eggs on about 10-50 eggs during its life of a few months. The eggs hatch in one week and grub bore into the corm where they feed making a tunnel. The grub full grown in 2-6 weeks and the larvae pupate in the same tunnel. The pupal stage lasts about one week. The adults, on emergence, remain in the soil for sometime, feeding on the underground parts of the plants.

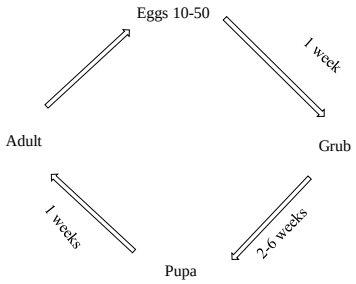

Fig. Life Cycle of Banana weevil

Management:

- Select healthy sucker and plant
- Destroying the sheltering and feeding places of the adult weevils.
- Do not take regular crop in the same field to avoid initial infestation
- Ensure clean cultivation
- Removal of infested pseudo stems below ground level.
- Trimming the rhizome
- Use pheromone trap, cosmolure trap @ 5/ha

Banana corm split trap

- Trap adult weevils with pseudostem chopped into small pieces kept near infested clump at 65/ha.
- Soil incorporation at the time of planting: carbofuran 3 G 10g, phorate 10 G 5 g/plant.
- Before planting, the suckers should be dipped in 0.1 per cent quinalphos emulsion.
- Apply castor cake 250g or carbaryl 50g dust or phorate 10g per pit before planting also prevents infestation.
- Severe attack dimethoate, methyl demeton @ 0.1 % may be sprayed around the collar region.

Lecture 12: Insect pests of Guava

Major insect pests of Guava

S. No.	Common Name	Scientific Name	Order	Family
1.	Guava fruit fly	*Bactrocera dorsalis, B. zonata*	Diptera	Tephritidae
2.	Fruit borer	*Duedorix Isocrates*	Lepidoptera	Lycaenidae
3.	Bark eating caterpillar	*Indarbela tetraonis*	Lepidoptera	Metarbelidae
4.	Guava mealy scale	*Chloropulvinaria psidii*	Hemiptera	Coccidae
5.	Guava mealy bug	*Ferrisia virgata, Planoccocus citri, P. lilacinus*	Hemiptera	Pseudococcidae
Minor insect pests of Guava				
1.	Tea mosquito bug	*Helopeltis antoni*	Hemiptera	Miridae
2.	Castor capsule borer	*Conogethes punctiferalis*	Lepidoptera	Pyralidae

1. Tea mosquito bug

Scientific Name- *Helopeltis antoni*
Order- Hemiptera
Family- Miridae
Distribution: This insect is widely distributed in Southern India, Sri-Lanta, Vietnam and Indonesia.
Host: Guava, cocoa, pepper, cinchona, tamarind, mango, neem, cotton and avocado tea, coffee and other plantation crops.
Identification: The adult is a reddish brown bug with red thorax and black and white abdomen. The nymphs are reddish brown and spider like, wingless.
Nature of damage: Both nymph and adult causing damage. The nymphs and adults suck 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.
Life cycle: The female bugs lays up to 500 eggs inserted into the epidermis of tender shoots, axis of inflorescence, the buds and midribs. They hatch in 5-7 days and freshly emerge nymph is wingless and look like a spider. It complete its development in about 2 weeks in summer and about 8 weeks in winter after passing through five moults. The life cycle is completed in 20-22 days and there are several generation are completed in a year.

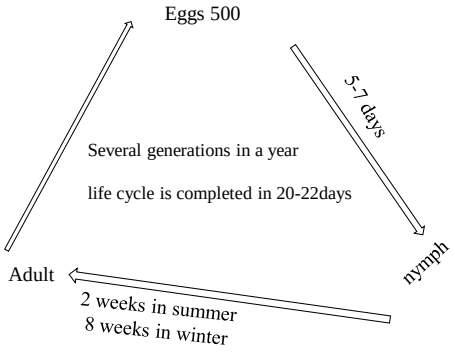

Fig. Life Cycle of tea mosquito bug

Management:

- Collect nymphs and adults with hand nets and destroy them.
- Collect and destroy damaged fruits
- Removal of alternate host and clean the orchard.
- Spray carbaryl 50 WP 2 g /litre or malathion 50 EC at 1ml/litre or neem oil 3 % spraying should be done..

Lecture 13: Insect pests of Anola and jack fruit

Major insect pests of Aonla

S. No.	Common Name	Scientific Name	Order	Family
1.	Shoot gall maker	*Hypolamprus stylophora*	Lepidoptera	Thyrididae
2.	Bark eating caterpillar	*Indarbela tetraonis*	Lepidoptera	Metarbelidae
3.	White tailedmealy bug	*Ferrisia virgata*	Hemiptera	Pseudococcidae
Minor insect pests of Aonla				
1.	Termite	*Odontotermes obesus*	Hymenoptera	Termitidae

Major insect pests of Jack fruit

S. No.	Common Name	Scientific Name	Order	Family
1.	Shoot and fruit borer	*Glyphodes caesalis*	Lepidoptera	Pyralidae
2.	Bark eating caterpillar	*Indarbela tetraonis*	Lepidoptera	Metarbelidae
3.	Stem borer	*Batocera rufomaculata*	Coleoptera	Cerambycidae
Minor insect pests of Jack fruit				
1.	Lace wing bug	*Stephanitis chariesis*	Hemiptera	Tingidae
2.	Spittle bug	*Cosmoscarta relata*, *Clovia lineaticollis*	Hemiptera	Cercopidae

Lecture 14: Insect pests of Grapevine

Major insect pests of Grapevine

S. No.	Common Name	Scientific Name	Order	Family
1.	Grapevine thrips	*Rhipiphorothrips cruentatus*	Thysanotptera	Heliothripidae
2.	Grape vine beetle	*Sinoxylon anale*	Coleoptera	Bostrychidae
3.	Stem girdler	*Sthenias grisator*	Coleoptera	Cerambycidae
4.	Flea beetle	*Scleodonta strigicollis*	Coleoptera	Chrysomelidae
Minor insect pests of Grapevine				
1.	Mealy bug	*Ferrisia virgata, Maconellicoccus hirsutus*	Hemiptera	Pseudococcidae
2.	Mite	*Oligonychus punicae*	Acari	Tetranychidae
3.	Leaf roller	*Sylepta lunalis*	Lepidoptera	Pyralidae

1. Grapevine thrips

Scientific Name- *Rhipiphorothrips cruentatus*
Order- Thysanotptera
Family- Heliothripidae
Distribution: This insect is widely distributed in India, South East Asia, Australia, Hawaii, Island, Tropical and South Africa and Tropical America.
Host: Grapevine, rose, jamun, oak etc.
Identification: The adult is minute, blakish brown, with yellowish wings.
Nature of damage: Both nymphs and adult causing damage. Both nymphs and adults lacerate/scrape the epidermis of leaves and suck the sap due to laceration silvery white scorch patches develop on the leaves. The leaves ultimately curl up and drop off the plant. The attacked vine either does not bear fruits or the fruit drop off prematurely.
Life cycle: The pests reproduce throughout the year except winter when it is hibernate as a pupa in the soil under the host plants. The female appear in March and lays 50 eggs singly in slits in the plant tissues of under surface of leaves. The eggs hatch in 3-8 days and young nymphs start feeding on the underside of leaves by rasping the surface and sucking the oozing cell sap. They are full grown in 1-3 weeks and pupate on leaves. The pupae possess power of locomotion and crawl away when disturbed. The pupa change to adult in 2-5 days. The female reproduce with or without fertilization; the fertilized eggs hatch into female and unfertilized eggs hatch into male. The life cycle is completed in 15-30 days and many generations are completed in a year.

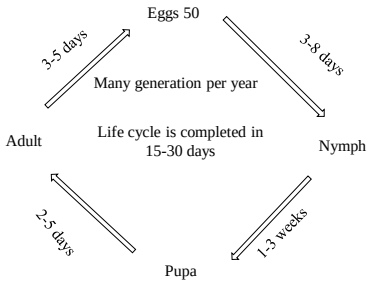

Fig. Life Cycle of Grapevine thrips

Management:

- Remove grasses from orchard regularly
- Prune the infested leaves
- Use of blue sticky trap @ 1 per vine
- Raking the soil for expose pupae and killing them.
- Spray thiamethoxam 25 WG @ 400g or imidacloprid 17.8 SL @ 500 ml or diamethoate 30 EC @ 2.0 lit or malathion 50 EC 1.25 litre in 1250 litre water per hectare once before flowering and again after the fruit set.

2. Grapevine beetle

Scientific Name- *Sinoxylon anale*
Order- Coleoptera
Family- Bostrychidae
Distribution: This insect is widely distributed in India, France Italy, Japan, USSR and China
Host: Grapevine, rose, jamun, oak, sal teak shisham, wooden packing materials etc.
Identification: The adult is sturdy, dark brown. Three bladed antennae and a pair of spines on the posterior elytra are present. The grub is thickly slightly curved and yellowish white in colour.
Nature of damage: Both grubs and adult causing damage. The adult beetle constructs a circular hole, extending to the centre of the stem and then make longitudinal galleries and form a number of exits. Both stages feeding inside the vine stem and the attacked plant gradually dry and dies away.
Life cycle: The pest is active on dormant vines. The female lay eggs in galleries constructed by adult beetles inside the attacked portion. After hatching the grubs feeding inside and show peculiar crackling noise, followed by the ejection of a dusty material from the exists of the feeding sites. The pupation also take place within the galleries.

Management:

- Remove grasses from orchard regularly
- Clean cultivation including removal of loose bark coupled with careful pruning and destruction of infested parts.
- Spray with quinalphos @ 1.5 litre or carbaryl 50 WP @ 2 kg / ha or indoxacarb 14.5 SC @ 500 g or fame 48 SC @ 500 g in 1250 litre of water to the dormant woody portion of the vines.

3. Grapevine stem girdler

Scientific Name- *Sthenias grisator*
Order- Coleoptera
Family- Cerambycidae
Distribution: This insect is widely distributed in India, South East Asia, Australia, Hawaii, Island, Tropical and South Africa and Tropical America.
Host: Grapevine, rose, jamun, oak, mulberry, bushes, shrubs, creepers, mango, almond, jack fruits etc.
Identification: 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 2.4 cm long.
Nature of damage: Both grub and adult causing damage. The grub bores into the bark and tunnels into the dry wood. The bark and wood are cut right up to the centre and at times even the branches are cut into two bits. The beetles have the habit of ringing the vines resulting in drying up of the regions beyond the cut.
Life cycle: The adult become active in spring and lay eggs in group od 2-4 underneath the bark of girdled branches. A slight bulge on the bark adjacent to the transverse cut indicates the presence of eggs. The eggs are hatch in one week and grubs bore into the stem. The grub full fed in 7-8 months and pupation also takes place within the girdles/gallaries. The pupal period is lasts 1 months. The adults appear again late in summer but they hibernate during winter. The life cycle from eggs to adult take 8-9 months and there are only one generation is completed in a year.

