

Good quality

Biology: The science which deals with the **study of living thing is called Biology.**

Zoology: The science which deals with the **study of animals.** Zoon=animal ,
logous=discourse, study.

Entomology:The term entomology has been derived from the **Greek words,**
entomon= insect and logos = knowledge.It is the **branch of zoology that deals**
with insects only under class **insecta** of the phylum **arthropoda.**

Agricultural entomology : This mainly concerns with the study of insects which
are **directly related with the crops and stored commodities.**

Applied entomology : The application of **pure entomology to the control of**
insect pests.

Insect: Insect are those **tracheae arthropod** in which the body is divided in to
three region head , thorax and abdomen with three pair of legs and **development**
through metamorphosis is known as insect. The word insect is derived
from **Latin world (Insectum=having cut into).** Insects are also known as
hexapoda owing to the presence of six legs. The true insects.

Mite:An organism whose body is divided into **two region (cephalothorax and**
abdomen), four pairs of legs and **sucking mouth** parts and **they have no antenna**
and compound eye.

What is a pest: An insect (or any other living being) whose **population**
increases to such an extent as to cause **economic losses** to crops or a nuisance and
health hazards to **man and his live stock** will be declared a pest.

Pest:Any organism **detrimental to man or its property** is known as pest.

Insect pest:When any insect **causes economic damage** is known as insect pest.

Host. The term host means **any plant or animal on or in which another**
organism lives for nourishment, or protection.

Host: This is an organism, which **harbor** another organism, e.g. the rice meal moth, *Corcyra cephalonica* St is a host of many natural enemies.

Alternative host: A host used by a pest or pathogen **when the primary or the preferred host is not present**. Alternative host are **not required for the completion of the pest or parasite life cycle**.

General equilibrium position: General equilibrium position is the **average population density** of an insect over a **long period of time, unaffected by the temporary intervention of pest control**.

Economic threshold level: The **pest population density** at which **control/management action should be taken** to prevent an increasing pest population from reaching the economic injury level. This is also known as action threshold.

Economic injury level: The **lowest numbers of insects** that will cause economic damage.

Damage boundary: The **level of injury** where **damage can be measured**.

Economic damage: The injury done to a crop which will justify the cost of artificial control measure.

Economic pest: A pest causing a crop loss of **about 5 to 10 per cent** according to definition.

Key pest: A **perennial, severe pest** that causes **serious and difficult crop production problems**; a pest that dominates cultural activities.

Minor pest: Insect which normally cause a **loss ranging from 05 to 10 per cent** is known as minor pest .

Major pest: The insect which normally cause **loss more than 10 per cent or more** is called major pest.

Secondary pest: Pest species **that are usually present at low levels and are held in check by the action of natural enemies**; can assume full pest status **when**

natural enemies are destroyed by the pest management tactic (e.g. insecticide application).

Monophagus: Monophagus insects are **confined to a single species of plants**. A strictly monophagus insect like the mulberry silkworm is rare to find.

Oligophagus: Oligophagus insects characteristically **feed on a group of botanically related plants. Usually within a single plant family**.eg the diamond back moth is confined to the plant of Cruciferae.

Polyphagus: Polyphagus insects are those that **accept many plant from a diverse range of plant family**, even though preference still exists, e.g. locust, grasshoppers hairy caterpillars, gram cutworm and termite.

Seasonal pest: The insect which **occur mostly during particular part of the year are called as seasonal pest** and the incidence of these pest are governed by climatic factor

Occasional pest: Many insects **occur rather infrequently and close association with a particular crop is absent** e.g mango stem borer. **Occasional pest:** a pest with general equilibrium position substantially below the economic injury level; highest pest population fluctuations occasionally and sporadically exceed the economic injury level.

Persistent pest: Insect which **occur on a crop almost throughout the year** are called as persistent pest.

Potential pest: These insects **normally do not cause any economic damage**, but may become serious pests resulting from some **changes in the ecosystem**, e.g. armyworm on wheat.

Sporadic pest: Insect which **occur in a few isolated localities** are known as sporadic pest

Epidemic pest: When pest **occur in a severe form in a particular area or locality** is known as epidemic pest

Endemic pest: When infestation occurs at a regular feature and confined mostly to a particular area or locality

Plant protection: refers to the measure which is used to protect the crop from pest and disease.

Pest control: Any method employed to reduce the pest population and to prevent damage caused by them are known as pest control.

Integrated pest control: A multidisciplinary ecological approach to the management of pest population which utilizes a variety of control tactics compatibility in a single coordinated pest management system is termed as integrated pest control.

IPM: According to FOA.(1967) it is the system that in context of the associated environment and population dynamics of pest species , utilizes all the suitable technique and methods in as compatible manner as possible and maintains the pest population at a level below those causing economic injury.

Biological control: Metcalf and flint (1962) defined biological control as the destruction and suppression of undesirable insects other enemies or weeds by the introduction, encouragement or artificial increase of their natural enemies.

Biological control: The employment of any biological agent for pest suppression.

Parasite: parasite is an organism which at one time or other lives on the body of the host which may or may not be killed after it has completed development.

Parasitoid: A parasitoid is an organism which completes its life on one host only and kills it.

Predator: Predator is a free living organism and kills the host immediately normally larger than prey (host) requires more than one host to develop and is very specific unlike parasitoids, e.g. lady bird beetle (*Coccinell septempunctata*, *Coccinella sexmaculata*) and green lace wing (*Chrysoperla carnea*)

Pesticide: Pesticide is a chemical which kills the pests by its chemical action. Insecticide is a pesticide and the term is used for those chemicals which kill the insects. The term pesticide is a broad group which contains chemicals used to kill a wide range of pests. These may be **Acaricide** (for the control of mites and ticks), **Algicide** (for killing algae and other aquatic vegetation), **Bacteriacide**(bacteria)**fungicide**(fungi)**herbicide**(weeds)**nematicide**(nematode)**rodenticide**(rodents)

Chapter-1.

POLYPHAGOUS PESTS

There are many **polyphagous** pests which damage a number of crops and cause substantial losses. Important polyphagous pests are as follows :

1. **Desert locust, *Schistocerca gregaria*, Bombay locust, *Patanga succincta* Linnaeus, Migratory locust, *Locusta migratoria*(Linnaeus).**

Orthoptera : **Acrididae**

2. ***Hieroglyphus banian* (Fabricius) and *H. nigrorepletus* Bolivar , Orthoptera: Acrididae ,**

3. **White grub, *Holotrichia consanguinea* blanch., Coleoptera : Scarabaeidae**

4. **Red hairy caterpillar, *Amsacta moorei* (Lepidoptera: Arctiidae)**

5. **Termite , *Odontotermus obesus* and *Microtermus obesi* , Isoptera : termitidae**

LOCUSTS

The larger grasshoppers which form swarms are called locusts and there are three species of the family Acrididae found in India.

(i) Desert locust, *Schistocerca gregaria* (Forsk.) (ii) Bombay-locust, *Patanga succincta* Linnaeus (iii) Migratory locust, *Locusta migratoria*(Linnaeus).

Of these, the desert locust is the most important. There are very few records of swarms involving other locusts, particularly of the migratory

locusts. The first and second species are important in Maharashtra, Gujarat and Rajasthan but the **desert locust is of all India importance. In fact, it is an international pest** and efforts are being made constantly to control it through the International Locust Control Organization of the Food and Agriculture Organization.

Desert locust, *Schistocerca gregaria* (Forsk.) (Orthoptera : Acrididae)

The desert locust is found in two phases, i.e. the solitary phase and the gregarious phase. Individuals having characteristics in between the two are often placed under the transient phase. The nymphs of the gregarious phase are yellow or pink, with distinct black markings, whereas the color of the solitary hoppers varies according to the color of the surrounding vegetation. The gregarious adults are pink on emergence, gradually turning grey and ultimately yellow, when sexually mature. The adults of the solitary phase remain greenish grey throughout their life.

Life cycle: A single female may lay up to **11 egg-pods**, each pod containing up to **120 eggs**. A female normally lays **500 eggs in about 5 pods**. Before egg laying the female, with the help of her ovipositor, bores a hole into the loose sandy soil, **5-10 cm deep**. Having laid a pod, she **secretes a frothy material over**. The eggs, which hardens on drying and makes the pod water-proof while laying eggs, the females may be

sitting very close to one another and as many as 5,000 eggs may be laid one square meter.

The **egg, resembling grain of rice**, is lightly curved and 79 mm long. The duration of the egg stage depends upon the soil conditions, temperature and moisture. **The eggs laid in February and March hatch in 34 weeks and those laid in May-September hatch in 12-15 days.**

The nymphs, at the time of emerging, break the egg-shell and creep out of the holes. **The duration of the nymphal (hopper) stage lasts 6-8 weeks in spring and 3-4 weeks in summer.**

Damage:

The locust is harmful in both the hopper and the adult stages. These gregarious and voracious feeders eat almost any vegetation, except a few plant species such as vegetation, **except a few plant species** such as **ak (Calotropis procera), dharek (Melia azedarch), neem (Azadirachta indica), dhatura (Datum stramonium)**, etc. When in swarms, they can consume all the green vegetation and cause a famine. In addition to the damage to **crops, orchards, forests, etc.**, the locust can be **nuisance in houses, as these creatures climb over the walls, invade kitchens, storerooms and even enter into the beds. They fall into wells** by the million and thus **make water unfit for drinking** If an army of hoppers or **adults marches on to the railway lines, all traffic is suspended because the crushed hoppers cause slippery rails.**

Management: Management operation can be carried out against all stages of the locust, the most practicable and effective measures are against the nymphs.

Eggs. If **eggs are laid in a well-defined area**, a trench may be dug around it, so that the young nymphs on emerging drop into it and can be buried alive, filling the ditch with soil. If these **trenches are heavily dusted with lindane**, it may not be necessary to bury the nymphs.

Nymphs. The hopper stage is the most vulnerable and control measures are most effective before the second moult. The nymphs may be destroyed either with chemicals or by using mechanical methods: (i) The principal mechanical method of control lies in **digging trenches in front of the moving army of nymphs** and driving them into these trenches, with brooms or with twigs of trees and then, buried alive. The nymphs can also be guided to the trenches along metal or canvas barriers 45 cm high. Two barriers, one, on each side of the army of the marching hoppers are so fixed that they converge on a narrow gap that leads to a trench in which they drop. The trench should be deep enough to accommodate a large number of hoppers most of which would then die under the weight of their own fellow creatures. Later, the trench can be filled with earth. In the early stages, a trench 30-45 cm wide and 60 cm deep, is sufficient but when the hoppers are older, the width should be 57 cm and the depth more than 60 cm. (ii) **At night** when the **hoppers rest on bushes**, they can be **burnt with flame-throwers**. (iii) **Poison**

baits such as the poisoned bran or sawdust, if scattered in the early morning or in the evening, are effective. During day, the bait dries quickly so the hoppers do not eat it. **The poison used is a sodium fluosilicate or Paris green.** (iv) **Lindane dust and lindane spray (0.2%) are very effective.** (v) Lindane as a spray can also be applied shortly before the emergence of the hoppers, so that as soon as they come out, they come into contact with the insecticide and die. (vi) **Spraying the crop with neem seed kernel powder suspension (1%) has been found to be very promising.** (vii) A number of birds attack locusts and of these, the common mynah and the tiliar (starling) are the most important. During the locust cycle, if practicable, these birds should be protected.

Adults (i) **The adults can be beaten to death with thorny sticks, brooms or can be swept together and buried underground in heaps.**

(ii) **Lindane 2 per cent**, if dusted on crops, trees and the ground, is very effective. (iii) **Lindane (2%), in an oil medium**, is also effective _ when sprayed with an aeroplane on top of a flying swarm. Lindane 20 EC in water suspension can also be sprayed on locusts, on the ground.

Anti-Locust Organization. The Anti-Locust Organisation in India consists of (a) The Central AntiLocust Organization, and (b) the State AntiLocust Organizations.

(a) Central AntiLocust Organization. **This organization is handled by the Plant Protection Adviser to the Government of India, who is also**

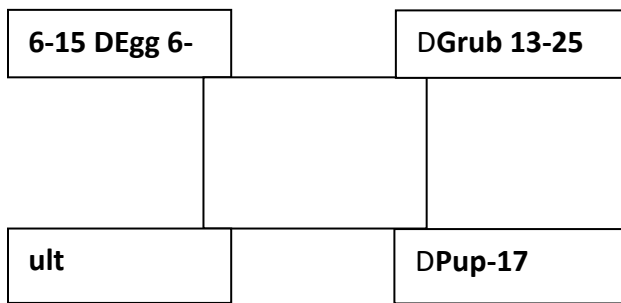
the Director of Locust Control, having his headquarters at Faridabad (Haryana). The Directorate is required to:

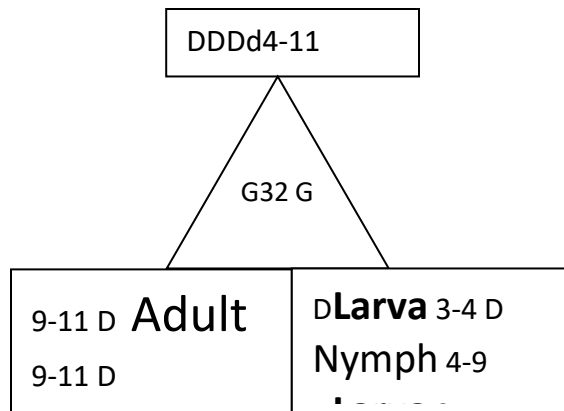
- Record the weekly density of locusts per unit area in the breeding areas located in India and to carry out control operations there.
- Interpret the records and pass on the information on locust movements to the various State Locust Control and Warning Officers and to the revenue authorities of the concerned districts before the locust reaches there so that arrangements for control can be made in advance.
- **Keep watch on the coming swarms** of extra-Indian origin, their direction and size. * Give technical and material assistance to the various States.
- **Coordinate the Antilocustwork in India** by issuing a fortnightly bulletin on the locust situation both in India and in foreign countries.

In India, the work of this organization extends both to the scheduled desert areas where locusts breed and to the cultivated areas where they do the damage.

In the scheduled desert areas, the Central Anti-Locust **Organization operates over an area of 2,05,785 square kilometers** in the States of **Rajasthan, Haryana, Maharashtra and Gujarat**. This area is **divided into 10 zones** which are grouped into **4 circles with headquarters at Bikaner, Jodhpur, Barmer and Palanpur (Gujarat)**. The responsibility of the control work is entrusted to the Locust Entomologist in charge of the circle.

(b) **State Anti-Locust Organization** In the scheduled area of the desert as well as in the adjoining States where locusts cause damage; there are State Anti-Locust Organizations to take suitable measures against the swarms. The State organization is headed by the Locust Control and Warning Officer, who is well connected with the local revenue authorities, from the Deputy Commissioner to the Tehsildar and Patwari. When the latter official receives information from district headquarters warning him of a locust invasion; he alerts the villagers to be ready with machines and insecticides, kerosene, flamethrowers, spades, etc. When the swarm actually arrives, the farmers try to kill it as well as they can and then the Patwari intimates the Locust Control Officer and his own Deputy Commissioner of the extent of success achieved. In case the swarm settles down to lay eggs, the Locust Control Officer or his staff visits the place to devise suitable control measures.





White grub, *Holotrichia consanguinea* blanch., Coleoptera : Scarabaeidae

Hindiname : Safed gidar

Scientific name : *Holotrichia consanguinea* blanch.

H. serrata fabr.

Anomala bengalensis blanch.

Order : Coleoptera.

Family : Scarabaeidae.

Host plants.

White grub is a **polyphagous** pest and feeds on almost all the kharif crops like, jowar, bajara, maize, groundnut, sesamum, sunflower, chillies, cotton, sugarcane, tobacco, brinjal, cucurbits, and bhindi.

Distribution : This is a **cosmopolitan** pest and attained a status of **major pest** in the states like **Rajasthan, Gujarat, Maharashtra, Karnataka, Tamilnadu, Bihar, U.P. and Orissa.**

Mark of identification :

The insect appear as a pest of groundnut in 1957 in the Gujarat state. The adult beetls are dull brown ,couper coloured and measure about 18 mm in length and 7 mm in width. The fully grown grub is curved **C-shaped and dirty white in colour**. Its posterior abdomen is shiny black devoid of folds through which intestinal contents are visible. The **head is dark brown with strong mandibles and prominent thoracic legs.**

Life history

The life cycle of this pest passes through the following four stages viz, **egg, grub, pupa, and adult**. With the **onset of monsoon** the beetles emerge from the soil at dusk (**7.30 to 8.00**). The eggs are generally laid singly in **loose soil** or in an earthen cell inside the soil up to the depth of **10 cm**. the eggs are oval, creamy white when fresh and later turn to brown in colour. The number of laid by a female may vary from **30-120**. The **hatching** period varies from **7-10 days**. The newly hatched grub is creamy white and they feed on organic matter. There are **three larval instar** of this pest. The fully grown grub is curved **C-shaped and dirty white in colour**. Its posterior abdomen is shiny black devoid of folds through which intestinal contents are visible. The **head is dark brown with strong mandibles and prominent thoracic legs**. The **total larval** period varies from **8-10 weeks**. The grub construct an earthen cell in which it passes a quiescent **pre pupal** stage which lasts for **one to 6 weeks**. The **freshly formed pupa** is **light yellow** and extremely tender, but as it grows older it **turn brown**. It is of excrete pupa i.e. the appendages are free from the body. The **pupal duration ranges from 14 day**. The freshly formed beetle is **cream coloured** but mature beetle has brown colour and elytra gets hardened. Generally the adults male are smaller than the females. The adult beetles remain in soil until the next years of summer rains. The total life cycle is completed from **90-108 days** and all the known species in india have one generation in a year.

Nature of damage.

The losses are caused by the **grub and the beetle**, the grub feeds on fine **rootlets, nodules** in case of leguminous crops and then girdles of the main root whereas the adult feeds on **shrub and tree** growing nearby the cultivated fields. The plants damaged by the grub gives a **wilted** appearance and finally **dries out**, while in case of **beetles** the attacked plant get **defoliated**. In case of severe grub infestation the entire crop is destroyed.

Control

1. The use of **light trap** is the successful method for the collection of beetles during emergence in the night in rainy season.
2. **Seed treatment** with following insecticides will reduce the attack of white grub, **Chloropyrifos** 20 EC @ 20ml/kg, **Imidacloprid** 17.8 sl @ 3 ml/kg, **Clothilidin** 50 wp @ 2 gm/kg and **Fipronil** 5 g @ 5gm/kg seeds.

3. The repeated **ploughing**, preferably soon after the summer rains, helps in exposing the various stages of the white grub to their natural enemies.
4. **Anisol (methoxy benzene)** attractants sponge @ three sponge(dipped in 3 ml) / tree. Tree must be treated with monocrotophos 0.04%.
5. The followings are are microorganism/ organism which are found parasiting the grub,
 - (A) *Bacillus thuringiensis*
 - (B) *Bacillus popillae*
 - (C) *Beuveria bassiana*
 - (D) *Aspergillus parasiticus*
 - (E) The grub is parasitized by *Scolia aureipennis*. A fungus , *Mettarrhizium anisopliae* parasitized the adult and the common Indian toad, *Bufo melanostictus*, and the wall lizard , *Gecko gecko* feeds on the beetles.
6. In standing crop white grub can be control with the following insecticides, **Imidacloprid** 17.8 sl @ 75 ml, or **Qunalphos** 25 EC @ 1.0 lit per Bigha with irrigation water can be applied.
7. The adult beetles can successfully be controlled by treating the trees with the following insecticides. **Monocrotophos** 36 wsc @ 25 ml or **Qunalphos** 25 EC @ 36 ml or **Carbaryl** 50 per cent @ 720gm/ 18 lit of water.

TERMITES

The termites, commonly called **white ants**, are among the common insect pests belonging to the **order Isoptera**.. They live in large communities, mostly in underground nests and are familiar because of their depredations. They make small **earthen mounds** or earthen passages that are visible above the ground. On opening a portion of an earthen passage, **grayish white**; Wingless insects are seen moving towards or away from the center of their nest, where the queen of the colony resides. They belong to many families and their nesting behavior is characteristic of every group.

The following **four families** of the order, Isoptera, are economically important, (i) **Kalotermitidae** (exclusively inhabit dead, dying and living wood, have no connection with the soil e.g. **Neotermes**, (Cryptotermes); (ii) **Hodotermitidae** (live In arid zones of India, attack grasses and stored grains, live and breed wholly underground, e.g. **Acanthotermes**); (iii) **Rhinotermitidae** (largely subterranean, some invade wood works in buildings, e. g **Heterotermes**, **Rhinotermes**, **Captotermes**, **Reticulotermes**); and (iv) **Termitidae** (largest and

economically most important, both under and above ground dwellers, e.g. **Odontotermes, Microtermes, Hypotermes, Nasutitermes**).

The termites are **social insects** and their colony organization is based on a. In a colony, there are numerous **workers**, lots of **soldiers**, one **queen**, a **king** and a good number of **complementary or the colonizing** forms of true but immature males and females. The various castes and their duties are described as under.

A. Productive Castes

1. **Colonizing individuals.** These are **winged individuals of both sexes** and are produced in large numbers during the rainy season. When the temperature and moisture conditions are optimum, they emerge from the parent colony and hover over street lamps early in the evening, usually after a shower of rain. The wings are meant for the **nuptial flight** only and when they have mated, the **wings usually drop** off. Most of the **winged insects are eaten up by frogs, lizards and snakes**. A pair that happens to escape may start a **new colony** in a crevice in the soil as the queen and the king of a colony. To start with, they themselves attend to the foraging and other duties which, later on, are performed by the workers.

2. **Queen.** This is the only **perfectly developed female in the colony**. She develops either from colonizing individuals described above or from the Wingless forms (complementals) present in an established colony. She attains a much larger size when developed from the former caste. Her reproductive system occupies almost the entire abdomen. **She is a phenomenal “egg-laying machine”, laying one egg per second or 70,000-80,000 eggs in 24 hours. There is only one queen in a colony and normally she lives from 5 to 10 years. The queen is fed by the workers on the choicest food, and is housed in a special area referred to as the ‘royal chamber’ which is situated in the centre of the nest, at depth of about 0.5 meter below the ground surface.**

3. **King.** A **king develops from an unfertilized egg** and becomes fully developed by consuming a superior diet. He is the father of the colony and is a constant companion of the queen, living with her in the **‘royal chamber’**. He is much **smaller than the queen** and is slightly bigger than the colonizing individuals. He **mates with the queen** from time to time and, thus, aids her in laying fertilized eggs from which the colonizing forms and workers develop. The **king’s life is much shorter** than that of the queen and, when he dies, he is replaced by a new one.

4. **Complementary castes.** They are **short-winged or Wingless creatures of both sexes** and lead a subterranean life. In the event of the **untimely death of the king or queen in a colony, the complementary castes replace them** they are induced by the workers to undergo sexual development.

B. Sterile Castes

5. **Workers.** The **workers develop from the fertilized eggs but remain stunted as they are reared on ordinary food.** Numerically, **they are the most abundant in a colony** but are smaller than the soldiers. Except for the reproduction and defense of the community, practically **all other duties are performed by the workers they take care of the eggs and the young ones and remove them to safe places at the time of danger. They also tend and feed the queen, collect food and cultivate a fungus food (ambrosia) in underground gardens.**

When a new colony is established, the earlier broods of workers construct a hemispherical chamber for the queen and it IS connected with innumerable galleries. **In certain species, the workers also construct a high mound above the ground, which is known as the termitarium.** Since the workers have to collect all provisions for the colony, they are notoriously destructive.

6. **Soldiers.** The soldiers develop from **unfertilized eggs and remain comparatively underdeveloped.** They are the most specialized members of the community and can be readily recognized by the large head and strongly **characterised sickle-shaped mandibles.**

Life-cycle. In the rainy season when atmospheric conditions are favorable, the **colonizing forms leave their parent colony.** As they are weak fliers, they do not travel a long distance unless aided by wind. As a rule, a particular species_ swarms at about the same time of season. The members of the swarm comprise individuals of both sexes. They are attracted to light where they mix with individuals of the neighboring swarms. A great majority of them fall prey to many types of predators and only a few individuals survive in the end. Sooner or later the survivors fall down and cast their wings and mate before or after shedding them. Both the male and female participate in the early operations of forming a nest by excavating small burrows or galleries or the nuptial chambers. In the beginning only a few eggs are laid and are looked after by them and the newly hatched nymphs are fed by the parents themselves. They develop into Workers and then take over all the brooding. During the first season, the reproductive castes are usually not produced. Gradually, the queen grows in size and the number of eggs laid increases.

The eggs hatch after one week during the summer and within 6 weeks the larvae develop to form soldiers or workers, as the case may be. **The reproductive castes when produced, mature in 1-2 years. The queen** is capable of laying many millions of eggs during her life, which is very difficult to estimate, **but probably 6-9 years is the approximate span.** The nests of many termites grow fungus gardens in the center, near about the 'royal chamber'. The fungus grows into a comb like structure and is fed to the royal pair and the larvae.

Damage. The **termites live on cellulose** which they obtain from dead and living vegetable matter to obtain their food, they destroy **wood-work, household articles, fences and wooden poles** that come into contact with the soil. They also damage **fruit and shade-trees, crops** such as sugarcane, chillies, wheat and peas.