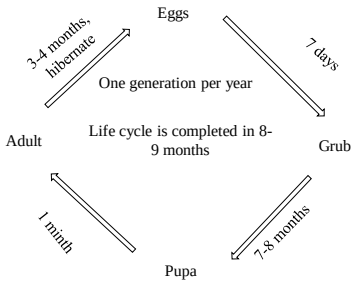

Fig. Life Cycle of Grapevine girdler

Management:

- Cutting and burning attacked branches below girdler point.
- Hand collection and destruction of beetles may help in mitigating the beetles.
- Swab the trunk with carbaryl 50 WP 4 g / litre of water

4. Grapevine flea beetle

Scientific Name- *Scelodonta strigicollis*
Order- Coleoptera
Family- Chrysomelidae
Distribution: This insect is widely distributed in India, South East Asia, Australia, Hawaii, Island, Tropical and South Africa and Tropical America.
Host: Grapevine rose, jamun, oak, etc.
Identification: The adult beetle is shining with metallic bronze colour and six dark spots on the elytra and 4.5 mm long.
Nature of damage: Both grub and adult causing damage. The grub feed on the cortex of the roots. Adults bore into the buds, nibble the leaves making hole, scratch the tendrils and eat the epidermis of the branches.
Life cycle: The female lays 220-570 eggs singly or in clusters of 20-40 in the bark or in the soil during its life of 8-12 months. The eggs hatch in 4-8 days the the grubs feed on roots and full fed in 35-45 days. The full grown grubs pupate in the soil and emerge as adults in 6-10 days. The life cycle is completed in 2 months.

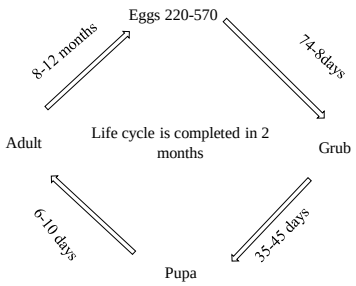

Fig. Life Cycle of Grapevine flea beetle

Management:

- Remove the loose bark after pruning
- Hand collection and destruction of beetles may help in mitigating the beetles.

- Raking around the vines and expose eggs and pupae and killed due to extreme heat or natural enemies.
- Spray of carbaryl 50 WP @ 2.5 kg or quinalphos 25 EC @ 3.5 litre or indoxacarb 14.5 SC @ 500 g or fame 48 SC @ 500 g in 1250 litre water per hectare after removal of loose bark.

Lecture 15: Insect pests of Ber and Pomegranate

Major insect pests of Ber

S. No.	Common Name	Scientific Name	Order	Family
1.	Ber fruit fly	*Carpomyia vesuviana*	Diptera	Tephritidae
2.	Ber beetle	*Adoretus pallens, A. nitidus*	Coleoptera	Scarabaeidae
Minor insect pests of Ber				
1.	Ber fruit borer	*Meridarchis scyrodes*	Lepidoptera	Carposinidae

Major insect pests of Pomegranate

S. No.	Common Name	Scientific Name	Order	Family
1.	Pomegranate butterfly	*Deudorix/virachola isocrates*	Lepidoptera	Lycaenidae
2.	Bark caterpillar	*Indarbela quadrinotata*	Lepidoptera	Metarbelidae
Minor insect pests of Pomegranate				
1.	Aphid	*Ahis punicae*	Hemiptera	Aphididae
2.	Mealy bug	*Ferrisia virgata, Pseudococcus lilacinus*	Hemiptera	Pseudococcidae
3.	Castor capsule borer	*Conogethes punctiferalis*	Lepidoptera	Pyralidae
4.	Fruit fly	*Bactrocera zonata*	Diptera	Tephritidae

1. Ber fruit fly:

Scientific Name- *Carpomyia vesuviana*

Order- Diptera

Family- Tephritidae

Distribution: The ber fruit fly is widely distributed in India, Indonesia, Malasiya, Sri- lanka, Pakistan etc. In India it is mainly found in Bihar, Rajasthan, Maharastra, UP, MP,

Host: Ber

Identification: The maggot is legless, 8-9 mm long, yellowish- white colour with dark brown head. The adult is brownish yellow with brown longitudinal stripes on the thorax. There are greyish brown spots on the wings and bristly hair on the tip of the abdomen.

Nature of damage: Damage caused by maggot only. The maggot feed on pulp and convert the pulp into a bad smelling, discoloured semi liquid mass making the fruit unfit for human

consumption. The infested fruit drop and start rotting from inside and on complete rotting of the fruits; the damaged fruit develop yellow spots with black centers through which liquid oozes out on pressing. The severe infestation is occur during the February month.

Life cycle: The pest is active during the winter months and passes the summer as a aestivation pupa in the soil during April to August. The adult flies emerge in August to mid November, synchronizing with the blossoming and fruit setting. At the age of one month the flies make cavities in the skin of fruit and lay one or two eggs out of 22 eggs per female. The eggs hatch in 2-3 days and maggots feed on the flesh of the fruits making galleries toward the centre. The maggots full grown in 7-10 days through three stages and move into the soil and pupate 8-13 cm below the surface. The pupal period is 2-4 weeks and the life cycle is completed in 4 weeks and 2-3 generations are completed in a year.

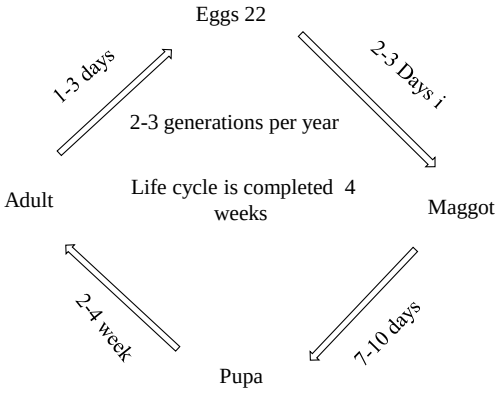

Fig. Life Cycle of Ber fruit fly

Management:

- Avoid infestation by early harvesting of mature fruits
- Plough the interspaces to expose and kill the pupae during the winter season.
- Collect and destroy the fallen fruits twice in a week
- Grow fruit fly resistant varieties such as Safeda Illaichi, Chinese, Sanaur-1, Tikadi and Umran.
- Use methyl eugenol lure trap (25/ha) to monitor and kill adults of fruit flies.
- Prepare methyl eugenol and malathion 50 EC mixture at 1:1 ratio. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am and collect and destroy the adult flies.
- Conserve parasitoids like *Optius compensates* and *Spalangia philippinensis*.
- Use polythene bags fish meal trap with 5 g of wet fish meal + one ml dichlorvos soaked in cotton @ 50 traps / ha. Fish meal and dichlorvos soaked cotton should be renewed once in 20 and 7 days respectively.

- Bait spray 1.25 litre of malathion 50 EC + 12.5 kg gur/ jiggery in 1250 lit. water per hectare and repeat spray 10 days interval if infestation continues.
- Spray malathion 50 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 at the time of flower formation and fruit set.
- Soil application of Quinalphos 5 % @ 20kg/ha or Carbofuran 3 % @ 30 kg /ha.

2. Ber beetle:

Scientific Name- *Adoretus pallens, A. nitidus*

Order- Coleoptera

Family- Scarabaeidae

Distribution: The ber beetle is widely distributed in India, Indonesia, Malasiya, Sri- lanka, Pakistan etc. In India it is mainly found in Bihar, Rajasthan, Maharastra, UP, MP,

Host: Ber, grapevine etc.

Identification: The adult are bright yellow colour, yellowish brown shiny wings, tarsi tip are red and the grub is whitish, "C" shaped.

Nature of damage: Damage caused by adult only. The adult make round hole cuts in the leaves during the night. Sometimes severe infestation the plant appear leafless and such trees do not bear any fruit.

Life cycle: The pest is active during the summer months and passes the winter as a larval stage. The adults appear in April – May and the female lays eggs singly in the soil near the plants and the eggs hatch in 6-9 days. The newly emerge grubs feed on soil humus, roots of grasses and other materials. The grubs is full grown in 10-11 months and makes an earthen cell in the winter and hibernate. Pupation take place in the soil and the adults emerge after 11-12 days. The life cycle completed in one year and only one generation is completed in a year.

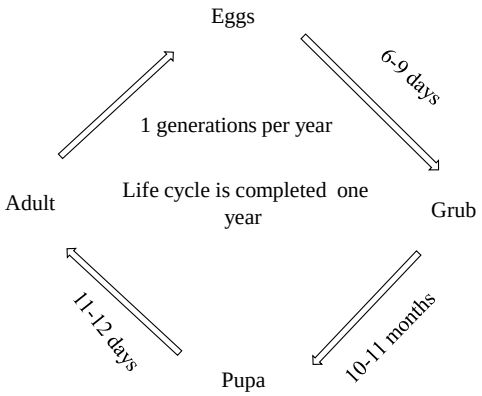

Fig. Life Cycle of Ber beetle

Management:

- Use of light traps to attract adults and killing them
- Raking around the trees to expose and kill the grubs during the winter season.

- Spray malathion 50 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 at the time of flower formation and fruit set.
- Soil application of Quinalphos 5 % @ 20kg/ha or Carbofuran 3 % @ 30 kg /ha.

3. Pomegranate butterfly:

Scientific Name- *Deudorix/Virachola isocrates*

Order- Lepidoptera

Family- Lycaenidae

Distribution: The butterfly is widely distributed in India, Indonesia, Malasiya, Sri- lanka, Pakistan etc. In India it is mainly found in Bihar, Rajasthan, Maharastra, UP, MP,

Host: Pomegranate, guava, loquat, citrus, aonla, apple, ber, litchi, peach, pear, sapota, plum and tamarind.

Identification: The full grown caterpillar are dark brown and whitish patches all over the body. The adult are glossy bluish violet male to brownish violet females in colour with an orange patch on the fore wings.

Nature of damage: Damage caused by larva. The caterpillars bore into the fruit and feed on its contens. It creates a lot of mess and offensive smelling matter ooze out from the entrance hole. The infested fruits are infected by fungi and bacteria causing fruit rot disease.

Life cycle: The pest is active throughout the year and after mating the female butterfly lays oval shaped eggs singly on the calyx of flowers or small fruits. The eggs hatch within 7-10 days and larva bore into the developing fruits. The larva is full grown in 18-50 days and pupates inside the fruits. The pupal stage lasts 1-5 weeks. The life cycle is completed from egg to adult in 33-95 days. There are four overlapping generations in a year.

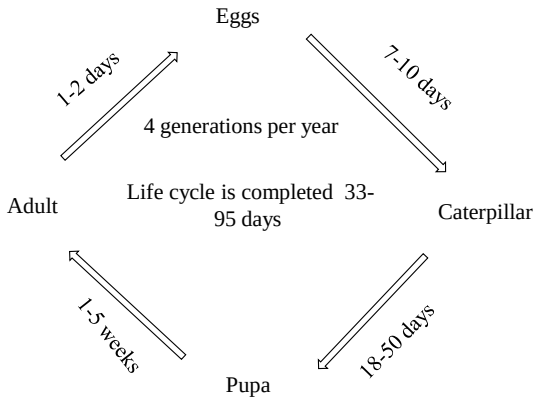

Fig. Life Cycle of Pomegranate butterfly

Management:

- Collection and destruction of fallen infested fruits
- Remove flowering weeds of Compositae family because it acts as alternate host.
- Cover the fruits with polythene or muslin bags during flowering period to prevent egg laying when fruits are up to 5 cm dia.

- Remove calyx from the fruits to prevent the hatching of eggs and subsequent damage.
- Spray with NSKE 5% or neem oil 2% at15 days interval commencing from flowering and during butterfly activity.
- Release egg parasitoid, *Trichogramma chilonis* at 1 lakh / acre.
- Spray malathion 50 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 or thiachloprid 2 ml/ litre of water during May- June.