Management of Termites

1. When a colony is established, it is not so easy to eradicate the pest. The only sure method is to reach the center of the nest and kill the queen and the complementary forms. **Since the termite tunnels run for hundreds of meters,** it the wood and in the crevices is the only remedy. For a lasting relief the nests should be located in the vicinity and **destroyed by flooding them with the insecticide emulsions.**

2. To avoid the attack of white-ants in cultivated fields, care should be taken not to **use green manure or raw farmyard manure.**

3. Insecticidal control

(a) Fruit trees

(1) In new plantations, **the pits should be treated with 0.2 per cent lindane** emulsion or crude-oil emulsion before planting the trees. This is done by thoroughly mixing 0.25 kg of crude-oil emulsion and a little arsenic in about 4 baskets of subsoil taken from the pit. The treated soil is returned to the pit.

(2) To protect the tree trunks, spraying them with **1 per cent lindane** is effective.

(3) To protect the roots, **0.5 per cent chlorpyrifos** or lindane or 3 per cent sanitary fluid in the irrigation basin should be applied.

(b) Field crops

(i) For protecting chillies in small plots, 3 per cent sanitary fluid should be applied to the soil. When large areas are to be treated, the sanitary fluid is put in a canvas bag at the rate of 25-35 liters per hectare. The bag is suspended in the irrigation channel.

(ii) Soaking the sugarcane setts in **0.5 per cent lindane/chlorpyrifos suspension or 0.25 per cent lindane/chlorpyrifos** emulsion in furrows at the time of planting, saves them from termite attack.

(iii), Wheat seed treatment before sowing, with **160 ml emulsion of chlorpyrifos in one liter of water spraying on thinly spread out 40 kg seeds with a water emulsion of chlorpyrifos 20EC** remains effective for the crop season. Termite damage in standing wheat crop can be minimized by application of **5 liters of lindane 20EC per hectare into irrigation water or field spreading of one liter of lindane 20EC** .mixed with sand or soil, followed by light irrigation.

(3) Buildings

(i) A **galvanized sheet of iron** with its outer edge turned downwards when placed just above the damp-proof layer makes the house white-ant-proof. Wooden structures such as **doorframes should not directly touch the ground and should be raised on a cement layer.**

(ii) **An insecticidal barrier between the ground and woodwork in building should be made by treating the soil beneath the building and around foundations with 0.5 per cent chlorpyrifos or lindane. The solution should be applied at the rate of 5 liters per m².**

4. **To protect wood-work, paint it with solignum.** The cupboards, almirahs, shelves, etc. should be sprayed with lindane or chlorpyrifos frequently. The place from where the galleries originate in the house should be either sprinkled over or injected with 0.5 per cent lindane or chlorpyrifos suspension in water. If wooden structures have already been attacked the injection of 0.5 per cent lindane or chlorpyrifos emulsions with a hypodermic needle into the wood and in the cervices is the only remedy.

5. **Mounds of termite, if any, in the area should be treated with 0.5 per cent chlorpyrifos or lindane after breaking open the earthen structure, and making holes with an iron bar.** The insecticidal emulsion should be used at the rate of 4 liters per m of the mound.

HAIRY CATERPILLARS

Red hairy caterpillar, *Amsacta moorei* (Lepidoptera: Arctiidae)

The red hairy caterpillar or **kutra** is widely distributed in the Orient, including India. It is a *polyphagous* insect and **feeds on all kinds of vegetation growing during the Kharif** season.

Its attack is particularly serious on **sunhemp, maize, sorghum, glwra, mung, math and sesamum.**

The moths are **stoutly built** and have **white wings with black spots.** **The outer margins of the fore wings, the anterior margin of the thorax and the entire abdomen are scarlet red.** **There are black bands and dots on the abdomen.** The full grown caterpillars are **reddish-amber to olive green** and the **body is covered with numerous long hairs arising from the fleshy tubercles.**

Lifecycle. **The female moths lay light-yellow spherical eggs in clusters of 700-850 each on the under surface of the leaves of host plants.** A single female may lay up to **1,500 eggs, which hatch in 2-3 days.** The young caterpillars **feed gregariously** and, as they grow older, they march in bands destroying field after field of various kharif crops. The caterpillars grow through **six stages and complete their development in 15-23 days.** They enter the soil, shed their hair and make earthen cocoons at a depth of about 23 cm. **Here they pupate and remain in this stage for many months till they emerge next year from the cocoons.** In a given population, probably **more than one generation is completed in a year.**

Damage. The young kutra caterpillars prefer to eat the growing points of plants. The older ones have no such discrimination and they **feed voraciously on all vegetation resulting in disaster.** **Field after field is devastated by the moving army of caterpillars.**

Management. (i) The moths are strongly **attracted to artificial light.** Therefore, **light traps** of electric or **petromax lamps** placed just above a broad flat basin full of **kerosenized water,** should be put on the night following the first shower of the monsoon and continued throughout the period of emergence for about one month. (ii) Young larvae can be destroyed by pulling out the infested plants and burying them under-ground. (iii) The grown up caterpillars may be **destroyed by crushing them under feet or picking and putting them into kerosenized water.** (iv) **In case of serious attack, spray 1.25 litres of endosulfan 35EC or quinalphos 25EC or 500 ml of dichlorvos 76EC in 500 litres of water per ha or dust 35 kg of trichlorphon 5% cent dust per ha.**

RICE GRASSHOPPERS

Hieroglyphus banian (Fabricius) and *H. nigrorepletus* Bolivar , Orthoptera: Acrididae) ,

Distribution. Rice grasshoppers are **sporadic pests of rice** distributed throughout India.

Identification. *H. banian* and *H. nigrorepletus* are somewhat like locusts but are smaller. The adults are **40-50 mm long** and are **shining greenish yellow**, having **three black lines running across the pronotum**. Nymphs are yellowish, with many reddish brown spots in the early stages, but become greenish as they grow older.

Life-history. *Hieroglyphus spp.* have one generation in a year and pass the winter and dry part of summer in the egg stage. The eggs are found on bunds in the soil during October-November and they hatch in June or in early July (Hatching period 9-10 month), a few days after the first shower, of the monsoon. On emergence, the nymphs start feeding actively and complete their development in seven stages, within 10-14 weeks. The adults are seen feeding voraciously during August and September. When they are two months old, they mate. The female starts laying eggs by inserting her abdomen in the soil. The eggs are laid 5-8 cm deep, in pods, each containing 30-40 eggs. The egg-laying continues from September to November and the adults die soon after, sometime in the winter.

Host plants. They are polyphagous and feed on leaves of rice, maize, mil-lets, sugarcane, grasses, sunhemp, arhar.

Damage. The greatest amount of damage is caused during August-September. When both adults and nymphs feed on paddy and other crops, causing defoliation. In certain years, they cause extensive damage, moving from field to field over large areas.

Management. Trim the bunds. Dust carbaryl 10 per cent or Malathion 5 percent @ 25 kg per ha, quinalphos 1.5% ha, and malathion 50 EC 500-800 ml per ha.

2. Bihar hairy caterpillar, *Spilarctia obliqua* Walker (Lepidoptera: Arctiidae)

Chapter-2.

RICE (*Oryza sativa*, Family: Gramineae)

More than **100 insect** species are associated with the rice crop at one stage or the other and 20 of these are pests of major economic significance. The following are the pests of rice crop.

1. **Brown plant hopper, (*Nilaparvata lugens*) (Hemiptera: Delphacidae)**
2. **Yellow stem borer (*Scirpophaga incertulas*) (Lepidoptera; Family - Pyralidae)**
3. **Rice hispa, (*Dicladispa armigera*) (Coleoptera: Chrysomelidae)**
4. **Pink borer (*Sesamia inferens*) (Lepidoptera : Noctuidae)**
5. **Rice leaf-folder (*Cnaphalocrocis medinalis*) (Lepidoptera: Pyralidae)**
6. **Rice gall midge, (*Orceolia oryzae*) (Diptera: Cecidomyiidae)**
7. **Whitebacked planthopper, (*Sogatella furcifera*) (Hemiptera : Delphacidae)**
8. **Green leafhoppers, (*Nephotettix nigropictus*) and (*N. virescens*) (Hemiptera: Cicadellidae)**
9. **Paddy root weevil (*Echinocnemus oryzae*) (Coleoptera : Curculionidae)**
10. **Rice bug (*Leptocorisa acuta*) (Hemiptera : Coreidae)**

1. **Brown plant hopper, (*Nilaparvata lugens*) (Hemiptera: Delphacidae)**

The brown plant hopper is the most destructive pest of rice in South and South-east Asia, China, Japan and Korea. In India, it has become very serious on the **high-yielding varieties** of paddy in many States including Uttar Pradesh, Madhya Pradesh, West Bengal, Andhra Pradesh and Tamil Nadu. Both adults and nymphs feed on paddy, sugarcane and grasses by sucking the cell sap. The brownish adults with brown eyes are 3.5-4.5 mm in length. The **nymphs are brownish-black** in colour and have **greyish-blue eyes**.

Life cycle

The females start laying eggs within 3-10 days of their emergence and deposit eggs in masses, by **lacerating the parenchymal tissue**. The number of eggs per mass varies from 2 to 11 and a female lays, on an average, **121 egg-masses**.

The eggs are somewhat **dark and cylindrical**, having two **distinct spots**. The **incubation period ranges between 4 to 8 days**. The nymphs, on emergence, start feeding on young leaves and after **moulting 5 times**, become adults **in 2-3 weeks**. The total cycle is completed in **18-24 days**.

Damage

Both the nymphs and adults cause damage by **sucking cell sap from the leaves** which **turn yellow**. If the insect **attacks** during the **early stages of growth**, the **entire plant may dry up**. The population increases very rapidly and the rice fields start drying up in patches known as **'hopperburn'**. The **loss in yield** may range from **10 to 70 per cent**. This insect is known to transmit the **grassy stunt virus** disease of rice.

Management

- (i) **Closer spacing of 15 x 10 cm creates favourable** microclimate in field for rapid development of hopper population. Hence, a spacing of **20 x 15 cm should be followed**.
- (ii) **Alternate drying and wetting** the field during peak infestation, and **draining out the standing water** from the field **2-3 times** checks the population of the hopper to a large extent.
- (iii) Three releases of **mirid bug, *Cyrtorhinus lividipennis* Reuter @100 bugs or 50-75 eggs/square meter at 10 day intervals have been found effective** for the control of brown planthopper. The presence of **3 predatory spiders, *Lycosa pseudoannulata* (Bosenberg & Strand), per hill** has been found to check the population of the pest.
- (iv) **Spray at economic threshold level of 5-10 insects per hill**, 100 ml of **imidacloprid 200SL**, **625 g of carbaryl 50WP** or **625 ml of fenthion 1000EC** or 2.0 litres of **quinalphos 25EC** or **2.5 litres of chloropyriphos 20EC** or 1.4 litres of **endosulphan 35EC** or **1.4 litres monocrotophos 36SL in 250 litres of water per ha**. Repeat application if hopper population persists beyond a week after application. **While spraying, nozzle should be directed at the basal portion of the plants**.

2. Yellow stem borer (*Scirpophaga incertulas*) (Lepidoptera; Family - Pyralidae)

The yellow stem borer is a **specific pest of rice** and is common in all the Asian countries. The **caterpillars** alone are **destructive** and, when full-grown, they measure about **20 mm** and are **dirty white or greenish yellow, having brown head and pronotum**. The **adults** have a **wing** **expanse of 25-45 mm** and are **yellowish white with orange yellow front wings**. The **females** have a **prominent tuft of brownish yellow silken hair at the tip of their abdomen**. The **female moth is bigger than the male** moth and has a **centrally situated black spot on each of the forewings**.

Life-cycle

In the northern regions of India, this pest is **active from April to October** and **hibernates from November to March** as a full-grown **larva in rice stubble**. The pupation starts sometimes in March and the emergence of moths begins in April. The moths become active after dusk when they mate and lay about **120-150 eggs on the underside** of the leaves in **2-5 clusters of 60-100 eggs each**. The **eggs** are covered with **yellowish brown hair** of the female tuft. They **hatch in 6-7 days** and the **tiny black-headed caterpillars soon bore into the stem from the growing points downwards**. The **larva** grows in **6 stages** and is full fed in **16-27 days**. It then **constructs an emergence hole which is always located above the water level and pupates inside the attacked plant**. Within **9-12 days (pupa)**, it emerges as a moth. The **life cycle** is completed in **31-46 days**. There are **3 broods in Bengal, 2 in Orissa, 4-5 in Punjab, Andhra Pradesh and Tamil Nadu**.

Damage

The larva feeds inside the **stem causing drying of the central shoot or 'deadheart'** in young plant and drying of the **panicle or 'white ear'** in older plant. **Basmati varieties suffer heavy damage** than coarse varieties.