Lecture 16: Insect pests of Fig and star gooseberry

Major insect pests of Fig

S. No.	Common Name	Scientific Name	Order	Family
1.	Stem borer	*Batocera rufomaculata*	Coleoptera	Cerambycidae
2.	Fruit fly	*Bactricera dorsalis, B. zonata*	Diptera	Tephritidae
3.	Fig midge	*Anjeerodiplosis peshawarensis*	Diptera	Cecidomyiidae
Minor insect pests of Fig				
1.	Fig mite	*Aceria ficus, Eriophyes ficivorus, Rhyncaphytopus ficifoilae*	Acari	Eriophyidae (Nymph and adult having two pairs of legs)
2.	Fig mite	*Tetranychus neocaledonicus, Eutetranychus hirsti*	Acari	Tetranychidae (Larvae two pairs, Nymph and adult having four pairs of legs)

Major insect pests of Star gooseberry

S. No.	Common Name	Scientific Name	Order	Family
1.	Leaf roller	*Caloptilia (Gracillaria) acidula*	Lepidoptera	Gracillaridae
Minor insect pests of Star gooseberry				
1.	Mealy bug	*Planococcus lilacinus*	Hemiptera	Pseudococcidae

1. Fig midge:
Scientific Name- *Anjeerodiplosis peshawarensis*
Order- Diptera
Family- Cecidomyiidae

Distribution: North India.
Host: Fig
Identification: The adult is small, light brown, maggot is creamy white, flattened dorsoventrally, being narrow anteriorly, two jointed antennae.
Nature of damage: Damage caused by Maggot. The maggot bores inside the fruit and feeds on the pulp within. The infested fruits become hard, hollow, deformed, irregular in outline, remain yellowish green and fail to ripen.
Life cycle: The pest is active throughout the year except in the summer at April to July. The female when one week old star laying eggs in cluster as many 16 in the fruits. The eggs hatch in 3-5 days and the maggot stage is completed inside the fruits each of which may contain 200-300 larvae. The total larval period is 21-28 days passes through four instar. The full grown maggot cut out of fruit and drop to the ground and pupate in the soil without forming a cocoon. The pupal period is completed in 10-26 days. The life cycle is completed in 35-50 days and seven generations are completed in a year.

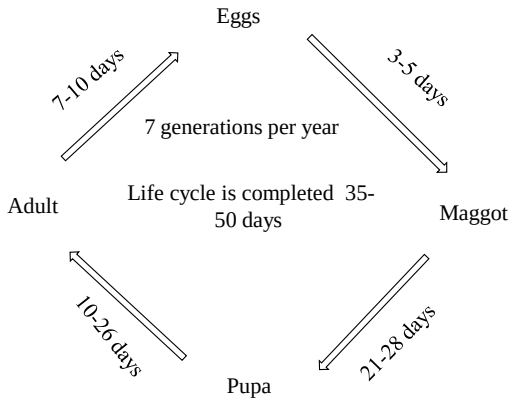

Fig. Life Cycle of fig midge

Management:

- Collection and destruction of fallen infested fruits
- Plough/raking the soil around the plants to expose and kill the pupae.
- Spray with NSKE 5% or neem oil 2% at15 days interval commencing from flowering to fruit set.
- Spray malathion 50 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 or thiachloprid 2 ml/ litre of water during flower bud formation and again when the fruit are pea size.
- Soil application of Quinalphos 5 % @ 20kg/ha or Carbofuran 3 % @ 30 kg /ha.

Lecture 17: Insect pests of Wood apple, custard apple

Major insect pests of Custard apple

S. No.	Common Name	Scientific Name	Order	Family
1.	Fruit borer	*Heterographis (Anonaepestis) bengalella*	Lepidoptera	Pyralidae
2.	Fruit fly	*Bactricera dorsalis, B. zonata*	Diptera	Tephritidae
Minor insect pests of Custard apple				
1.	Mealy bug	*Ferrisia virgata, Maconellicoccus hirsutus*	Hemiptera	Pseudococcidae

Major insect pests of Wood apple

S. No.	Common Name	Scientific Name	Order	Family
1.	Wood apple borer	*Euzophera plumberijascilla*	Lepidoptera	Pyralidae
2.	Fruit borer	*Argyroploce illipida*	Lepidoptera	Eucosmidae

Lecture 18: Pineapple, papaya, tamarind, Date palm, Jamun and Litchi

Major insect pests of Pineapple

S. No.	Common Name	Scientific Name	Order	Family
1.	Pineapple thrips	*Thrips tabaci*	Thysanoptera	Thripidae
2.	Slug caterpillar	*Parasa lepida*	Lepidoptera	Limacodidae
Minor insect pests of Custard apple				
1.	Mealy bug	*Pseudococcus bromiliae, P. brevipes*	Hemiptera	Pseudococcidae

Major insect pests of Papaya

S. No.	Common Name	Scientific Name	Order	Family

1.	Ak grasshopper	*Poekilocerus pictus*	Orthoptera	Acrididae
2.	Red spider mite	*Tetranychus urticae*	Acari	Tetranychidae
3.	Mealy bug	*Paracoccus marginatus*	Hemiptera	Pseudococcidae
4.	Aphid	*Myzus persicae, Aphis gossypii, A. malvae*	Hemiptera	Aphididae Vector of papaya mosaic
Minor insect pests of Papaya				
1.	Whitefly	*Bemisia tabaci*	Hemiptera	Aleurodidae
2.	Fruit fly	*Bactrocera diversus, Ceratitis capitata, B. cucurbitae*	Diptera	Tephritidae

Major insect pests of Tamarind

S. No.	**Common Name**	**Scientific Name**	**Order**	**Family**
1.	Coconut scale	*Aspidiotus destructor*	Hemiptera	Diaspididae
2.	Fruit borer	*Phycita orthoclina*	Lepidoptera	Pyralidae
3.	Mealy bug	*Nipaecoccus viridus, Planococcus lilacinus*	Hemiptera	Pseudococcidae
4.	White grub	*Holotrichia insularis*	Coleoptera	Scarabaeidae
Minor insect pests of Tamarind				
1.	Pomegranate butterfly	*Deudorix/Virachola Isocrates*	Lepodoptera	Lycaenidae
2.	Castor capsule borer	*Conogethes punctiferalis*	Lepidoptera	Pyralidae

Major insect pests of Date palm

S. No.	**Common Name**	**Scientific Name**	**Order**	**Family**

1.	Coconut scale	*Aspidiotus destructor*	Hemiptera	Diaspididae
2.	Black palm/rhinoceros beetle	*Oryctes rhinoceros*	Coleoptera	Scarabaeidae
3.	Red palm weevil	*Rhynchophorus ferrugineus*	Coleoptera	Curculionidae
Minor insect pests of Date palm				
1.	Termite	*Odontotermes obesus*	Isoptera	Termitidae
2.	Black headed caterpillar	*Opisina arenosella*	Lepidoptera	Xyloryctidae

Major insect pests of Jamun

S. No.	**Common Name**	**Scientific Name**	**Order**	**Family**
1.	Bark caterpillar	*Indarbela, tetraonis, I. quadrinotata*	Lepidoptera	Metarbelidae
2.	Jamun leaf miner	*Acrocercops phaeospora*	Lepidoptera	Gracilliariidae

Major insect pests of Litchi

S. No.	**Common Name**	**Scientific Name**	**Order**	**Family**
1.	Litchi bug	*Chrysocoris stolii*	Hemiptera	Pentatomidae
2.	Litchi mite	*Aceria litchi*	Acari	Eriophyidae

1. Ak grasshopper

Scientific Name- *Poekilocerus pictus*

Order- Orthoptera

Family- Acrididae

Distribution: This insect is widely distributed in India, Pakistan, Baluchistan and Africa.

Host: Ak, papaya, citrus, fig, banana, cotton, castor, cowpea etc.

Identification: The adult is stout, 5-6 cm length, blue green with yellow marking on the body, red wings. The nymph is yellowish with orange and black stripes all over the body.
Nature of damage: Both nymph and adult causing damage. The nymphs and adults feed voraciously on leaves and skeletonize them. In the case of severe infestation, it feeds on the bark of the plant.
Life cycle: This pest is active during July- August and passes winter in the egg stage. The female lay 145-170 eggs in the soil at a depth of 18-20 cm in a spiral manner to form a compact mass which is covered with a frothy secretion. The eggs laid in summer overwinter for nearly four months. The eggs hatch in 30 days and the nymph become adult in 60 days. The life cycle is completed in 3--4 months and there are two generation are completed in a year.

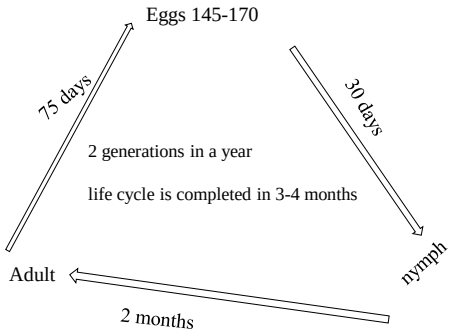

Fig. Life Cycle of Ak grasshopper

Management:

- Collect nymphs and adults with hand nets and destroy them.
- Use light trap to attract the insects
- Spray NSKE @ 5% or neem oil 2ml/litre
- Dusting carbaryl 10 per cent @ 25 kg/ha or malathion 5 per cent @ 50 kg/ha.

2. Papaya mealy bug
Scientific Name- *Paracoccus marginatus*
Order- Hemiptera
Family- Pseudococcidae
Distribution: This insect is widely distributed throughout the world.
Host: papaya, hibiscus, avocado, citrus, cotton, tomato, eggplant, peppers, beans and peas, sweet potato, mango, cherry, and pomegranate.
Identification: The adult female is yellow and is covered with a white waxy coating, A series of short waxy caudal filaments less than ¼ the length of the body exist around the margin, eight antennae segment. Adult males have ten-segmented antennae, a distinct aedeagus, lateral pore clusters, a heavily sclerotized thorax and head, and well-developed wings.

Specimens of papaya mealybug turn bluish-black when placed in alcohol, as is characteristic of other members of this genus.

Nature of damage: Both nymph and adult causing damage. Both feeds on the sap of plants by inserting its stylets into the epidermis of the leaf, as well as into the fruit and stem. It injects a toxic substance into the leaves resulting 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.

Life cycle: 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 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.

Management:

- Clean the orchard from weeds which act as additional host for nymphal stage..
- Judicious use of nitrogenous fertilizer.
- Don't give regular irrigation
- Avoid waterlogged condition
- Release encyrtid endoparasitoid, *Acerophagus papaya*
- Spray of NSKE @ 5.0 % is also effective. .
- The pest can also be controlled by spraying of two spray, acephate 75 SP at 1 g /litre or phoasalone 35 EC at 1.5 ml / litre or carbaryl 50 WP at 2 g / litre or diamethoate 30 EC at 2 ml/litre of water.

3. Tamarind fruit borer

Scientific Name- *Phycita orthoclina*

Order- Lepidoptera

Family- Pyralidae

Distribution: India and subcontinents.

Host: Tamarind and others store seeds

Identification: The moth are small, delicate insects having elongate fore wings and broad hind wings with hairs on dorsal side.

Nature of damage: Damage caused by caterpillar. The larvae feed on the pulp and their casting, excrements and webbing. The infestation makes the fruit unfit for consumption.

Life cycle: The pest is active during December to April. The female when one week old start laying 190 eggs, singly on the pulpy portion inside the rough shelled pod. The eggs hatch in 4-5 days and the larvae enter into the fruit pulp and feed there by making a silken web. The total larval period is 27-40 days. The full grown larva enter pupation by making silken cocoon inside pod. The pupal period is completed in 6-8 days. The life cycle is completed in 35-50 days and 2-3 generations are completed in a year.

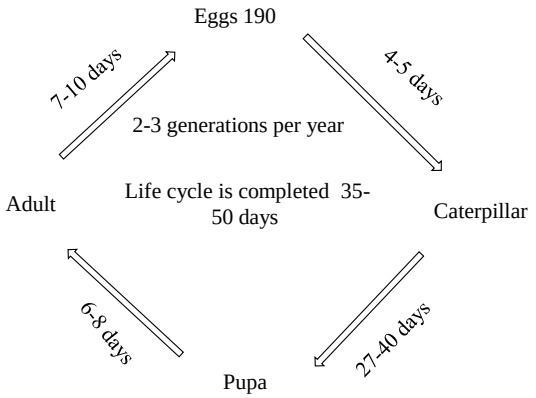

Fig. Life Cycle of tamarind fruit borer

Management:

- Collection and destruction of fallen infested fruits
- Erect light trap @ 1/hectare
- Spray with NSKE 5% or neem oil 2% at15 days interval commencing from flowering to fruit set.
- Spray malathion 50 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 or thiachloprid 2 ml/ litre of water.

4. White grub

Scientific Name- *Holotrichia insularis*

Order- Coleoptera

Family- Scarabaeidae

Distribution: India and subcontinents. In India, it is distributed Rajasthan, Gujrat, Haryana,Bihar, Tamil Nadu, Karnataka, AP, UP, MP and Punjab.

Host: Tamarind, ber, falsa, guava, jamun, karaunda, mango, anar, Kharif crops, plantation etc.

Identification: The adults are brownish black convex beetles, lamellate antennae. The full grown grubs are white, fleshy, curved.

Nature of damage: Damage caused by grubs and adults. The grub feed on rootlets resulting in gradual drying up of seedlings and young plants and the affected plants are easily pull out. The adults feed on leaves and defoliated them.

Life cycle: The adults emerge in June and the female lay 30-120 eggs in the soil at 3 -15 cm depth. The eggs hatch in 8-12 days and the grub feed on the root of host plants. The larval stage is completed in 94-96 days through passes three instar i.e 16 days first instar, 32 days second instar and 46-48 days third instar. The full grown grubs make earthen cells in the soil for pupation. The adult emerge from pupa take 8-12 days and the adult hibernate from November to June. The life cycle is completed in 110-120 days and only one geretion is completed in a year.

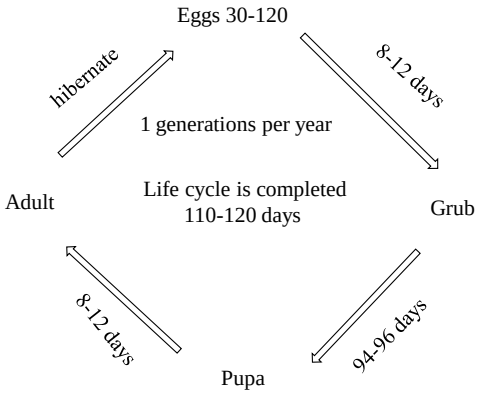

Fig. Life Cycle of White grub

Management:

- The use of light traps for collection of beetles during emergence in the night and destroy them.
- Hand picking of beetles and killing them
- Deep summer ploughing to expose various stages of white grub to their natural enemies.
- Use of pheromone trap, Anisol @ 1 per 15 meter radius tree.
- Spray with NSKE 5% or neem oil 2% at15 days interval.
- Spray of Bt, *Beuveria bessiana*, *Metarrhizium anisoplie* @ 3 kg in 1250 liter of water per hectare.
- Spray malathion 50 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 or thiachloprid 2 ml/ litre of water.
- Soil application of Quinalphos 5 % @ 20kg/ha or Carbofuran 3 % @ 30 kg /ha.

Lecture 19: Apple, pear peach and plum

Major insect pests of Apple, pear peach and plum

S. No.	Common Name	Scientific Name	Order	Family
1.	San jose scale	*Quadraspidiotus perniciosus*	Hemiptera	Diaspididae
2.	Apple woolly aphid	*Eriosoma lanigarum*	Hemiptera	Aphididae
3.	Peach leaf curl aphid	*Brachycaudus helichrysi*	Hemiptera	Aphididae
4.	Apple codling moth	*Carpocapsa/Cydia pomonella*	Lepidoptera	Tortricidae
5.	Apple fruit moth	*Argyresthia conjugella*	Lepidoptera	Pyralidae
6.	Fruit fly	*Bactrocera zonata*	Diptera	Tephritidae
7.	Walnut weevil	*Alcidodes porrectirostris*	Coleoptera	Curculionidae
8.	Apple stem borer	*Apriona cinerea*	Coleoptera	Cerambycidae
9.	Peach stem borer	*Sphenoptera lafertei*	Coleoptera	Buprestidae
10.	Apple root borer	*Dorysthenes hugelii*	Coleoptera	Cerambycidae
11.	Tent caterpillar	*Malacosoma indicum*	Lepidoptera	Lasiocampidae
12.	Indian gypsy moth	*Lymantria obfuscate*	Lepidoptera	Lymantriidae
13.	Cottony cushion scale	*Icerya purchase*	Hemiptera	Margarodidae
14.	Cherry stem borer	*Aeolesthes holosericca*	Coleoptera	Cerambycidae

1. San jose scale

Scientific Name- *Quadraspidiotus perniciosus*

Order- Hemiptera

Family- Diaspididae

Distribution: This insect is widely distributed in temperate country.

Host: Apple, pear, peach, plum, willow, rose and other Rosaceae

Identification: The scale which form a covering of black or brown colour. The female scale is round slightly convex with a black pustule and the male is linear.

Nature of damage: Both nymph and adult causing damage. Both nymph and adult suck cell sap a bove the all ground parts. The infested region of the bark becomes reddish pink and purple colouration in fruits

Life cycle: This pest is active during March to December and passes winter in the nymphal stage. The female give birth to young ones of 200-400 nymphs which hatch from eggs

developed within the body. They become full grown in 30-40 days and the female again start giving birth to young ones within the next 10-14 days. The gravid female may live for about 50-53 days. The total life cycle is completed in 35-40 days and four overlapping generations are completed in a year and the fifth generation nymphs overwinter.

Management:

- Sanitation of orchard in which infested materials should be collected and burnt.
- Encourage activity of parasitoids, *Prospaltella perniciosi* and *Aspidiotophagus sp.* and / or coccinellid *Chilocorus circumdatus* predator.
- Select nursery stock free from scale infestation.
- Summer spray with contact or systemic insecticides like phosalone 0.05%, fenitrothion 0.05% and methyl demeton 0.025%.
- Incorporate carbofuran granules @ 1g a.i. per plant in the nursery.
- Winter spray of diesel oil emulsion + Bordeaux mixture (diesel oil 68 litre + copper sulphate 15 kg+ unslacked lime 3.75 kg) to be emulsified and diluted 5-6 times before spraying.

2. Apple wooly aphid

Scientific Name- *Eriosoma lanigerum*

Order- Hemiptera

Family- Aphididae

Distribution: This insect is widely distributed in temperate country.

Host: Apple, pear, peach, hawthorn, mountain ash etc.

Identification: The aphid is purplish aphid covered with white cottony mats

Nature of damage: Both nymph and adult causing damage. Both nymph and adult suck cell sap from the bark of the twigs and root underground. Swelling or gall appears on the roots. It crowds together covered with woolly white patches on the trunk.

Life cycle: This pest is active during March to December. The aphids reproduce parthenogenetically and the sexually. The female give birth to young ones of 116 in her life times at the rate of 1-4 nymphs per day in spring and vary according to environmental condition. There are four nymphal instars and total duration of the nymphal period is 5-6 weeks in spring, 30 days in rainy season and 10-19 days in summer. There are 13 generations are completed in a year. In December, there is a partial migration from aerial parts to roots of infested plants and the reverse migration from the roots to the aerial parts take place in May.

Management:

- Use of resistant root stock like goldel delicious, northern spy, M778, M779, MM 14, MM 110, MM 112.
- Remove the aphids mechanically by rubbing with clothes without causing any damage to the developing buds.

- Release specific eulophid parasitoid *Aphelinus mali* during December and June to obtain maximum parasitization and predators, *Chilomenes bijugus* and *Coccinella septumpunctata.*
- 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.
- Spray malathion 50 EC 750 ml in 500 litres of water.
- 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.

Lecture 20: Insect pests of Coconut, oil palm and Areca nut

Major insect pests of Coconut and oil palm

S. No.	Common Name	Scientific Name	Order	Family
1.	Coconut scale	*Aspidiotus destructor*	Hemiptera	Diaspididae
2.	Black headed caterpillar	*Opisina arenosella*	Lepidoptera	Xyloryctidae
3.	Rhinoceros beetle	*Oryctes rhinoceros*	Coleoptera	Scarabaeidae
4.	Red palm weevil	*Rynchophorus ferrugineus*	Coleoptera	Curculionidae
5.	Coconut weevil	*Diocalandra frumenti*	Coleoptera	Curculionidae
6.	White grub	*Leucopholis coneophora*	Coleoptera	Scarabaidae/Melolonthidae
7.	Eriophyid mite	*Aceria guerreronis*	Acari	Eriophyidae
Minor insect pests of Coconut and oil palm				
1.	Mealy bug	*Pseudococcus coccotis*	Hemiptera	Pseudococcidae
2.	Lace wing bug	*Staphantis typicus*	Hemiptera	Tingidae

Major insect pests of Arecanut

S. No.	Common Name	Scientific Name	Order	Family
1.	Mirid bug	*Carvalhoia arecae*	Hemiptera	Miridae
Minor insect pests of Arecanut				
1.	Inflorescence aphid	*Cerataphis lataniae*	Hemiptera	Aphididae
2.	White grub	*Leucopholis coneophora*	Coleoptera	Melolonthidae/Scarabaeidae

1. Black headed caterpillar

Scientific Name- *Opisina arenosella*

Order- Lepidoptera

Family- Xyloryctidae

Distribution: India and subcontinents. In India, it is distributed in Kerala along with western coast.

Host: Coconut, Oil palm, Date palm and other palm.

Identification: The adult moth is small and greyish white with black head. The larva is light green with a dark brown head measures 1.5 cm in length.

Nature of damage: Damage caused by caterpillar. 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 with the patches seen on the fronds also. When a large number of leaves are affected the crown presents a scorched appearance from a distance.

Life cycle: The female lays 125 eggs in groups on the underside of tip of leaves.The eggs hatch in 3-5 days in summer and 10 days in winter. The young larva feed on the green parenchymatous tissues of leaflets from under surface and it construct small galleries with silk frass. The larvae full grown in about 6 weeks and the larva transform itself into a brownish pupa inside the gallery. The pupal period is lasts about 12 days. The total life cycle is completed in about two months and 5-6 generations are completed in a year.