Management

The **removal and destruction of stubbles** at the time of the **first ploughing after harvesting** the crop decreases the carry-over to the next crop. (2.) **Ploughing and flooding** the field is also effective in **killing the larvae**. (3.) Since the **eggs** of stem borer are **laid near the tip of leaf, clipping of tips of seedlings before transplanting** can reduce the carryover of eggs to the field. (4.) **Inundative releases of *Trichogramma japonicum* Ashmead @ 50,000 ha. during**

egg laying period of rice stem borer reduced borer damage and increased yield. (5.) The fields showing more than **5 per cent deadhearts** should be sprayed with **875ml of triazophos 40EC** or **2 litres of quinalphos 20AF** or **1.4 litres of monocrotophos 36SL** or **2.5 litres of chlorpyrifos 20EC in 250 litres of water per ha**. Alternatively, apply 19 kg cartap hydrochloride 4G or 18.75 kg of carbaryl + gamma HCH4G (Sevidol 4G) or 7.5 kg of phorate 10G or 20 kg carbofuran 3G or quinalphos 5G or 15 kg of fipronil 0.3G or 10 kg of chlorpyrifos 10G per ha in the standing water in the field. Same chemical should not be used repeatedly.

3. Rice hispa, *Dicladispa armigera*, Coleoptera : Chrysomelidae

Rice hispa is distributed throughout India but often **serious on young rice crop** in parts of Andhra Pradesh, Tamil Nadu, West Bengal, Punjab, Haryana and Himachal Pradesh.

The **adult is a small bluish black beetle measuring 5 mm in length** and is recognized by **numerous short spines on the body**. The **legless, creamy-white larvae are not easily seen, because they are concealed inside the leaf tissue**.

Life-cycle

The **eggs are embedded in the leaf tissue towards the tip**. On hatching, the young **grubs feed as leaf-miners, between the upper and lower epidermis**. The **attacked leaves turn membranous, showing characteristic blisters or blotches**. Later on, the **attacked leaves wither and die**. When the larvae are full-grown, they pupate inside and finally emerge as black beetles. The insect passes through about **six generations in a year**.

Damage

Apart from the damage caused by **larvae as leaf-miners, the adults also feed on green matter and produce parallel whitish streaks on the leaves**. The damage starts in **nurseries and spreads to the rice fields**. The **infestation varies from 6 to 65 per cent**.

Management

- (i) The pest is suppressed if the **infested leaf tips are clipped off and destroyed, while transplanting**.
- (ii) If the **nursery beds are flooded, the beetles float and can be swept together with brooms and then destroyed**.

- (iii) Spray at **economic threshold level**(1 adult or 1-2 damaged leaves per hill) with **300 ml of methyl parathion 25EC** or **625 ml of fenitrothion 50EC** or **chlorpyrifos 20EC** or **2.5 litres of lindane 20EC** in **250 litres of water per ha**. If the attack continues, repeat spray after two weeks.

Chapter-3.

SORGHUM (*Sorghum bicolor*, Family: Gramineae)

More than **150 species** of insects have been reported to damage sorghum. However, over a dozen species are very serious and constitute a major constraint in sorghum production.

1. Sorghum shoot fly (*Atherigona soccata*) (Diptera : Muscidae)

2. Sorghum earhead bug, (*Calocoris angustatus*) (Hemiptera:Miridae)

3. Sorghum shoot bug, (*Peregrinus maidis*) (Hemiptera : Delphacidae)

4. sorghum midge, *Contarina sorghicola* (Diptera : cecidomyidae)

5. stem borer, *Chilo partellus* (Lepidoptera : pyralidae)

6. Pink borer, (*Sesamia inferens*) (Lepidoptera : Noctuidae)

7. aphid, *Rhopalosiphum maidis*, (Hemiptera : Aphididae)

8. Leaf hopper, *Pyrilla perpusilla* (Hemiptera : Lophopidae)

9. Hairy caterpillar, *Amsacta moorei* (Lepidoptera : Arctiidae)

10. white grub, *Holotrichae consanguinea* (Coleoptera : scarabaeidae)

11. whitefly, *Neomaskellia bergii* (Hemiptera : Aleyrodidae)

1. Sorghum shoot fly (*Atherigona soccata*) (Diptera : Muscidae)

The sorghum shoot fly, also known as the **sorghum stem fly**, is a widely distributed pest in Europe, Africa and Asia. In India, it is more serious in southern parts. Besides **sorghum**, it infests **maize, wheat, broom corn, small millets** (*Panicum spp.*) and **grasses**.

Life-cycle

The female fly lays approximately **40 eggs singly on the underside of the leaves** during its life span of about one month. The **eggs hatch in 1-2 days** and the tiny maggots creep out and reach in between the sheath and the axis, and bore into the stem.

They feed (**maggot**) inside the main shoot for **6-10 days** and, when full grown, they may **pupate** either **inside the stem** or come out and pupate in the **soil**. The **pupal period** in the **summer** lasts **about a week**. **Several generations** are completed in a year. In northern India, the **pest over-winters in the pupal stage**.

Damage

The insect attacks the young crop when it is in the **six-leaf stage**. As the maggots feed on the main shoot, the growing point is destroyed and by the time they pupate, the plant is almost dead. The young plants show typical **dead-heart** symptoms. When the attacked plants are somewhat older, tillers are produced, which mature later than the main crop. The total loss in yield is sometimes as high as **60 per cent**.

Management

- (i) Seed coating with imidacloprid 600 FS @ 15 ml per kg seed or isofenphos 5G @ 30 g per 100 g seed provides protection against shoot fly upto 2 weeks.
- (ii) In case seed treatment has not been done; apply 12.5 kg of carbofuran 3G, 10 kg of phorate 10G/ha, in furrow before sowing (iii) spray 1.25 litres of malathion 50 EC or 2.0 kg cararyl 50 WP in 500 liters of water/ha.

MAIZE (*Zea mays*, Family : Gramineae)

More than 130 insects have been recorded causing damage to maize in India. Among these, about half a dozen pests are of economic importance.

1. Maize borer, (*Chilo partellus*) (Lepidoptera: Pyralidae)

It is the most destructive pest of maize and sorghum in Sri Lanka, India, Pakistan, Afghanistan, Uganda, Central and East Africa. It is found throughout India. This insect has also been recorded on **bajra** (*Pennisetum typhoides*), **sugarcane**, Sudan grass, **baru** (*Sorghum halepense*), **sarkanda** (*Saccharum munja*) and some other **grasses**. The grown up **caterpillars**

are about **20-25mm** long and **dirty greyish white**, with **blackhead** and **four brownish longitudinal stripes on the back**. The adults are **yellowish greymoths**, about **25 mm** across the **wings** when spread.

Life-cycle

The **eggs** are laid in **clusters of 50-100** in rows on the **undersurface of the leaves** during **April-May**. A female lays over **300 eggs** during its life-span of **2-12 days** and the eggs hatch in **4-5 days** in **summer**. The young **larvae first feed on the leaves**, making a **few shot holes** and then **bore their way downward through the central whorl as it opens**. The **larva becomes full-fed in 14-28 days**, **passing through six stages** and **after making a hole in the stem pupates inside it**. The **life-cycle** is completed in about **3 weeks** and there are probably **5 generations** in a year. The full-grown **caterpillars of the last generation hibernate in stubble, stalks, etc., and remain there till the next spring**.

Damage

The **damage** is done by the **caterpillars by feeding inside the stem** and producing '**deadhearts**'. About **25-50 per cent of the plants are destroyed**.

Management

- (i) The potential for carry over may be reduced by **destroying the stubble, weeds and other alternate hosts of the stem borer by ploughing the field after harvest**.
- (ii) **Removal and destruction of dead-hearts** and destruction of **infested plants showing early pin-hole damage** has been found to be successful practice in reducing the pest incidence.
- (iii) **Destruction** of crop residues and chopping of stems **harbouring diapausing larvae** be very effective in reducing borer population.
- (iv) **Release** laboratory bred adult populations of *Trichogramma spp.* at the first sight of egg masses of maize borer and synchronize the release of *Apanteles sp.* or *Microbracon sp.* adults with the larval development.
- (v) (a) **Spray** the crop **2-3 weeks after sowing** or as soon as borer injury to the leaves is noticed with any of the following synthetic pyrethroids using 150 litres of water per ha. **fenvalerate 20EC @ 100 ml/ha, cypermethrin 10EC 100 ml/ha or deltamethrin 2.8EC @ 200 ml/ha**. Usually, no additional spray or granular application is required after the spray with pyrethroids.
- (b) Alternatively, the crop should be sprayed with any of the following insecticides: **monocrotophos 36SL @ 275 ml/ha, or carbaryl 50WP @ 250 g/ha**.

- (c) After this spray, apply twice at 7-10 days intervals any of the following insecticides in the whorls of only infested plants that show fresh borer injury in the central leaves: fenitrothion or trichlorphon 5 D or endosulfan 4G, lindane 6G, carbaryl 4G or trichlorphon 4G. In case of dust, mix it with equal quantity of moist soil before application. Apply a pinch of this mixture to the whorl of plants. Usually 1.5-2.5 kg of the insecticide would be required per ha for one application. Apply granules to the whorl of plants @ 0.5-1.25 kg/ha per application through a bottle with a few holes in its cap.

SUGARCANE PESTS

In India, sugarcane is produced in both **tropical** and **subtropical** regions. The major

sugarcane growing districts **Kurukshetra, Yamunanagar, Karnal, Sonipat, Rohtak, Faridabad and Panipat** in which farming of this crop is done. Besides sugar, cane juice possesses several vitamins and minerals that provide immense health benefits for people suffering from variety of conditions. Among various limiting factors for low yield of pulse crops, the incidence of insect pests assumes high significance. These are describing as below:

- ***Early Shoot Borer (Chilo infescatellus)***
- ***Internode Borer (Chilo Saccharifagus Indicus)***
- ***Top Borer (Scirpophaga Excerptalis)***
- ***Scale Insect (Melanaspis Glomerata)***
- ***Pyrilla (Pyrilla purpusilla Walker)***
- ***Termites (Odontotermes assmuthi)***
- ***Whitefly (Aleurolobus barodensis Mask)***

- **Leaf hopper, *Pyrilla perpusilla* (Hemiptera : Lophopidae)**

Identification:

The leaf hopper is very **agile** and jumps around in large numbers, making a **faint noise** when a person walks through a heavily infested field. The adult is equally active, has a **straw colored body with dark patches or spots on the wings**. **At the front end it has a snoutlike prolongation and prominent red eyes.**

Damage

- **Pyrilla adults and nymphs both suck the cell sap from the lower side of sugarcane leaves.** Due to continuous de-sapping by large number of hoppers top leaves in the affected canes dry up and lateral buds germinate. The hoppers **exude a sweet sticky fluid known as honeydew**, which promotes quick and luxuriant growth of the fungus and as a result the leaves are completely covered by the **sooty mould**. This affects **photosynthesis** activity of the plant and growth of the plant is affected adversely. Affected canes when planted give **poor germination** and **low yield**. **Heavy rainfall followed by 75-80% humidity, intermittent drought periods, high temperature (26-30°C) and wind movement favors rapid buildup of pyrilla.** Other factors favoring pyrilla buildup are **dense and luxuriant crop, excess nitrogen application, water logging, lodging of cane and varieties with broad and succulent leaves.**

- **Management:**

- (1) Sometimes leafhopper will be attacked in April to June. To spray 400 ml malathion 50 EC in 400 L water per acre.
- (2) July- November: Sugarcane leafhopper becomes very destructive due to changing environment. But at that mean time egg parasitoid also present in the field. These egg parasitoid to grow inner side of the leafhopper egg. Due to

this egg colour become brown, pink or black and they control itself. These parasitoids are reared in biocontrol laboratory of Sonapat, Shahabad, Meham and Jindsugar milles. If these are not controlled by parasitoid then spray with 400-600 ml Malathion 50 EC in 400- 600 L

8. Whitefly

Identification:

Nymph of the whitefly is oval, black in color and has a silvery grey waxy coating on the body. The adults are small delicate, pale yellow and their wings have a whitemealy appearance, molted with black dots. They flutter about briskly, but they are not easily noticed in the field.

Symptoms:

Waterlogging and nitrogen starvation cause severe outbreak of whiteflies. Varieties with broad and long leaves are more susceptible to this pest. The nymphs of whiteflies suck the sap from the under surface of leaves which turn yellow and pinkish in severe cases and gradually dry up. Heavy infested leaves are covered by the sooty mould caused by the fungus, which adversely affects photosynthesis. The whitefly infestation retards cane growth and reduces sugar content.

Management:

July-November:- Use **800ml of malathion 50 EC or methyl demeton 25 EC (Metasystox) or 600 ml dimethoate 30 EC for spray in 400 ml water per acre. In this solution use 10 Kg urea for spray due to this leaves become green frequently.**

1. Early shoot borer , *Chilo infescatellus*

Identification:

Adult moth is straw colour and laid eggs in the clusters of **10-30 eggs** on the **under surface of the leaves** by the side of the mid rib. The **eggs are creamy-white** in colour and has **scale like appearance**. The larvae are **dull white in colour** with a number of **brownish-red longitudinal stripes on the back** and they bore a number of times, either in the same stalk or in the neighboring ones. The larval period lasts for **about three weeks**, after which the larvae pupates in the tunnel within the sugarcane stalk where they had been feeding before.