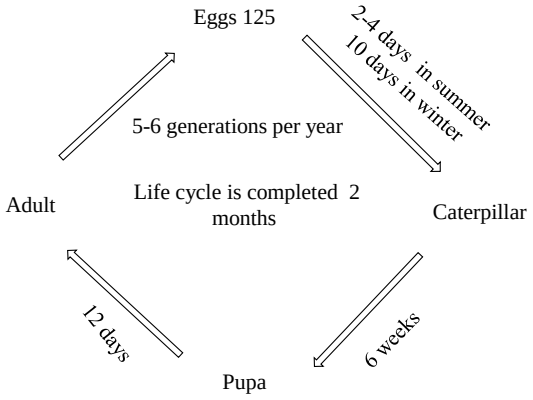

Fig. Life Cycle of Black headed caterpillar

Management:

- Cut and destroy the infested fronds by burning.
- Release larval parasitoids Apenteles taragammae, Bracon brevicornis, Elasmus nephantids @ 3000-4500 per hectare and predators periodically from January to check the build up of pest during summe.r
- Spray with NSKE 5% or neem oil 2% at15 days interval.

- Spray of Bt, *Beuveria bessiana*, *Metarrhizium anisoplie* @ 3 kg in 1250 liter of water per hectare.
- Spray malathion 50 EC 2 ml/1 or dimethoate 30 EC 2 ml/1 or thiachloprid 2 ml/ litre of water.

2. Rhinoceros beetle

Scientific Name- *Oryctes rhinoceros*

Order- Coleoptera

Family- Scarabaeidae

Distribution: South east asia, Phillipines, Southern China. In India, it is distributed in Kerala along with western coast.

Host: Coconut, Oil palm, Date palm and other palm.

Identification: The Stoutly built beetle has a pointed horn on its head, black, stout measures 5 cm long. The horn is longer in male and shorter in female beetle. The grub is stout, white, 'C shaped, sluggish and has a pale brown head.

Nature of damage: Damage caused by adult. The throw out a fibrous mass while feeding in the burrows made in the young fronds. The infested fully opened fronds showing the characteristic 'v' shaped cuts on leaf lets. 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.

Life cycle: The female may lay 100-150 oval, white, seed like eggs in 5-15 cm below the soil surface in decaying organic matter. The eggs hatch in 8-18 days and the grubs start feeding on the decaying matter. The developmental period of larva is about 99-182 days pss through three instars. The pupation is take place in soil chamber at a depth of about 30 cm and the pupal period is about lasts 10-25 days. The adults remain in pupal cell for about 11-20 days before coming out of the soil. The adult beetles lives for more than 200 days.The adult lay eggs after 20-60 days. There is only one generation is completed in a year.

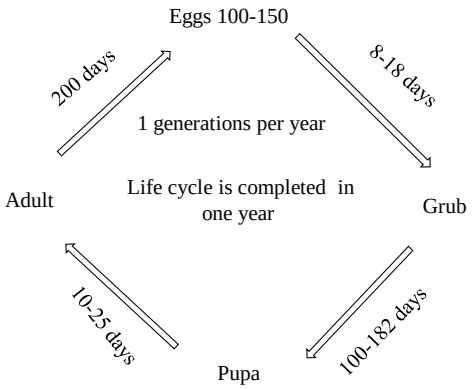

Fig. Life Cycle of Rhinoceros beetle

Management:

- Maintenance of sanitation in orchards by proper disposal of decaying organic debris.

- Use of light trap to attract and kill the adult beetles.
- Hook out the beetles from the affected crowns during July-August.
- Collect and destroy the various stages of beetles from the manure pit whenever the manure is lifted from pits.
- Keep the mud pots having soaked castor cake 1 kg in 5 litres of water to attack and kill the adults.
- Drench the manure heaps up to a depth of 60 cm at quarterly intervals.
- Incorporate entomopathogenic fungus, *Metarrhizium anisopliae* in manure pits.
- 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 aggregation pheromone, ethyl 4-methyl octonate, trap (bucket type trap).
- Baculovirus inoculated beetles @ 10-15 per hectare can be released.
- Treat the breeding places with 2 kg carbaryl 50 WP in 250 litre water per hectare.
- Apply the mixture of NSKE + sand (1:2) @ 150 kg per palm in the base of the 3 inner most leaves in the crown effectively control the beetle.

3. Red palm weevil

Scientific Name- *Rhyhchophorus ferrugineus*

Order- Coleoptera

Family- Curculionideae

Distribution: India, Pakistan, Bangladesh, Sri-Lanka, Malaysia, Phillipines and New guinea. In India it is most destructive pests in Maharastra, Assam, Kerala, Tamil-Nadu, Karnataka and Orissa.

Host: Coconut, Oil palm, Date palm and other palm.

Identification: The weevil is reddish brown, cylindrical, with a long curved snout with 6 dark spots on the thorax a conspicuous snout with tuft of hairs in the male whereas the female having no hairs on the snout.

Nature of damage: The grub and adult cause damage. The grub bore 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.

Life cycle: The female scoops out small holes with its snout or existing wounds and lays an oval, whitish 200-500 eggs during 3-4 months. The eggs hatch in 2-5 days and the grubs feed on the soft tissues and tunnel in to the tree trunks. The larval period lasts about 2-4 months and the full grown grubs change into the pupa after spinning a cocoon. The pupal stage lasts about 2 weeks. The adult life span is 7-16 weeks, the male surviving for longer

times than female. The total life cycle is completed in about 4 months and there are only three generations are completed in a year.

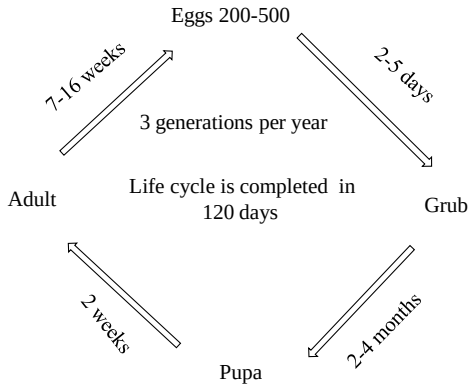

Fig. Life Cycle of Red palm weevil

Management:

- Destroy the infested, drying and dead palm in regular interval.
- Use of light trap to attract and kill the adult beetles.
- Cut petioles 1.20 meter away from the trunks to prevent enter of weevils.
- Avoid injuries or wound on stems as they serve as oviposition site for weevil.
- Fill all the holes with mud on the stem or trunk of coconut.
- 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 @75 per hectare.
- Set up male aggregation pheromone, ferruginol (4 methyl 5 nonanol) trap and ferrolure to attract the weevil and killing them.
- 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.
- Inject emulsion of dimethoate 30 EC @ 40 ml or carbaryl 50 WP @ 250 g in 25 litre of water in to the live holes and plaster them with mud.
- Follow the root feeding of monocrotophos 36 WSC 10 ml + 10 ml of water per tree.

4. Eriophyid mite

Scientific Name- *Aceria gurreronis*

Order- Acari

Family- Eriophyidae

Distribution: India, Pakistan, Bangladesh, Sri-Lanka, Malaysia, Phillipines and New guinea. In India it is most destructive pests in Kerala and Tamil-Nadu.

Host: Coconut

Identification: It is pale in colour with elongate body and worm like in appearance with two pairs of legs.

Nature of damage: The nymph and adult cause damage. The mite suck the cell sap from meristematic tissues of the growing nuts under the perianth. 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. The feeding results in warts and longitudinal fissures and splits occur on the outer surface of the husk. Occasionally brownish gummy exudates are seen oozing out from the affected surface.

Life cycle: The female lays about 18 eggs. The eggs hatch about 1-2 days and newly emerge protonymph suck the cell sap of different parts of plants. The nymphal/larval period last about 5-6 days through complete 2 instars. The adult live only 3-4 days and the life cycle is completed in 7-10 days and there are 30-35 generations are completed in a year.

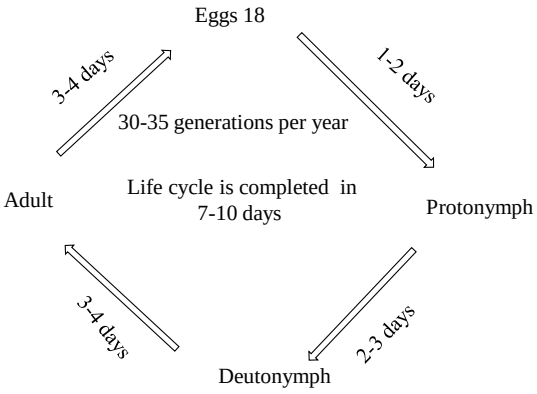

Fig. Life Cycle of Eriophyid mite

Management:

- Destroy the infested, drying and dead palm in regular interval.
- Follow the root feeding of monocrotophos 36 WSC 10 ml + 10 ml of water per tree.
- A combination treatment involving 500 ml (0.03 %) neem oil + 100 g *Hirsutella thomsonii* biofungul agent in 200 litres of water.
- Apply urea 1.3 kg, super phosphate 2.0 and murate of potash 3.5 kg/palm/year.
- 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.

5. Arecanut mired bug

Scientific Name- *Carvalhoia arecae*

Order- Hemiptera

Family- Miridae

Distribution: Southern India

Host: Arecanut

Identification: The adukt is red and black bug, 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.

Nature of damage: The nymph and adult cause damage. Nymphs and adult suck sap, which results in linear black necrotic streaks on the central shoot, stunted and twisted growth. In case of severe infestation, the leaves get shredded and stand erect.

Life cycle: The pest is active during February. The female lays 50-80 eggs having two bristle like structures arising from the operculum, singly into the tissue of tender spindle. The eggs hatch in 9 days and the newly emerge young ones suck cell sap from the tender parts of plants. The nymphs full grown in 14-21 days after undergoing six instars. The life cycle is completed in 23-29 days and several overlapping generations are completed in a year.

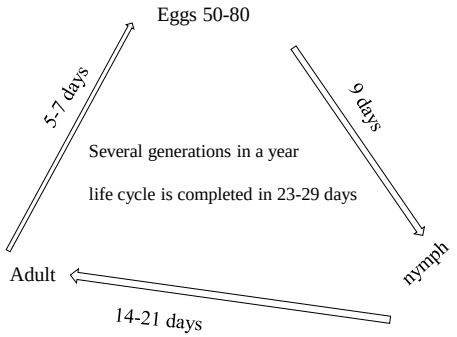

Fig. Life Cycle of Arecanut mirid bug

Management:

- Sanitation the orchard regularly
- Apply recommended dose of fertilizers.
- Spray quinalphos 25 EC @ 375 ml in 250 litres of water per hectare.

Lecture 21: Insect pests of Coffee and Tea

Major insect pests of Coffee

S. No.	Common Name	Scientific Name	Order	Family
1.	White stem borer	*Xylotrechus quadripes*	Coleoptera	Cerambycidae
2.	Coffee berry borer	*Hypothenemus hampei*	Coleoptera	Scolytidae
3.	Shot-hole borer	*Xylosandrus compactus*	Coleoptera	Scolytidae
4.	Striped mealy bug	*Ferrisia virgata*	Hemiptera	Pseudococcidae
5.	Coffee green bug	*Coccus viridis*	Hemiptera	Coccidae
6.	Helmet scale	*Saissetia coffeae*	Hemiptera	Coccidae
Minor insect pests of Coffee				
1.	Mealy bug	*Planococcus citri* and *P.lilacinus*	Hemiptera	Pseudococcidae
2.	Red borer	*Zeuzera coffeae*	Lepidoptera	Cossidae
3.	White grub	*Holotrichia conferta*	Coleoptera	Melolonthidae/ Scarabaeidae
4.	Aphid	*Toxoptera aurantii*	Hemiptera	Aphididae

Major insect pests of Tea

S. No.	Common Name	Scientific Name	Order	Family
1.	Tea mosquito bug	*Helopeltis theivora* (Eastern India), *H .antonii* (Southern India),	Hemiptera	Miridae
2.	Bunch caterpillar	*Andraca bipunctata*	Lepidoptera	Bombycidae
3.	Humped slug	*Spatulicraspeda*	Lepidoptera	Cochlididae

	caterpillar	*castaneiceps*		
4.	Red crevice tea mite/Scarlet mite	*Brevipalpus phoenicis*	Acari	Tenuipalpidae
5.	Yellow tea mite (Cause Murda disease in chilli)	*Polyphagotarsonemus latus*	Acari	Tarsonemidae
Minor insect pests of Tea				
1.	Red borer	*Zeuzera coffeae*	Lepidoptera	Cossidae
2.	Purple mite	*Calacarus carinatus*	Acari	Eriophyidae
3.	Pink mite or orange mite	*Acaphytta theae*	Acari	Eriophyidae
4.	Red spider mite	*Oligonychus coffeae*	Acari	Tetranyehidae

1. Striped mealy bug

Scientific Name- *Ferrisia virgata*

Order- Hemiptera

Family- Pseudococcidae

Distribution: Eastern and Southern India, Pakistan, Bangladesh, Myanmar, Sri-Lanka, Malaysia, Phillipines, Java and New Guinea.

Host: It is polyphagous pests, Coffee, cocoa, citrus, cotton, jute, groundnut, cassava, beans, cashew, sugarcane, guava, sweet potato etc.

Identification: The adult female with a pair of conspicuous longitudinal submedian dark stripes and long glossy wax threads and pronounced tail.

Nature of damage: The nymph and adult cause damage. Nymphs and adult suck sap, from the young shoots, berries and leaves resulting in the withering and yellowish plants. It also act as a vector of virus which causes the swollen shoot disease of cocoa.

Life cycle: The sessile female lays 300-400 eggs on the tender parts of plants. The eggs hatch few hrs after laid and the young nymphs start feeding by sucking cell sap. The nymphs become full grown in 40-42 days and the life cycle is completed in about six weeks. The pests are multiplied past in drought condition. There are many overlapping generations are completed in a year.

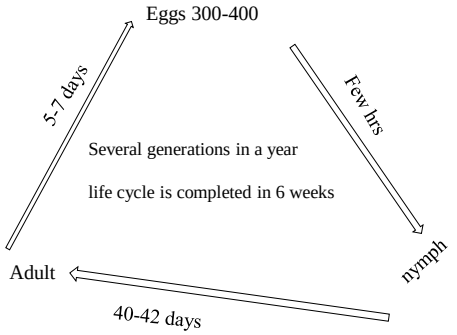

Fig. Life Cycle of striped mealy bug

Management:

- Sanitation the orchard regularly
- Apply recommended dose of fertilizers.
- Maintain the orchard moist.
- Spray quinalphos 25 EC @ 500 ml in 250 litres of water per hectare.

2. Coffee green bug/scale

Scientific Name- *Coccus viridis*

Order- Hemiptera

Family- Coccidae

Distribution: Southern India, Pakistan, Bangladesh, Myanmar, Sri-Lanka, Malaysia. In India, Kerala, AP, Karnataka and Tamil-Nadu.

Host: It is polyphagous pests, Coffee, citrus, guava, mango, loquat and other plants.

Identification: The adult scale is flat, oval, slightly convex, pale green to yellow green with an irregular dark distinct loop on the middle of the dorsum.

Nature of damage: The nymph and adult cause damage. The scale attacks tender parts, underside of the leaves close to midrib, veins, and tips of green shoots. As a result of heavy feeding, the leaves and fruit become discoloured and malformed and drop off. 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.

Life cycle: The scale are ovoviviparous and the female lays 300-500 eggs in her life span of 2-5 months. The eggs hatch after few hrs and the young ones remain under the scale for a few days and then crawl out. There are three nymphal instars and then they become adult in 1-2 months. The life cycle is completed in 30-60 days and there are many generations are completed in a year.

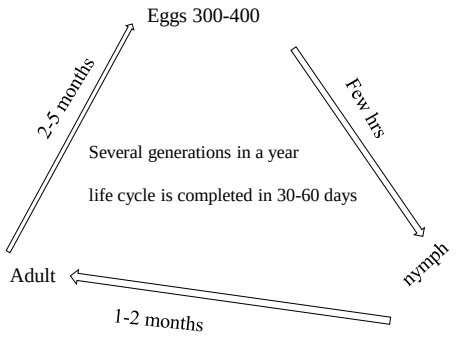

Fig. Life Cycle of Coffee green bug

Management:

- Sanitation the orchard regularly
- Maintain optimum shade
- Remove and destroy weeds, as many of them harbor the pest.
- Apply recommended dose of fertilizers.
- Association of ants, *Oecophylla smaragdina*, *Camponotus sp* with green scale is similar to that explained for mealybugs.
- The entomophagous fungi, *Empusa lecanii*, *Cephalosporium lecanii* infect the soil and thus play an effective role in the natural control of the pest.
- Spray quinalphos 25 EC @ 500 ml or malathion 50 EC @750 ml or dimethoate 30 EC @ 500 ml in 500 litres of water per hectare.

3. Coffee stem borer or white borer

Scientific Name- *Xylotrechus quadripes*

Order- Coleoptera

Family- Cerambycidae

Distribution: India, Pakistan, Bangladesh, Sri-Lanka, Malaysia, Phillipines and New guinea. In India it is most destructive pests in southern India and Assam.

Host: Arabica Coffee.

Identification: The adult is a blackish brown beetle about 12 mm long with prominent antennae and yellowish bands on elytra.

Nature of damage: The grub and adult cause damage. The grub bore in to the stem, killing the young plants. Infested plants show external ridges around the stem and exhibit signs like

yellowing and wilting of leaves. There are two flight (emergence) periods from April to May and October to December.

Life cycle: The female lays about 100 eggs during 21-28 days in the crecks and crevices of trunk bark or branches. The eggs hatch in about 10 days and firstly feeding on soft bark for sometime then start boring into the woody tissue. The larval period lasts about ten months. Larva pupates in a chamber close to the periphery of the stem and the pupal stage lasts for 3 to 4 weeks after which it transforms into an adult. The only one generation is completed in a year.

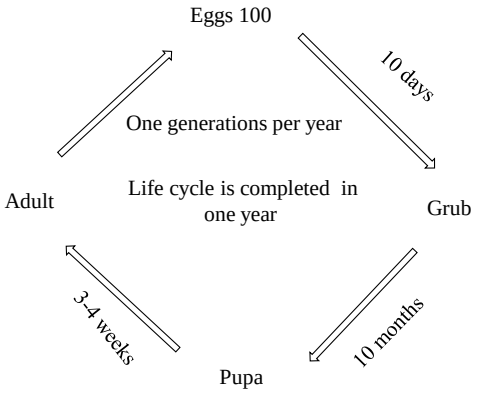

Fig. Life Cycle of Coffee stem borer

Management:

- The pest can be reduced by removing and destroying the affected shoots along with borer.
- Catching and killing the beetles during their egg laying period.
- Dislodging the eggs and young borers with tough brushes.
- Maintain optimum shade.
- Set up of pheromone traps to monitor incidence.
- Proper agronomic practices to retain plant vigour.
- 10% lime application on main stem and thick primaries during April to May and October to December.
- Repeated application of neem oil on the stem.
- Swabbing of main stem and branches with quinalphos emulsion @ 1.25 litre mixed in 125 litre of water per hectare during April to May and October to December.

4. Coffee shot hole borer

Scientific Name- *Xylosandrus compactus*

Order- Coleoptera

Family- Scolytidae

Distribution: India, Pakistan, Bangladesh, Sri-Lanka, Malaysia, Phillipines and New guinea. In India it is most destructive pests in southern India.

Host: Robusta Coffee.

Identification: The adult beetle is brown to black with a short, sub-cylindrical body. The grub is legless and milky white larvae with brownish head.

Nature of damage: The grub and adult cause damage. The tunnelling made by grub and adults results in wilting, defoliation and dieback of the plants. The area around a shot hole become discoloured and secondary infection occurs due to microorganisms hastens the death of affected shoots.

Life cycle: the female bore into the bark of tertiary branches and lays 50 eggs into the tunnels. The eggs hatch in 7 days and white apodous grub feed on ambrosia, a fungal growth developed on the beetle excreta inside the tunnels. The larval stage lasts for 2 to 3 weeks and the full grown larvae make cocoons near the exits. The pupal period lasts about 10 days and the life cycle is completed from egg to adult in 5-6 weeks. There are many generations during a year.

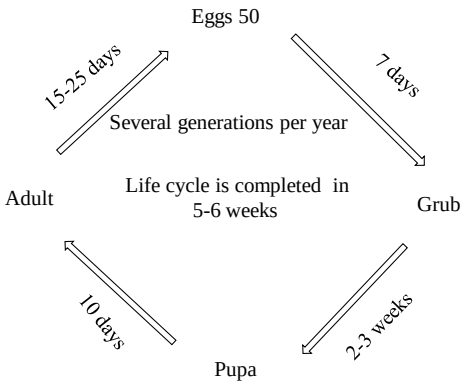

Fig. Life Cycle of Coffee shot hole borer

Management:

- The pest can be reduced by removing and destroying the affected shoots along with borer during 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.

- Proper agronomic practices to retain plant vigour.
- Repeated application of neem oil on the stem.
- Spray quinalphos 25 EC @ 500 ml or malathion 50 EC @750 ml or dimethoate 30 EC @ 500 ml in 250 litres of water per hectare.

5. Coffee berry borer

Scientific Name- *Hypothenemus hampei*

Order- Coleoptera

Family- Scolytidae

Distribution: India, Pakistan, Bangladesh, Sri-Lanka, Malaysia, Phillipines and New guinea. In India it is most destructive pests in southern India.

Host: Robusta Coffee and Arabica and Leguminoseae.

Identification: The adult is a small black beetle with a sub-cylindrical body covered with thick hairs and the female is winged and male wingless. The grub is legless and milky white larvae with brownish head.

Nature of damage: The grub and adult cause damage. The beetle at a time make one or more pin head size holes near the apex of green or the ripe berries. A powdery substance pushed out through the holes reveals the active tunneling and feeding within the beans. Infested tender berries may fall due to injury or secondary infection by fungi.

Life cycle: The activity of the beetles starts with the appearance of berries. The female lay 30-60 eggs in groups of 8-12 on the beans during an oviposition period of 21-28 days. Eggs hatch in about 10 days and the larvae feed on the beans making small tunnels. The larval period is completed in 14-21 days after passess 3 moult. The pupal stage lasts about one week and is spent in larval galleries. The life cycle from egg to adult take 30-37 days. There are several generations are completed in a year.

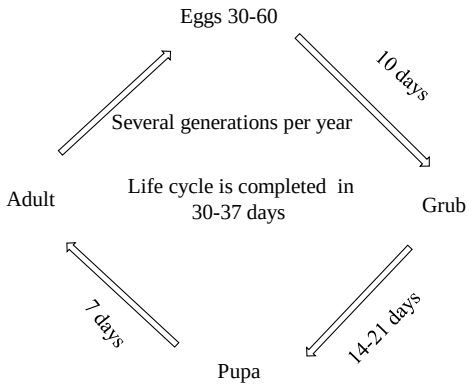

Fig. Life Cycle of Coffee berry borer

Management:

- Removal of off-season berries to break the continuity of the breeding.