Symptoms:

Shoot borer **infestation is high during pre-monsoon period** (April-June) when ambient temperature remains usually high with low relative humidity. Borer attacks the crop during the **early part of cane growth, before internode formation**. Larvae enter the cane laterally through one or more holes in the stalks (shoot) just above the ground level and bores **downwards as well as upwards killing the growing point** this leads to gaps in the field. Thus, it cuts off the central leaf spindle, which eventually dries forming a '**dead heart**'. **Dead heart in 1-3 month old crop**, which can be easily pulled out, **dead heart emits an offensive odour**. A single caterpillar may destroy **three or four shoots** before it pupate. Borer activity decreases appreciably with the onset of monsoon.

Management:

(1) February – March: At the time of sowing Setts are treated with 2.5 L **chlorpyrifos 20 EC** or 600 ml **fipronil 5 EC** (Reagent) (for sandy soil 700 ml) in 600-1000 L water per acre spray on the furrow with the help of knapsack sprayer or use 150 ml **imidachloprid 200 SL** in **250-300 L water** or 8 kg **Dursban 10G** / 10 kg **fipronil 0.3 G** / **7.5 kg Sevidol 4G** per acre.

(2) April- June: When the soil testing is not done at the time of sowing treat the setts with above any one insecticide. In May-June giving irrigation at 10 days intervals to protect the crop.

Chapter-4.

Pests of pulses

Gram pod borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae)

The gram pod-borer or the gram caterpillar is **cosmopolitan** and is widely distributed in India. It is a serious pest of **chickpea, pigeon pea, mungbean, urdbean, lentil soybean and cowpea**. The insect has also been found damaging **cotton, sorghum, okra, maize, tomato, berseem, sunflower and lately wheat also**.

The moth is **stoutly built** and is **yellowish brown**. There is a **dark speck and a dark area the outer margin of each forewing**. The forewings are marked with **greyish wavy lines and black spots of varying size on the upper side and a black kidney shaped mark and a round spot on the underside**. The hind wings are **whitish and lighter in colour with a broad blackish band along the outer margin**. The caterpillars when full-grown, are **3.5 cm in length, being greenish with dark broken grey lines along the sides of the body**.

Life-cycle. The females lay **eggs singly on tender parts of the plants**. A single female may lay as many as **741 eggs in 4 days**. The eggs are **shining greenish yellow and are round**. They hatch in **2-4 days in April to October and 6 days in February** and the **young larvae feed on the foliage** for some time and later here into **the pods and feed** on the developing grains, **with their bodies hanging outside**. They move from pod to pod and are full-fed in **13-19 days** and

measure 35 mm in the last instar. The full-grown larvae come out of the pod and **pupate in the soil**. In the active season, the **pupal period lasts 8-15 days**, but in winter the duration is prolonged, particularly in northern India. Some of the **pupae** remain in a facultative **diapause** during **November** April in northern India. There may be as many as **8 overlapping generations in a year**.

Campoletis chloridae Uchida (Ichneumonidae) is a larval parasite of major importance. In vegetative phase, during the peak of its activity, it may parasitize 50-60 per cent of *H. armigera* larvae, whereas during podding phase, 30-40 per cent parasitization has been recorded.

Damage. Although they prefer food plants like gram and red gram, the larvae are **polyphagous**. They feed on the **foliage, when young**, and on the seed in later stages, and thus reduce yield. A single larva may **destroy 30-40 pods before it reaches maturity**.

Management.

- (i) **Timely sowing**, i.e. up to mid October or growing early maturing cultivars which complete podding by first week of March in northern region helps in escaping peak activity period of *H. armigera*.
- (ii) Use of Helicoverpa-tolerant varieties like JG 315 and JG 74 for central zone and ICCV 7 for southern zone is recommended.
- (iii) **Mixed intercropping with non-preferred host** plants like **barley, wheat, mustard and linseed** should be preferred over sole crop.
- (iv) **Hand picking** of the older larvae during early hours of the day is helpful as these are less susceptible to insecticides.
- (v) **Apply nuclear polyhedrosis virus (NPV) @ 250-500 larval equivalents/ha** alone or along with half dose of endosulfan 35EC (1.25 liter/ha). Spraying should be carried out in the evening hours.
- (vi) The pod borer can be managed by spraying the insecticides at the **economic threshold level of one larva per five plants** at pod initiation stage. The recommended insecticides are **2.5 litres of endosulfan 35EC or 250 ml of fenvalerate 20EC or 200 ml of cypermethrin 25EC or 400 ml of deltamethrin 2.8EC in 625 liters of water per ha** at the start of pod formation and repeat after two weeks, if necessary. Alternatively, **Apply fenvalerate 0.4 per cent dust @ 20 kg/ha or**

Malathion 5 per cent Dust @ 25 kg/ha or endosulfan @ 25 kg/ha. For consuming any part of the raw gram plant observe waiting period of 20 days after application of the insecticide.

CUTWORMS

The term cutworm or surface caterpillar is applied to the larvae of several species of noctuid moths which have, in common, the habit of biting through the stems of seedlings at ground level and eating the leaves or the entire seedlings. The various species of cutworms have a wide range of food plants, both cultivated and wild.

The majority of cutworms found in India fall under the genera *Agrotis* and *Euxoa*. Of the recorded species, only four are widespread in the plains and have considerable economic importance. *Agrotis ipsilon* (Hufnagel) is the commonest and *Ochropleura flammatrix* (Denis & Schiffermüller) is occasionally abundant in India, the latter being particularly destructive in the north.

Gram cutworm, *Ochropleura flammatrix* (Denis & Schiffermüller) (Lepidoptera: Noctuidae)

The gram cutworm is one of the most important pests of chickpea or gram in northern India particularly in the Punjab, Haryana and in the sub-Himalayan region. Its distribution extends to Europe, Syria, Iran, western Siberia and Pakistan. It is a polyphagous pest besides gram, it feeds on the seedlings of many vegetables and other plants such as potato, cucurbits, peas, okra, wheat, tobacco, opium, poppy, etc.

The adult is a heavy bodied, grayish-brown or wheat-colored insect which measures 5.0-6.2 cm in wing expanse. Its fore wings have characteristic markings and smoky patches. The caterpillars are dark grey or dull green and their skin is smooth and greasy.

Life-cycle. The female moths lay yellowish-white eggs on the under surface of leaves, shoots, stems, or in the soil, within 5-9 days of their short life span of 7-13 days. A female lays up to 980 eggs in its life time. The eggs hatch in 4-7 days during summer and 10-14 days during winter. The larvae remain hidden in soil during the daytime and feed at night on young shoots or underground tubers. They are full grown in 4-7 weeks and then make earthen cells in the soil for pupation. The pupal stage lasts 12-15 days but during winter it extends up to 5 weeks. The life cycle is completed in 7-11 weeks and there are generally two generations in a year.

Damage. This cutworm is a sporadic pest of major importance. In some years, 50 per cent of the gram crop may be destroyed. The caterpillars spend the day hiding near and about the plant bases. They remain in the top 5-10 cm of the soil near the plants that might have been cut the night before. At night, they come out and become active, cutting down the young plants of gram, potato, vegetable seedlings, etc. just above or slightly below the surface of the soil they seem to be very voracious eaters and they cut more plants than they can consume.

Management. The pest can be controlled with lindane 2D @ 35 kg per ha or fenvalerate .4D @ 25 kg per ha or spray 80ml fenvalerate 20 EC or 50 ml cypermethrin 25 EC or 150 ml decamethrin 2.8EC in 100 litres of water per ha.

Greasy cutworm, *Agrotis ipsilon* (Lepidoptera: Noctuidae)

This is a pest of worldwide occurrence and is found in America, Europe, North Africa, Syria, Japan, China, Indonesia, 'Australia, New Zealand, Hawaii, Sri Lanka, Myanmar and India. It has been reported from almost all the potato growing regions of northern India, forming a continuous belt from the Punjab in the west of Bengal in the east and Madhya Pradesh in the south it causes considerable damage to potato. In Punjab, it is not as common as *O.flammatrix*, but along with other cutworms it causes much damage to the crop.

Damage is caused by the caterpillars only. The slightly yellowish caterpillar, on emergence, is 1.5 mm long with a shiny, black head and a black shield on the prothorax. The full-grown larva is about 42-45 mm long and is dark or dark-brown with a plump and greasy body. The adult moth measures about 25 mm from the head to the tip of the abdomen and looks dark or blackish with some greyish patches on the back and dark streaks on the fore wings.

Life cycle. The pest is active from October to April and probably migrates to the mountains for further breeding during summer. The moths appear in the plains in October and come out at dusk and fly about until darkness sets in. They oviposit at night and lay creamy-white, dome-shaped eggs in clusters of about 30 each, either on the undersurface of the leaves of food plants or in the soil. The number of eggs laid by a female varies from 199 to 344. Oviposition continues from 5 to 11 days and the duration of the egg stage varies from 2 days in summer to 8-13 days in winter. The newly hatched larvae feed on their egg shells and move like a semilooper. The larval stage varies from 30 to 34 days in February-April. The advanced-stage larvae may become cannibalistic. The caterpillars are found throughout the winter and become active at

night when they cut off and fell the young plants. During the day, they hide in cracks and crevices in the soil. When full-grown, they make earthen chambers in the soil and pupate underground. The pupal stage varies from 10 days in summer to 30 days in winter. The moths usually emerge at night. The life cycle is completed in 48-77 days and generally three generations are completed in a year. It is a cold-weather pest and is active from October to March in the plains. It suddenly disappears with the onset of summer during April and is not traceable during the off-season, from April to August-September.

Damage. The young caterpillars feed on the epidermis of the leaves. As they grow, their habit changes. During the daytime they live in cracks and holes in the ground and come out at night and fell the plants by cutting their stems, either below the surface or above the ground. The cut branches are sometimes seen to have been dragged into the holes where the leaves are eaten at leisure. The larvae may also bore into cabbages. Damage to the rabi crops may go as high as 37 per cent and to the potato crop may be as high as 80 per cent.

Management. Management. The pest can be controlled with lindane 2D @ 35 kg per ha or fenvalerate .4D @ 25 kg per ha or spray 80ml fenvalerate 20 EC or 50 ml cypermethrin 25 EC or 150 ml decamethrin 2.8EC in 100 litres of water per ha.

3. Tobacco caterpillar, *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae)

The tobacco caterpillar is found throughout the tropical and sub-tropical parts of the world. It is widespread in India and besides tobacco feeds on castor, groundnut, tomato, sunflower, cabbage and various other cruciferous crops.

The moths are about 22 mm long and measure 40 mm across the spread wings. The fore wings have beautiful golden and greyish brown patterns. The caterpillars are velvety black with yellowish-green dorsal stripes and lateral white bands.

Life-cycle. The female lays about 300 eggs in clusters. These clusters are covered over by brown hair and they hatch in about 3-5 days. The larvae feed gregariously for the first few days and then disperse to feed individually. They pass through 6 stages and are full-fed in 15-30 days. The full-grown larvae enter the soil where they pupate. The pupal stage lasts 7-15 days and the moths, on emergence, live for 7-10 days. The life cycle is completed in 32-60 days and the pest completes eight generations in a year.

Damage. The larvae feed on leaves and fresh growth. They are mostly active at night and cause extensive damage, particularly in tobacco nurseries.

Management.

- (i) **Remove the egg masses and clusters of larvae and destroy them.**
- (ii) Chemical sprays recommended against diamondback moth will also work against this pest but in this case spot application may be enough if the attack is not widespread in the field.

Chapter-5

Pests of Oilseeds

Among the principal commercial crops grown in India, the oilseeds occupy a prominent place with a production of 25.1 million tonnes from an area of 23.4 million ha in 2003-04. These crops are damaged by a number of pests, of which **mustard aphid, mustard sawfly and the painted bug** are more serious.

1. **Mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Hemiptera : Aphididae)**
2. **Mustard sawfly, *Athalia lugens* (Klug) (Hymenoptera: Tenthredinidae)**
3. **Painted bug, *Bagrada hilaris* (Burmeister) (Hemiptera : Pentatomidae)**
4. **Groundnut aphid, *Aphis craccivora* Koch (Hemiptera: Aphididae)**
5. **Soyabean, Girdle beetle *Obereopsis brevis* , Coleoptera : Cerambycidae**
6. **Castor semilooper, *Achaea janata* (Linnaeus) (Lepidoptera: Noctuidae)**
7. **Castor capsule borer, *Conogethes puntiferalis* (Lepidoptera : pyralidae)**
8. **Til leaf and pod caterpillar, *Antigastra catalaunalis* (Lepidoptera: Pyralidae)**
9. **white grub, *Holotrichia consanguinea*, Coleoptera : Scarabaeidae**
10. **Ground nut bruchid, *Carydon seratus*, Coleoptera :**

BRASSICA CROPS (Brassica spp.; Family : Cruciferae)

1. **Mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Hemiptera : Aphididae)**

The mustard aphid is worldwide and is a serious pest of cruciferous oilseeds like **toria, sarson, raya, taramira and Brassica vegetables like cabbage, cauliflower, knol-khol, etc.** The aphids are **minute, soft-bodied and light green** insects having a **pair of short tubes called cornicles on the postero-dorsal region of the abdomen.**

Life cycle.