- Timely harvest, reduces carry over inoculums and thorough harvest breaks the life cycle.
- Spread gunny/plastic sheets (picking mats) below the plants minimizes the gleaning.
- Avoid excess shade. Train bushes properly
- 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, Phosphine tablet to avoid cross infestation.
- Proper agronomic practices to retain plant vigour.
- Spray entomo-fungus *Beauveris bassiana* @ 1-25 kg in 500 litre of water per hectare when the beetles are in the pulp..
- Use of parasitoids – Cephalanomia stephanoderis
- Repeated application of neem oil on the stem.
- Spray quinalphos 25 EC @ 1000 ml or malathion 50 EC @1250 ml or dimethoate 30 EC @ 1000 ml in 500 litres of water per hectare.

6. Bunch caterpillar

Scientific Name- *Abdraca bipunctata*

Order- Lepidoptera

Family- Bombycidae

Distribution: India, Indonesia, Formosa and Vietnam

Host: Tea

Identification: The adult moth is brownish with dark wavy lines on the wings and two white spots distally on fore wings near the outer margins. The larva is smooth, greyish in colour with brown patches.

Nature of damage: The caterpillar causes 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.

Life cycle: The female moth lays 500 eggs in group of 120 on the under surface of leaves. The egg hatch in about 10 days and first they eat up their egg shell and later on, start feeding on leaf tissue. The larval period is about 20-30 days passes through five instars. The full grown larvae descend to the ground and spin cocoon among dry leaves and pupate inside it. The pupal period is completed in 15-30 days. The life cycle is completed in 45-70 days and there are 4-5 generations are completed in a year.

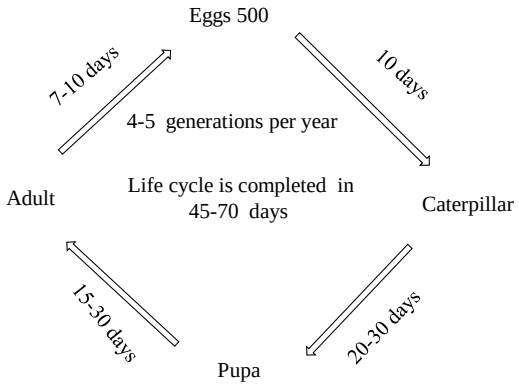

Fig. Life Cycle of bunch caterpillar

Management:

- Collecting the caterpillars manually and destroying them.
- Proper agronomic practices to retain plant vigour.
- Spray entomo-bacteria *Bt* @ 1-25 kg in 500 litre of water per hectare when the beetles are in the pulp..
- Repeated application of neem oil on the stem.
- Spray quinalphos 25 EC @ 1000 ml or malathion 50 EC @1250 ml or dimethoate 30 EC @ 1000 ml in 500 litres of water per hectare.

6. Tea mosquito bug:

Nature of damage: Damage cause by nymph and adult. The bug puncture the leaf frequently to suck the juice. While feeding, the saliva is injected and the tissue around the site of feeding are necrosed, becoming brownish or black. By the coalescence of a large number of such patches, the entire leaf may become black and shrivelled and may fall off. In severe attack, causing defoliation, the shoots are killed and the plants appear like brooms.

Lecture 22: Insect pests of Cocoa

Major insect pests of Cocoa

S. No.	Common Name	Scientific Name	Order	Family
1.	Red borer	*Zeuzera caffeae*	Lepidoptera	Cossidae
2.	Fruit borer	*Dichocrocis (Conogethus) punctiferalis*	Lepidoptera	Pyralidae
3.	Stem girdler	*Sthenias grisator*	Coleoptera	Cerambycidae
4.	Tea mosquito bug	*Helopeltis theivora*	Hemiptera	Miridae
5.	Mango hopper	*Idioscopus clypealis*	Hemiptera	Cicadellidae

Lecture 23: Insect pests of Rubber and Cinchona

Major insect pests of Rubber and Cinchona

S. No.	Common Name	Scientific Name	Order	Family
1.	Rubber bark caterpillar	*Aestherastis circulate*	Lepidoptera	Hyponomentidae
2.	Stem borer	*Batocera rufomaculata*	Coleoptera	Cerambycidae
3.	Scale	*Aspidiotus destructo, Saisettia nigra*	Hemiptera	Coccidae
4.	Weevil	*Apoderus chrysochlorus*	Coleoptera	Curculionidae

Lecture 24: Insect pests of Cashew nut

Major insect pests of Cashew nut

S. No.	Common Name	Scientific Name	Order	Family
1.	Cashew tree borer	*Plocaederus ferrugineus*	Coleoptera	Cerambycidae
2.	Cashew leafminer	*Acrocercops syngramma*	Lepidoptera	Gracillaridae
3.	Tea mosquito bug	*Helopeltis antonni*	Hemiptera	Miridae
Minor insect pests of Cashew nut				
1.	Bark caterpillar	*Indarbela tetraonis*	Lepidoptera	Metarbelidae
2.	Flower thrips	*Scirtothrips dorsalis*	Thysanoptera	Thripidae

1. Cashew tree borer

Scientific Name- *Plocaederus ferrugineus*

Order- Coleoptera

Family- Cerambycidae

Distribution: India, Indonesia, Formosa and Vietnam

Host: Plantation, fruit crops.

Identification: The adult beetle is medium sized reddish brown measuring 25-40 mm in length. The grub is white colour and the grown up grub measures 60-75 mm in length.

Nature of damage: The grub and adult causes damage. The grubs tunnel make in the stem and feed inside the tree trunks and branches and damage cambial tissues and stop the flow of sap. Old plantation affect by this pest.

Life cycle: The female lays eggs singly under the loose bark on the trunk. The egg hatch in 4-6 days and newly emerge grubs bore into the bark and feed on soft tissues, making tunnels in all directions. The opening of tunnels is plugged with reddish mass of chewed fibre and excreta. The grub stage last for 6-7 months and the fully grown grub descends to root zone through tunnels where it forms a calcareous shell for pupation. The pupal period last 60 days inside the cocoon. The life cycle is completed in one year and there is one generation is completed in a year.

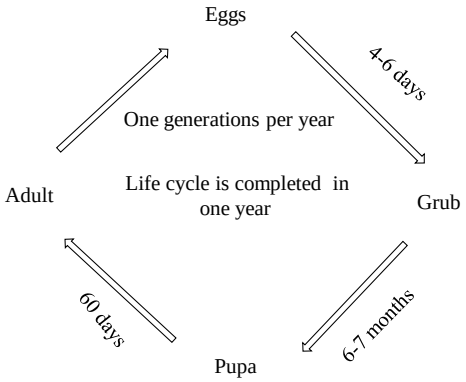

Fig. Life Cycle of Cashew nut tree borer

Management:

- Remove the grubs by peeling the bark and destroy them.
- The severe infested trees should be uprooted and destroy by burning.
- Drench the basal trunk and root zone with 2 litre of quinalphos in 250 litre of water per hectare.
- Inject carbon disulphide into the tunnels and plaster them with mud.
- Apply coal tar and kerosene (1:2) on the trunk up to 1 metre height which prevent the beetles from egg laying.
- Adopt stem padding with cotton wool soaked in quinalphos at 30 ml /tree gives good recovery.
- Root feeding of quinalphos 10 ml +10 ml of water kept in a polythene bag in two places (20 ml / tree) gives good protection to the trees.

Lecture 25: Pest Management in Mint, betel vine, senna

Major insect pests of Mint

S. No.	Common Name	Scientific Name	Order	Family
1.	Lace wing bug	*Cochlochila bullita*	Hemiptera	Tingidae
2.	Cut worm	*Agrotis segetum*	Lepidoptera	Noctuidae
3.	Semilooper	*Plusia orichalcea*	Lepidoptera	Noctuidae

Major insect pests of Betel vine

S. No.	Common Name	Scientific Name	Order	Family
1.	Aphid	*Aphis gossypii*	Hemiptera	Aphididae
2.	Whitefly	*Aleurocanthus nubilans, Dialeurodes pallid*	Hemiptera	Aleyrodidae
3.	Shoot bug	*Pachypeltis politus, P.measarum*	Hemiptera	Miridae
4.	Leaf eating caterpillar	*Spodoptera litura*	Lepidoptera	Noctuidae

Major insect pests of Senna

S. No.	Common Name	Scientific Name	Order	Family
1.	White butterfly or mottled emigrant	*Catopsilia pyranthe*	Lepidoptera	Pieridae
2.	Pod borer	*Etiella zinckenella*	Lepidoptera	Pyralidae

1. **Leaf eating caterpillar:**

Nature of damage: The caterpillar causes damage. The larva feeds on leaves and fresh growth of the plants. They are voracious feeder of leaves and several of them when present on plant cause defoliation. The larva is active in night and feeds by biting large holes in the leaves.

Management:

- Hand picking and destroy the infested plants from the field.
- Hand picking of the egg masses of *S.litura* and destroy them.
- Hand picking and destroy the larvae of the *S.litura.*
- Set up light traps to attract and kill the moths.
- Set up pheromone traps, spodolure, litulure @ 12 / hectare to attract the male moths *S.litura.*
- Release an egg parasitoid *Trichogramma chilonis* @ 150,000 / hectare.
- Spray SlNPV @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 trap crop around the main field like America tall marigold.
- Spray thiodicarb 2 ml / litre or fame 0.5 ml/litre or Indoxacarb 0.5 ml/liter or spinosad 0.5 ml/litre or emamectin benzoate 0.5 g/litre of water.
- Spray of *Bacillus thuringiensis* @ 2 g. / litre of water.

2. Cut worm:

Nature of damage: The caterpillar causes damage. The larvae first feed on epidermis of the fallen leaves or green leaves touching the ground. Later, caterpillars cut the leaf, shoot or the plants just above the ground level and buried in the soil.

Management:

- Hand picking and destroy the infested plants from the field.
- Hand picking and destroy the larvae.
- Set up light traps to attract and kill the moths.
- Flooding of field may kill the larvae.
- Soil application of carbofuran 3 G @ 30 kg/ha.
- Spray thiodicarb 2 ml / litre or fame 0.5 ml/litre or Indoxacarb 0.5 ml/liter or spinosad 0.5 ml/litre or emamectin benzoate 0.5 g/litre of water.
- Spray of *Bacillus thuringiensis* @ 2 g. / litre of water.

3. Lace wing bug:

Nature of damage: The nymph and adult cause damage. The nymphs and adults suck the cell sap 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.

Lecture 26: Pest Management in Neem and Indian belladona

Major insect pests of Neem

S. No.	Common Name	Scientific Name	Order	Family
1.	Stem Borer	*Plocaederus ferrugineus*	Coleoptera	Cerambycidae
2.	Anthribid fruit borer	*Araecerus fasciculatus*	Coleoptera	Anthribidae
3.	Tea mosquito bug	*Helopeltis antonii*	Hemiptera	Miridae
4.	Slug caterpillar	*Parasa lepida*	Lepidoptera	Cochildiidae
5.	Termite	*Odontotermes obseus*	Isoptera	Termitidae

Major insect pests of Indian belladona

S. No.	Common Name	Scientific Name	Order	Family
1.	Cut worm	*Agrotis flammatra*	Lepidoptera	Noctuidae
2.	Leaf feeder	*Archips micaceana*	Lepidoptera	Tortricidae

1. Termite

Nature of damage: The worker caste of termite is cause damage. Termites infest stems and feed internal tissues of trunks and fill with sand and excreta. Affected young plants show drying of shoots and wilting of plants and the infested plants are easily uprooted.

Management:

- Identify termite mound and destroy queen by physical or chemical means.
- To avoid the attack of white ants care should be taken not to be used green manure or raw farmyard manure.
- Apply neem cake @ 250 kg per hectare.
- Apply mustard straw in the field.
- Flooding the field is an effective method of termite control.
- Soil application of fipronil 0.3 G @ 12.5kg per hectare at the time of field preparation.
- Spray neem oil 5% once at the base up to 2 m height of the trunk for effective control.

- Destroy mound building, termites by treating with aluminnium phosphide or sulfex tablets @ 2 tablets / meter diameter of mound. Close all openings of the mound after inserting tablets.
- Mix 60 ml of quinalphos 25 EC in 18 litre of water and pour into the mound through a hole made in the centre, or through open chimneys in case of open mounds.

Lecture 27: Pest Management in Long pepper, Medicinal yam, Aswagandha, Sarpagandha, Opium poppy and Geranium

Major insect pests of Opium poppy

S. No.	Common Name	Scientific Name	Order	Family
1.	Root weevil	*Sternocarus fuliginosus*	Coleoptera	Curculionidae
2.	Cutworm	*Agrotis suffusa*	Lepidoptera	Noctuidae
3.	Gram pod borer	*Helicoverpa armigera*	Lepidoptera	Noctuidae

Major insect pests of Long pepper

S. No.	Common Name	Scientific Name	Order	Family
1.	Mealy bug	*Dysmicoccus sp.*	Hemiptera	Pseudococcidae
2.	Tea mosquito bug	*Helopeltis theivora*	Hemiptera	Miridae

Major insect pests of Medicinal yam

S. No.	Common Name	Scientific Name	Order	Family
1.	Aphids	*Aphis gossypii*, *Pentalonia nigronervosa*	Hemiptera	Aphididae
2.	Red spider mite	*Tetranychus sp*	Acari	Tetranychidae

Major insect pests of Aswagandha

S. No.	Common Name	Scientific Name	Order	Family
1.	Grasshopper	*Trilophida annulata*	Orthoptera	Acrididae
2.	Cutworm	*Agrotis suffusa*	Lepidoptera	Noctuidae
3.	Ash weevil	*Myllocerus viridanus*	Coleoptera	Curculionidae
4.	Mealy bug	*Coccidohystrix insolita*	Hemiptera	Pseudococcidae
5.	Leaf hopper	*Penthina sp.*	Hemiptera	Cicadellidae

Major insect pests of Sarpagandha

S. No.	Common Name	Scientific Name	Order	Family
1.	Leaf caterpillar	*Glyphodes vertumnalis*	Lepidoptera	Pyralidae
2.	White grub	*Anomala polita*	Coleoptera	Scarabaeidae/Melolonthidae

Major insect pests of Geranium

S. No.	Common Name	Scientific Name	Order	Family
1.	Termite	*Odontotermes sp.*	Isoptera	Termitidae

Lecture 28: Important insect pests attacking stored fruits, plantations, arometic and medicinal plants.

S. No.	Common Name	Scientific Name	Order	Family
1.	Cigarette or tobacco beetle	*Lasioderma serricorne*	Coleoptera	Anobiidae
2.	Drug store beetle	*Stegobium paniceum*	Coleoptera	Anobiidae
3.	Tamarind beetle	*Pachymeres gonagra*	Coleoptera	Bruchidae
4.	Indian meal moth	*Plodia interpunctella*	Lepidoptera	Pyralidae
5.	Almond moth	*Ephestia cautella*	Lepidoptera	Pyralidae
6.	Khapra beetle (Only grub damage)	*Trogoderma granarium*	Coleoptera	Dermestidae
7.	Red flour beetle	*Tribolium castaneum*	Coleoptera	Tenebrionidae
8.	Lesser grain borer	*Rhyzopertha dominica*	Coleoptera	Bostrychidae
9.	Fruit fly	*Bactrocera dorsalis*	Diptera	Tephritidae

1. **Indian meal moth:**

Scientific Name- *Plodia interpunctella*
Order- Lepidoptera
Family- Pyralidae
Distribution: Worldwide.
Host: It infests grains, meals, dried fruits, nuts, seeds etc
Identification: The larvae is whitish, tinge with green or pink, a light brown head, prothoracic shield. The moth has coppery on the outer wings and whitish grey inner wings. The palps form a characteristics cone like beak in front of the head.
Nature of damage: The caterpillar causes damage. The larvae feed on the stored product and contaminate with excrement, webbing, dead individuals and cocoons.
Life cycle: The insect overwinter in larval stage and the adult breeds in warm climate. The female lays 30-350 eggs singly or in groups on the foodstuffs. The eggs hatch in 2-14 days and the larvae feed upon the foodstuffs and become full grown in 30-35 days. The larvae pupate within a thin silken cocoon on the food. The pupal stage lasts about 4-35 days. The life

cycle is completed in 5-6 weeks in summer and there are about 4-6 overlapping generations in a year.

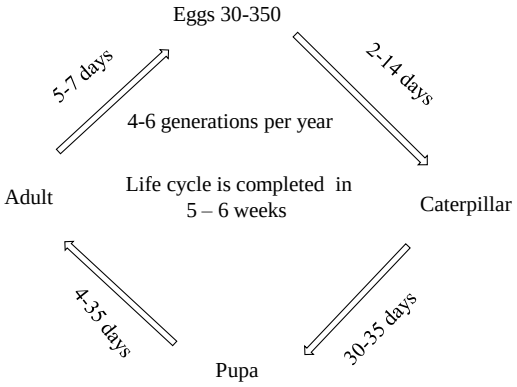

Fig. Life Cycle of Indian meal moth

2. Cigarette or tobacco beetle

Scientific Name- *Lasioderma serricorne*

Order- Coleoptera

Family- Anobiidae

Distribution: Worldwide.

Host: It infests dried fruits, nuts, seeds, stored tobacco, ginger, turmeric, chillies etc

Identification: Adult light brown round beetle with its thorax and head bent downwards and this presents a strongly humped appearance to the insect.

Nature of damage: The grub and adult causes damage. Boths are bore into the stored seeds and presence of circular pin head sized bore holes on processed product is the typical symptom of attack.

Life cycle: The insect overwinter in grubstage and the adult breeds in warm climate. The female lays 70-130 eggs singly or in groups on the foodstuffs. The eggs hatch in 9-14 days and the grub feed upon the foodstuffs and become full grown in 7-29 days. The grubs pupate within a thin cocoon on the food. The pupal stage lasts about 2-8 days. The life cycle is completed in 3-7 weeks in summer and there are several overlapping generations in a year.

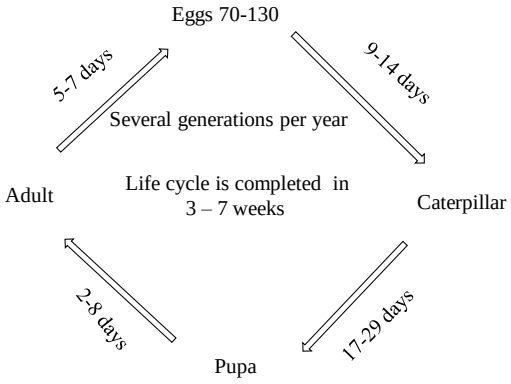

Fig. Life Cycle of Cigarette beetle

Lecture 29: Integrated Management of Stored Produce Pests

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 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 42 ^{o}C and below 15 ^{o}C retards reproduction and development of insect while prolonged temperature above 45 ^{o}C and below 10 ^{o}C 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.

- Manipulate and reduce oxygen level by 1% to increase the CO2 level automatically, which will be lethal to all the stages of insects.

ii. Physical methods

- 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.
- 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 55-60 ^{o}C in 10-20 minutes.

iii. Cultural methods

- Store the food grains in airtight sealed structures to prevent the infestation by insects.

iv. Mechanical methods

- Stitch all torn out bags before filling.

vi. Chemical methods

- Treat the walls, dunnage materials and ceilings of empty godown with Malathion 50 EC 10 ml / 1 at 3 litre spray solution / 10 sq.m.
- Use EDB ampoules (available in different sizes of 3 ml, 6 ml, 10 ml, 15 ml and 30 ml) at 3 ml / quintal.
- 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.
- 21 tablets of aluminium phosphide 3 g each for 28 cubic meters (For shed fumigation).

Lecture 30: Integrated rodent management

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. They are as follows:

- Mole rat or lesser bandicoot or field rat - *Bandicota bengalensis*
- Bandicoot rat - *Bandicota indica*
- Grass rat - *Millardia meltada*
- Gerbil rat - *Tatera indica*
- Common house rat - *Rattus rattus rufescens*
- Indian field mouse - *Mus booduga*
- Brown ring mouse - *Mus platythrix*
- House mouse - *Mus musculus*

Integrated rodent management

I. Field

1. Cultural methods

- Dig burrows and kill rats at the beginning of crop season.
- 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 50-60 per hectare.

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.

3. Chemical Methods

- Use acute or single dose poision bait at 1 part Zinc phosphide with 49 parts popped corn / rich / dry fish.
- 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.
- 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 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.
- 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.

Lecture 31: Toxicology- insecticide residue problems in fruit, plantation medicinal and aromatic crops and their tolerance limits

Terms related to toxicology:

- **LD_{50}:** The lethal dose kills 50 percent population of test animals. It expressed as mg/kg body weight.
- **LC_{50}:** The lethal concentration kills 50 percent population of test animals. It expressed as ppm.
- **EC_{50}:** It is the concentration of chemical resulting sterility in 50 per cent of test animals.
- **ED_{50}:** It is the dose of chemical which brings sterility in 50 per cent of test animals.
- **Hazard:** It is probability of being harmed due to use/exposure/handling of the toxic substance.
- **Risk:** It is the degree of physical, biochemical and histochemical changes acceptable in terms of usefulness of a chemical and its possible effects on public health.
- **Tolerance/Maximum Residual Limit (MRL):** It is defined as the maximum concentration in ppm of pesticide residue that is permitted in or on food at a specified stage of the harvesting, storage, transport, marketing or preparation of food upto the final point of consumption.
- **Acceptable Daily Intake (ADI):** It is the daily dose of a chemical which during an entire life time, appears to be without appreciable risk on the basis of all facts known at that time. It is expressed in mg/kg body wt/day.
- **Deposit:** The amount of initially laid down insecticidal chemical on the surface.
- **Residue:** The amount of insecticide left over after a lapse of time.
- **Half life:** The rate of disappearance of insecticide residue.
- **Co-distillation:** Distillation of insecticide away from the soil surface along with water vapour.
- **Wick-effect:** The movement of insecticide towards the surface of the soil alongwith water.
- **Terminal residues:** Several breakdown products of the insecticides are stable and create as many problems as the original compound. These breakdown products are called terminal residues.
- **Bioaccumulation:** The accumulation of insecticides in various biological systems.

Impact of pesticides on agroecosystem:

I. **Abiotic environment:** Include soil, air and water.

II. **Plants:**

1) Presence of residual amount
2) Damage because of phytotoxicity
3) Changes in the vegetative development

III. Animals:

1) Domestic animals
2) Wild life
3) Natural enemies

Effect

- Pest resurgence
- Secondary pest outbreak
- Pollinators

IV. Man:

a) Operational hazards
b) Accidental and intentional poisoning
c) Indirect hazards through food chain
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:

- **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'.

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.

- **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).