The insect **breeds parthenogenetically** and the **females give birth to 26-133 nymphs.** They grow very fast and are full-fed in **7-10 days.** About **45 generations** are completed in a year. The **winged forms are produced in autumn and spring,** and they spread from field to field and from locality to locality.

Damage.

Both the **nymphs and adults suck cell-sap from leaves, stems, inflorescence or the developing pods.** Due to the very high population of the pest, the **vitality of plants is greatly reduced.** The **leaves acquire a curly appearance,** the flowers fail to form pods and the developing pods do not produce healthy seeds. The **honey dew excreted** by the aphids provides congenial conditions for the growth of **sooty mould** on the plant. In case of severe infestation the crop yield may be reduced by even **80 per cent** or more.

Management.

Early sowing reduces the incidence of mustard aphid at many locations in India. Three rounds of manual **removal (clipping) of aphid infested twigs** at 15 day intervals starting with the first appearance of the pest has been found effective if cheap labour is available. Apply any one of the following insecticides **when the population of the pest reaches 50-60 aphids per 10 cm terminal portion of the central shoot or when an average 0.5-1 cm terminal portion of central shoot is covered by aphids or when plants infested by aphids reach 40-50 per cent:** (i) Foliar sprays. 625-1000ml of **oxydemeton methyl 25EC, dimethion 30EC, endosulfan 35EC, quinalphos 25EC, formathion 25EC, malathion 50EC;** 940-1500 ml of **chlorpyrifos 20EC** in 200-315 litres of water per ha depending on the stage of the crop. (ii) Granular insecticides. 10 kg of phorate 10G, 33 kg of carbofuran 3G per ha followed by a light irrigation.

2. Mustard sawfly, *Athalia lugens* (Klug) (Hymenoptera: Tenthredinidae)

The mustard sawfly is widely distributed in Indonesia, Taiwan, Myanmar and the Indian Subcontinent. It **feeds on various cruciferous plants like mustard, toria, rapeseed, cabbage, cauliflower, knol-khol, turnip, radish, etc.**

The **larvae are dark green** and have **8 pairs of abdominal prolegs.** A full-grown larva measures **16-18 mm in length.** The adults are small **orange yellow insects with black markings on the body and have smoky wings with black veins.**

Life-cycle.

The adults lay **30-35 eggs singly, in slits made** with saw like ovipositors along the **underside of the leaf margins**. The eggs **hatch in 4-8 days** and the larvae feed exposed in groups of 3-6 on the leaves during morning and evening. They pass through **seven stages** and are **full-grown in 16-35 days**. The full-fed larvae **descend** the plant and **enter the soil to a depth of 25-30 mm**. There, they **pupate** in water proof oval **cocoons made of silk** and emerge from them as adults in **11-31 days**. Thus, the **life-cycle** is completed in **31-34 days**. The pest completes **2-3 generations from October to March**.

Damage.

It is a **serious pest** of all **crucifers at the seedling stage**. The grubs alone are destructive. They **bite holes into leaves preferring the young growth and skeletonize the leaves completely**. The **older plants, when attacked, do not bear seed**.

Management.

Clean cultivation and quick threshing of harvested crop helps in lowering the incidence of the pest. Spray one litre of **malathion 50EC** or 625 ml of **endosulfan 35EC** or **quinalphos 25EC in 150-200 litres of water per ha** once in **October** and again in **March-April**.

3. Painted bug, *Bagrada hilaris* (Burmeister) (Hemiptera : Pentatomidae)

The painted bug is a **serious pest of cruciferous crops** and is widely distributed in Myanmar, Sri Lanka, India, Iraq, Arabia and East Africa. Besides cruciferous crops, it has also been observed feeding on **rice, sugarcane, indigo and coffee**.

The full-grown nymphs are about **4 mm long and 2.66 mm broad**. They are **black with a number of brown markings**. The adult bugs are **3.71 mm long and 3.33 mm broad**. They are sub-ovate, **black and have a number of orange or brownish spots**.

Life-cycle.

These bugs lay **oval, pale-yellow eggs singly or in groups of 3-8 on leaves stalks, pods and sometimes on the soil**. A female bug may lay **37-102 eggs** in its life-span of 3-4 weeks. The eggs **hatch in 3-5 days during summer and 20 days during December**. The nymphs develop fully in live stages and transform themselves into adults in **16-22 days during the summer and 25-34 days during the winter**. The entire lifecycle is completed in **19-54 day**, and it passes through **9 generations** in a year.

Damage.

The painted bug appears at two stages of crop growth, i.e. seedling and maturity and many times infestation is carried even to threshing floor. Both **nymphs and adults suck cell sap from the leaves and developing pods, which gradually wilt and dry up**. Severe attack at seedling stage may even kill the plants. The nymphs and adult bugs also excrete a sort of resinous material which spoils the pods.

Management.

Clean cultivation and quick threshing of harvested crop helps in lowering the incidence of the pest. Spray one litre of **malathion 50EC** or **625 ml of endosulfan 35EC** or **quinalphos 25EC** in **150-200 litres of water per ha** once in October and again in March-April.

GROUNDNUT (*Arachis hypogaea* L: Family: Leguminosae)

4. Groundnut aphid, *Aphis craccivora* Koch (Hemiptera: Aphididae)

This is one of the most **serious pests of groundnut**. It also attacks **peas, beans, pulses, safflower and some weeds**. Its distribution is throughout India. It has also been recorded in Africa, Argentina and Chile. **The winged adults are soft-bodied insects with black wings and** they reach the freshly germinated groundnut plants after overwintering on collateral host plants.

Life cycle.

Even without fertilization the females may produce **8-20 young** ones in a life span of 10-12 days.

The young nymphs are **brownish and they pass through four moults to become adults in 5-8 days**. The **apterous females** start producing brood within **24 hours of attaining that stage**. Breeding occurs almost throughout the year and **both alatae and apterae are present**. The coccinellid beetle, *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae) and *Ischiodon javana* (Wiedemann) (Diptera: Syrphidae) are the main predators of this aphid pest.

Damage.

The **nymphs and adults suck the sap**, usually from the **underside of leaves**. Infestation in the early stages causes stunting of the plants as well as **reducing their vigour**. When the attack occurs at the time of flowering and pod formation, the yield is reduced considerably. Infestation on the groundnut crop usually occurs **4-6 weeks after sowing**. The aphid is also **vector of rosette disease of groundnut**.

Management.

As soon as the pest appears on growing points, spray 625 ml of **malathion 50EC** or 425 ml of **dimethoate 30EC** or 425 ml of **oxydemeton methyl 25EC** in 200 litres of water per ha.

5. SOYBEEN GIRDLE BEETLE

***Obereopsis brevis* (Gahan) (Girdle beetle, Coleoptera : Cerambycidae)**

Identification. The adult is a small **black beetle** with hard shell-like exterior and rather on antennae. The freshly emerged **adult is yellow, red, brown on the head thorax and bases of elytra**. **The larva is white, soft-bodied worm with a dark head**.

- **Life-history.** The ovipositing female beetle **girdles the stem twice and makes it 3 punctures Just above the lower ring before inserting a single egg through the largest whole into the pith. This results in dropping of the upper part of the stem.** A female beetle lays **7 -13 eggs** and they hatch in **4-5 days.** The **larva tunnels upwards and downwards within the stem** and a single larva can destroy the whole plant. The **larval period lasts 34-47 days.** Over-wintering takes place as the full-grown larva within the feeding tunnel in a gall-like chamber near the base of the plant in the girdled portion of the stem which has fallen out or under plant debris. The **Pupal period is 8-11 days.**

Host plants. This is an important **pest of soybean** and also attacks cowpea and lablab.

Damage. The **attack** of this insect begins initially in the **last week of July to fortnight of August.** The female of this insect feeds on the **xylem of the stem.** The **larvae further damage the stem and make tunnels inside and fill these with excreta.** The **leaves and the growing points dry up.** In later stages, **the plant is cut at about 15-25 cm above the ground and broken stems can be seen in the field.**

Management. Same as in case of **bean fly.**

CASTOR (*Ricinus communis* L; Family: Euphorbiaceae)

6.Castor semilooper, *Achaea janata* (Linnaeus) (Lepidoptera: Noctuidae)

This is a **serious pest of castor** in all parts of India and Pakistan and has also been reported from Sri Lanka and Thailand.

The adult of *A. janata* is a **pale reddish brown moth** with a wing expanse of **6-7 cm.** The wings are decorated with **broad zig-zag markings, a large pale area and dark brown patches.** The **full grown larva is dark and is marked with prominent blue-black, yellow and reddish stripes.**

Life cycle.

A female lays up to **450 eggs** during its life span. The **egg, being about 1 mm in length, is fairly large and also has on its surface a few ridges and furrows which radiate from the circular depression at the apex.** The **larva emerges by cutting a hole in the egg-shell in 2-5 days and devours it immediately.** The larva feeds and **moults 4-5 times** and becomes full-grown in **15-20 days.** The **grown-up larva prepares a loose cocoon of coarse silk and some soil particles, and pupates under the fallen leaves on the soil, usually at the edge of the field.** In some cases, **pupation also takes place within the folded leaves** on the plant itself. The **pupal stage lasts 10-15 days** and the moths, on emergence, feed on the soft fruits of **citrus, mango, etc.** There are **5-6 generations** in a year.

Damage.

The **caterpillars feed voraciously on castor leaves, starting from the edges inwards and leaving behind only the midribs and the stalks.** With the excessive loss of foliage, the **Seed yield is reduced considerably.**

Management.

Apply 1.5 litres of diazinon 20EC or 625 ml of methyl parathion 25EC In 625 litres of water per ha.

7. Castor capsule borer, *Conogethes puntiferalis* (Lepidoptera : pyralidae)

This bore is distributed through India wherever castor is grown such as **Utter Pradesh, Bihar, Orissa, Maharastra, Gujarat, Karnataka, Andhra Pradesh and Tamil Nadu**. The full- grown caterpillar measures **25-30 mm in length, is radish brown, with black blotches all over the body and a pale stripes on the lateral side**. The **moth are orange yellow with black markings on both the wings**.

Life cycle. The moth lays **eggs on leaves and other soft parts of the plant**. The eggs hatch in **about a week**. The larvae passes through **4-5 instars** and are full fed in **2-3 weeks**. **Pupation** takes place **inside the seedor some times in the frass** that collects after feeding. The **pupal stage lasts about a week**. The **life cycle** is completed in **4-5 week and 3 generation** are completed in a year.

Damage. The attack by this borer is recognized from a distance by the **webbed capsule heads**. The **yield is reduced** considerably since the capsules and **seeds** within are **damaged**.

Management. (1) it is advisable that the **infested shoots and capsules may be collected and destroyed**. (2) **Spray 2.5 kg of carbaryl 50WP in 625 liters** of water per ha and repeat at 15 days intervals.

SESAME (*Sesamum indicum* L.; Family : Pedaliaceae)

8. Til leaf and pod caterpillar, *Antigastra catalaunalis* (Duponchel) (Lepidoptera: Pyralidae)

The sesame leaf and pod caterpillar is a serious and regular **pest of til (*Sesamum orientale* and *S. indicum*)** and is also distributed throughout India. This species has also been reported from Europe, Africa, Cyprus, Malta, Indonesia and South-east Africa.

The **caterpillars are pale yellow, when young, but gradually become green and develop black dots all over the body**. The full-grown **larva** measures **14-17 mm**. The **moth is a small insect with a wing span of about 2 cm** having **dark brown markings on the wing-tips**.

Life cycle.

Females lay up to **140 eggs singly on the tender portions of plants at night**. The eggs are **shiny, pale-green and they hatch in 2-7 days**, depending upon the season. On emerging, the young **larva**, which measures **about 2 mm in length, feeds for a little while on the leaf epidermis or within the leaf tissue**. Soon after, it **binds together the tender leaves of the growing shoot with the help of silken threads and continues to feed in the webbed mass**. The size of this rolled mass increases gradually as the caterpillar grows older. It becomes full-grown in about **10 days in summer, but the period may be prolonged to 33 days in winter**. The grown-up **larvae creep to the ground and pupate in silken cocoons in soil**. Sometimes, **pupation also takes place in the plant itself**. Pupal development is

completed in **4-20 days**, depending upon the season. In summer, **a generation is completed in about 23 days but in the winter it takes about 67 days.**

Damage.

Young **caterpillars feed on leaves.** They also **bore into the shoots, flowers, buds and pods.** An **early attack kills the whole plant,** but infestation of the shoots at a later Stage hampers further growth and flowering.

Management.

Spray the crop twice (first at pest appearance and then at flowering stage) with **250 ml of fenvalerate 20EC or 375 ml of deltamethrin 2.8 EC or, thrice with 500 ml of cypermethrin 10EC at pest appearance, flowering and pod formation in 250 litres of Water per ha.**

Chapter-6.

PESTS OF COTTON

COTTON (*Gossypium* spp.: Family : Malvaceae)

Although **India occupies the largest area** in the world under cotton, it ranks **third in production.**

More than 1326 species of insects have been reported attacking cotton in the World However, **in India, only 162 species have been recorded,** among which only **15 species may be called as major pests** due to their occurrence in serious proportions almost every year.

1. Pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera - Gelechiidae)
2. Spotted bollworms, *Earias insulana* (Boisduval) and *E. Vittella* (Fabricius) (Lepidoptera: Noctuidae)
3. American bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae)
4. Cotton leafhopper, *Amrasca biguttula biguttula* (Ishida) (Hemiptera Cicadellidae)
5. Cotton whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera : Aleyrodidae)
6. Cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae)
7. MEALYBUG, *Phenacoccus solenopsis* Tinsley (Cotton mealy bug, Hemiptera: Pseudococcidae)
8. Red cotton bug, *Dysdercus koenigii* (Hemiptera: Pyrrhocoridae)
9. Dusky cotton bug, *Oxycarenus laetus* Hemiptera : Lygaeidae

10. Cotton leaf roller, *Sylepta derogate*, Lepidoptera : Pyralidae
11. Bud moth, *Phycitia infusella*, Lepidoptera : Pyralidae
12. Cotton semi looper, *Tarache notabilis*, Lepidoptera : Noctuidae
13. Green semi-looper, *Anomis flava*, Lepidoptera : Noctuidae
14. Cotton grey weevil, *Mylocerus undecimpustulatus*, Coleoptera : Curculionidae
15. Cotton stem weevil, *Pempherulus affinis*, Coleoptera : Curculionidae

1. Cotton leafhopper(Jassid), *Amrasca biguttula biguttula* (Ishida) (Hemiptera Cicadellidae)

The cotton leafhopper is widely distributed in India and is the **most destructive pest of American cotton** in the north-western regions. Besides cotton, it also feeds on **okra, potato brinjal** and some wild plants, like **hollyhock, kangi buti**, etc. Adults are about **3 mm long** and **greenish yellow during the summer, acquiring a reddish tinge in the winter.**

Life cycle. The females lay about **15 yellowish eggs on the underside of the leaves, embedding them into the leaf veins.** The **eggs hatch in 4-11 days** and give rise to nymphs which are **wedge-shaped** and are very active. They **suck cell-sap from the underside of the leaves** and pass through **six stages of growth in 7-21 days.** On transformation into winged **adults**, they live for **5-7 weeks**, feeding constantly on the plant juice. The pest **completes seven generations** in a year.

Damage. Injury to plants is caused **both by the nymphs and the adults which suck sap from the foliage and probably also due to the injection of toxins into the plant tissues.** The attacked leaves **turn pale and then rust-red.** With change in appearance, the leaves also **turn downwards, dry up and fall to the ground.** Owing to the loss of plant vitality, the **cotton bolls also drop off, causing upto 35 per cent reduction in yield.**

Management. Grow **American cotton varieties** which are **resistant or tolerant** to leafhopper attack. In Punjab, recommended varieties are F1861, F1378, F846, LH1556 and hybrid LH144, all of which are moderately resistant or tolerant to leafhopper attack. Spray against leafhopper should be done only at **economic threshold level of 1-2 nymphs per leaf or when second grade injury symptoms (yellowing and curling at margins of leaves) appear in 50 per cent of the plants.** Any one of the following insecticides can be used in **250 litres of water per ha: 750 ml of formothion 25EC or oxydemeton methyl 25EC, 625 ml of dimethoate 30EC, 100**

m1 of imidacloprid 200 SL, 50g of acetamiprid 20SP, 100g of thiamethoxam 25WG. At the time of sowing, smear the cotton seed with imidacloprid 75WS@ 5g/kg seed.

2. Cotton whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera : Aleyrodidae)

This pest is distributed throughout the northern and western regions of the Indian Subcontinent and is a very serious pest of American cotton, particularly in the dry areas. Apart from cotton, this insect also **feeds on** various other plants such as **cabbage, cauliflower, sarson, toria, melon, potato, brinjal, okra and some weeds.**

In the winged stage, they are **1.0-1.5 mmlong** and their **yellowish bodies are slightly dusted with a white waxy powder.** They have **two pairs of pure white wings and have prominent long hind wings.**

Life-cycle : Females lay **stalked eggs singly on the underside of the leaves, averaging 119 eggs per female.** The eggs **hatch in 3-5 days during summer, 5-33 days in winter.** The nymphs **feed on cell-sap** and grow into **three stages** to form the **pupae within 9-14 days in summer and in 17-81 days in winter.** In **2-8 days, the pupae change into whiteflies.** The total **life-cycle is completed in 14-122 days and 11 generations** are completed in a year.

Damage. The damage is caused by both the **nymphs and the adults by sucking the sap from the leaves.** Insects **exude honeydew which attracts sooty mould.** Therefore, in severe infestation, the **plants** not only become weak, but the mould **interferes** with the normal **photosynthesis** resulting in poor growth and yield of cotton. *B. tabaci* is known to transmit number of virus diseases including the **cotton leaf curl, the leaf curl disease of tobacco, the vein clearing disease of okra and the leaf curl of sesame.**

Management. Chemical control measures are same as in case of cotton leafhopper the

3. Red cotton bug, *Dysdercus koennigii* (Hemiptera: Pyrrhocoridae)

This insect is widely distributed in India and is a **minorpest of cotton** in the Punjab and UP. Apart from **cotton** it feeds on **okra, maize, pearl millet, etc.** The bugs are **elongated slender insect crimson red with white bands across the abdomen.** The **membraneous portion of their fore wings, antennae and scutellum is black.** Both **adults** and their **nymphs feed** on the **cell-sap of cotton, hollyhock, wheat, maize, pearl-millet, clovers etc.**

Life cycle : This insect is active throughout the year and **passes winter in the adult stage**. In spring the bugs becomes active and lays, egg on an average , **100-130 eggs in moist soils or in crevices in the ground**. The eggs are **spherical , bright yellow** and are laid in the in cluster or in loose irregular masses of 70-80 eggs each. They **hatch in 7-8 days** and the young nymphs have flabby abdomens, but as they grow older, they become more slender and develop black markings on the body. There are **five nymphal stages** and the development is completed in **49-89 days**. In summer, the life of an adult is very variable, but in winter, it may live up to three months .The predacious bugs like *Antilochus cocqueberti* and *Harpactor costalis* feed on **nymph and adults**.

Damage : the insect **sucks the cell-sap from the leaves and green bolls of cotton**. Heavily attacked **bolls open badly** and the **lint is of poorer quality**. The seeds produced may also have **low germination and less oil**. The bugs **stain the lint with their excreta or body juice as they are crushed in the ginning factories**. The staining of lint by the **growth of certain bacteria** inside the bolls is also believed to be initiated by these bugs.

Management. Any one of the following insecticides can be used in **250 litres of water per ha: 750 ml of formothion 25EC or oxydemeton methyl 25EC, 625 ml of dimethoate 30EC, 100 ml of imidacloprid 200 SL, 50g of acetamiprid 20SP, 100g of thiamethoxam 25WG**. At the time of sowing, smear the cotton seed with imidacloprid 75WS@ 5g/kg seed.

4. Cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae)

The cotton aphid is worldwide in distribution and is known as a potential pest of cotton. Though it is a **polyphagous** pest infesting a variety of plants, it is of more significance on crops like **lady's finger, brinjal, guava, gingelly**, etc. The **adults are small, greenish brown and soft-bodied insects** found in colonies on the tender parts of the plants and under surface of the leaves.

Life-cycle : The **adults exist in both winged and Wingless forms**. The alate as well as apterous females **multiply parthenogenetically and viviparously**. In a day, a female may give birth to **8-20 nymphs**. The **nymphs moult four times** to become adults in **7 -10 days**.

The *coccinellid* beetles, *Menochilus sexmaculatus* (Fabricius) and *Coccinella septempunctata* Linnaeus are some common insects found to be **predaceous on the aphid**.

Damage. The damage is caused both by the nymphs and adults by sucking plant sap. Severe infestation results in curling of leaves, stunted growth and gradual drying and death of young plants. Black sooty mould develops on the honey dew of the aphids which falls on the leaves. Dry conditions favor rapid increase in pest population and the younger plants are more susceptible than the older ones.

Management. Chemical control measures are same as in case of cotton leafhopper.

5. Pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera - Gelechiidae)

The pink bollworm is one of the most destructive pests of Cotton and is found in America, Africa, Australia and Asia. It is highly destructive in India and Pakistan.

The adult is a deep brown moth, measuring 8-9 mm across the spread wings. There are blackish spots on the fore wings, and the margins of the hind wings are deeply fringed.

Life-cycle. The females lay whitish, flat eggs singly on the underside of the young, new shoots, flower buds and the young green bolls. The eggs hatch in one week and the caterpillars, on emergence, are white and turn pink as they grow older. Soon after emergence, the larvae enter the flower-buds, the flowers or the bolls. The holes of entry close down, but the larvae continue feeding inside the seed kernels. They become full-grown (8-10 mm) in about two weeks and come out of the holes for pupation on the ground, among fallen leaves, debris, etc. Within one week, the moths emerge to start the life-cycle all over again. By October-November, 4-6 generations are completed.

Full-grown larvae of the last generation do not, however, pupate. Just a few of them reach the ground, but the great majority keep feeding inside the bolls and continue to produce what are known as the 'double seeds'. The hibernating larvae lie curled in double seeds for many months and after passing the winter, they emerge as moths. The last life-cycle is very long covering 5-10 months, although during the active season, the life cycle is short, taking only 3-4 weeks. The pest passes through several broods during its active period.

Damage. There is excessive shedding of the fruiting bodies. The attacked squares, buds, flowers (called rosetted flowers) and young bolls fall off pre-maturely and those which do mature do not open properly. The damaged seed-cotton is difficult to pick, discoloured and

gives a lower ginning percentage, lower oil extraction and inferior spinning quality. The infestation ranges from 40 to 85 per cent.

Management.

- (i) **Cultural and mechanical control.** The carryover and multiplication of this pest can be appreciably reduced by the following **cultural and mechanical control measures:**
1. **Pick the seed cotton completely.** Partially unpicked locule (burs) should not be left on the plants.
 2. After the last picking, **sheep, goats and other animals should be let into the cotton fields to feed on the plant debris and unopened bolls.** Goats are most effective as they can browse even on the standing plants.
 3. The **leftover, unopened and partially picked bolls should be dislodged** by beating against the ground or by plucking them. The burs and bolls so collected should be burnt immediately.
 4. **Cut the cotton sticks 5-6 cm below ground level to prevent their re-growth.**
 5. **Do not keep the cotton sticks in the fields.** Stack them in the Village premises. This would reduce the number of focal points from which initial infestation spreads to the fields.
 6. **Plough the cotton fields deep by the end of February,** preferably with a furrow-turning plough.
 7. **Crushing of cotton seed** should be completed before sowing of cotton begins in the area and seed left uncrushed should be sun-dried in thin layers for three consecutive days in the middle of April or fumigated to kill the diapausing larvae of the pink bollworm. For fumigation one 3-g aluminium phosphide (Celphos) tablet should be used per cubic meter of space giving an exposure period of 48 hours or 2 tablets per cubic meter of space with an exposure of 24 hours.
 8. **The seed should be acid-delinted or fumigated before sowing.**
 9. Replace the cotton seed by seed-cake for feeding the animals.
 10. The damage of the pest can be reduced **by sowing short-duration varieties** and by early termination of last irrigation to the crop.
- (ii) Biological control. **The releases of Trichogramma spp. @ 1,50,000 parasitized eggs ha** at weekly intervals have proved promising for bollworm control.
- (iii) Chemical control. In case the bollworm damage exceeds 5 per cent, the crop should be sprayed immediately and thereafter at 10 day interval with any of the following insecticides in 315-375 litres of water per ha.

(a) Organochlorine. 2. 5 litres of endosulfan 35EC. (b) Organophosphates. **2. 0 litres of fenitrothion 50EC, 2.0 litres of quinalphos 25EC, 1. 25 litres of monocrotophos 36SL, 1.0 liters of phenthoate 50EC, 5.0 litres of chlorpyriphos 20EC, 2. 0 litres of quinalphos 25EC, 1.25liters of quinalphos 20EC 1.25 litres of fenitrothion 82.5EC, 1.5 litres of triazophos 40EC, 2.0 litres of ethion 50EC, 2.0 kg of acephate 75SP, 1.25 litres of profenophos 50EC.** (c) Carbamctes **2.5 kg of carbaryl 50WP, 3.125 kg of carbaryl 40LV, 1. 5 kg of carbaryl 58, 3.0 litres of carbaryl 42F** (d) Synthetic pyrethroids. **500 ml of cypermethrin 10EC, 200 ml of cypermethrin 25EC 400 ml of deltamethrin 2.8EC, 275 ml of deltamethrin 4EC, 250 ml of fenvalerate 20EC 300 ml of Fluvalinate 25EC, 250 ml of alphamethrin I0EC or asymethrin 5EC.** (e) **150 ml of spinosad 48 SC.**

(iv) **At least 5-6 sprays are required for effective control of bollworms. Same insecticide should not be sprayed repeatedly** to avoid the development of pesticide resistance and appearance of secondary pests. Also, avoid using insecticides of the same group in more than three sprays.

6. Spotted bollworms, *Earias insulana* (Boisduval) and *E. Vittella* (Fabricius) (Lepidoptera: Noctuidae)

These **two species** of bollworms are widely distributed in North Africa, India, Pakistan and other countries and are serious pests of cotton. The full-grown **dull-green caterpillars are 20 mm long having tiny stout bristles and a series of longitudinal black spots on the body.** The moths are yellow green and measure about **25 mm across the wings.** *E. vittella* moths are of the same size and have a narrow light longitudinal green band in the middle of the forewing.

Life cycle. The female moths lay **200- 400 eggs** at night, singly on flower buds, brackets and tender leaves of okra or cotton plants. The eggs hatch in **3-4 days** and the caterpillars passthrough **6 stages**, becoming full-grown in **10-16 days**. They pupate either on the plants or on the ground (during November December) among fallen leaves and the moths emerge in **8-14 days in summer and 18-23 days in winter.** The life cycle is completed (usually August to October) in **17-29days.** Several overlapping generations are completed in a year.

Damage. When cotton plants are young, the larvae bore into the terminal portions of the shoots, which wither away and dry up. Later on, they cause shedding of the fruiting bodies.

The **green bolls attacked by spotted bollworm are often infected by fungi which causes bolls to rot and dry up without opening. The infested bolls called aborted bolls open prematurely and produce poor lint, resulting in lower market value.**

Management. (i) The pest can be suppressed **with clean cultivation and the destruction of alternative food plants** (*Abutilon indicum* Sweet, *Malvastrum tricuspidatum* A. Gray, *Sida* spp) particularly when cotton or okra is not growing in that locality. (ii) The **withering tops** of the plants damaged by the spotted bollworm during June-July should be removed and destroyed to check the multiplication of the pest in the initial stage. (iii) Chemical control measures are same as in case of pink bollworm. The economic threshold level is **10 percent incidence** in shoots or reproductive parts. (iv) *Trichogramma chilonis* and *Trichogramma brasiliense* are the egg parasitoid against spotted boll worm.

7. American bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae)

The American bollworm has become a **serious pest of cotton** in northern parts of India. It was first **reported on cotton in 1977 in Punjab**. In 1983, it appeared in serious form in the northern cotton growing belt and **reduced yield by 40-50 per cent**. Again in 1990, it caused severe losses to cotton in Haryana, Punjab and Rajasthan. It has now become a major pest of cotton all over the country.

Damage. The extent of its damage depends upon the time of attack and the relative length of the effective growing season. The squares, buds, flowers and young bolls are pierced and shed to the ground. **The older bolls are perforated and contents partially eaten resulting in rotting. The growing points of the plants are damaged by young larvae. In case of severe attack even the leaves are eaten up.**

In case of *H. armigera* attack, prefer to use **acephate/chlorpyrifos/ fenitrothion** from the insecticides recommended against the pink bollworm. The **economic threshold level is 5 percent incidence in fruiting bodies**. Cultivation of berseem, tomato, sunflower and groundnut favours the survival of this pest during hot summer months of April-June. Growing Of **arhar and moongin and around cotton fields increases the overwintering population.**

PESTS OF COTTON

COTTON (Gossypium spp.: Family : Malvaceae)

Although **India occupies the largest area** in the world under cotton, it ranks **third in production**.

More than 1326 species of insects have been reported attacking cotton in the World However, **in India, only 162 species have been recorded**, among which only **15 species may be called as major pests** due to their occurrence in serious proportions almost every year.

Sucking pests of cotton :

1. Cotton leafhopper, *Amrascabiguttulabiguttula* (Ishida) (Hemiptera Cicadellidae)
2. Cotton whitefly, *Bemisiatabaci* (Gennadius) (Hemiptera : Aleyrodidae)
3. Cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae)
4. Cotton mealy bug, *Phenacoccusolenopsis* Tinsley (Hemiptera: Pseudococcidae)

Lint stainer :

1. Red cotton bug, *Dysdercuskoennigii* (Hemiptera: Pyrrhocoridae)
2. Dusky cotton bug, *Oxycarenuslaetus* Hemiptera : Lygaeidae

Boll worm of cotton :

1. Pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera - Gelechiidae)
2. Spotted bollworms, *Eariasinsulana* (Boisduval) and *E. Vittella* (Fabricius) (Lepidoptera: Noctuidae)
3. American bollworm, *Helicoverpaarmigera* (Hubner) (Lepidoptera: Noctuidae)

Folliage fedder :

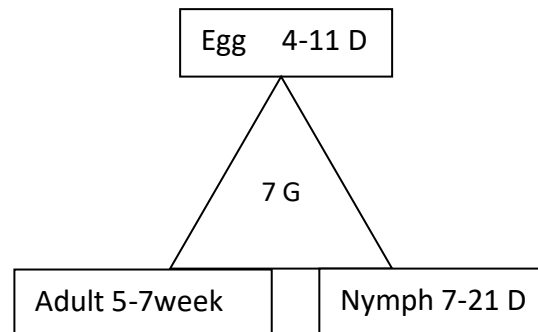
1. Cotton leaf roller, *Sylepta derogate*, Lepidoptera : Pyralidae
2. Bud moth, *Phycitaiainfusella*, Lepidoptera : Pyralidae
3. Cotton semi looper, *Tarachenotabilis*, Lepidoptera : Noctuidae
4. Green semi-looper, *Anomis flava*, Lepidoptera : Noctuidae
5. Cotton grey weevil, *Myllocerusundecimpustulatus*, Coleoptera : Curculionidae

6. Cotton stem weevil, *Pempherulus affinis*, Coleoptera : Curculionidae

Cotton leafhopper, *Amrascabiguttulabiguttula* (Ishida) (Hemiptera : Cicadellidae)

Mark of Identification :-Adult, Very **agile**, **wedge shaped greenish yellow** during the summer, acquiring a **reddish tinge** in the winter. Move **briskly** forward and sideways. **3 mm** long **jump and fly** with slight disturbance and attracted to **light**.

Damage :-Injury to plants is caused both by the **nymphs and the adults** which suck sap from the **foliage** and probably also due to the **injection of toxins** into the plant tissues. The attacked leaves turn **pale yellow and then rust-red**. With change in appearance, the **margins of leaves start curling downwards**, dry up and fall to the ground. In case of severe infestation leaves get a **bronze or brick red color** which is typical **hopper born symptoms**. The leaves **dries up, shed** and growth of plant is retarded. Owing to the loss of plant vitality, the cotton **bolls also drop off**, causing upto **35 per cent** reduction in yield.



Life Cycle :-

- The females lay about **15 yellowish** eggs on **underside of the leaves**, **embedding** them into the **leaf veins**.
- The eggs **hatch in 4-11 days** and give rise to nymphs which are wedge-shaped and are very active. They suck cell-sap from the underside of the leaves and pass through **six stages** of growth in **7-21 days**. On transformation into winged **adults**, they live for **5-7 weeks**, feeding constantly on the plant the juice. The pest completes **seven generations** in a year.

Management :-

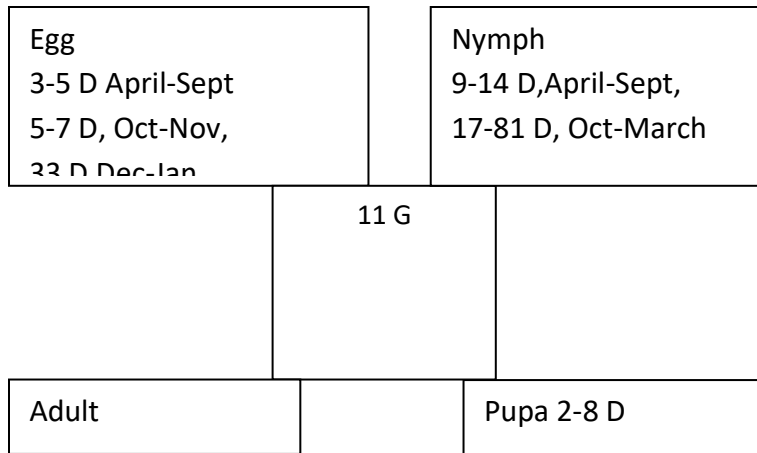
- Economic threshold level (ETL) **2-3 nymphs per leaf** or when **second grade** injury symptoms (yellowing and curling at margins of leaves) appear in **50 per cent** of the plants.
- Resistant variety **Bikaneri Nerma, RST-9, RS 810**
- **10000** (Ten thousand)/ Bigha *Chrysoperla* release in field.
- Use **Light Trap** and also **trap crop Bhendi**.
- Spray the following insecticides.
 1. Imidacloprid 17.8 SL - 0.3 ml/lit
 2. Monocrotophos 36 SL - 2.0 ml/lit
 3. Acephate 75 SP – 2.0 ml/lit
 4. Dimethoate 30EC – 2.0 ml/lit
 5. Thiomethoxam 25 WG – 0.5 gm /lit

Cotton whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera : Aleyrodidae)

Mark of Identification :- Adult : They have **purewhite wings** , their **yellowish bodies** are slightly dusted with a **white waxy powder**. They have **two pairs of pure white wings** and have prominent long hind wings. (In the winged stage, they are **1.0-1.5 mm long**)

Nymph : Louse like, delicate and sluggish creature.

Damage :-The **damage** is caused by both the **nymphs and the adults** by **sucking** the sap from the **leaves**. Insects **exude honeydew** which attracts **sooty mould**. Therefore, in severe infestation, the plants not only become weak, but the mould interferes with the normal **photosynthesis** resulting in poor growth and yield of cotton. **B. tabaci** is known to transmit number of virus diseases including the **cotton,tobacco and sesame leaf curl,, the vein clearing disease of okra**



Life Cycle :-

- Females lay **stalked eggs** singly on the **underside of the leaves**, averaging **119 eggs** per female.
- The eggs **hatch** in **3-5 days** during **summer**, **5-33 days** in **winter**. The nymphs feed on cell-sap and grow into **three stages** to form the **nymph** within **9-14 days** in **summer** and in **17-81 days** in **winter**. In **2-8 days**, the **pupae** change into whiteflies. The total **lifecycle** is completed in **14-122 days** and **11 generations** are completed in a year.
- The pupa of white fly is immobile nymph and **not a true pupa** this is a **homopteran** but called white fly because of presence of pupal stage in life cycle.

Management :-

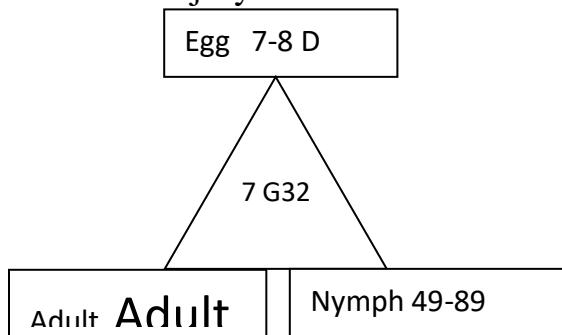
1. *Chrysoperla* (Chrysopidae) and *Brumus* sp (Coccinellidae) prey upon nymphs and adults.
2. **ETL** of white fly :- Adult 8-12/ leaf , Nymph 16-20/ leaf.
3. 8-12 yellow sticky trap/Bigha
4. Predator *Chrysoperla* **12000/ Bigha**
5. Field sanitation
6. Remove **alternate hosts** in surrounding area
7. **Wider spacing and late sowing may be avoided**
8. Adopt **crop rotation** sorghum, Ragi, Maize.
9. Spray following Insecticides for control of white fly
 - i. Triazophos 40 EC - 2.5 ml/lit
 - ii. Imidacloprid 17.8 SL - 0.3 ml/lit

- iii. Methyl demeton 25 EC – 2.0 ml/ lit
- iv. Acetamiprid 20 SP -0.4 gm/lit
- v. Thiocloprid 240 SC 1.0 ml/lit
- vi. Thiomethoxam 25 WG – 0.5 gm /lit
- vii. Difenturon 50 WP – 2.0 gm/lit

Red cotton bug : *Dysdercus koenigii* Hemiptera, Pyrrhocoridae

Mark of Identification:- Adult, **crimson red** with **white band** across the **abdomen**. **Membranous** portion of their **fore wings**, **Antennae** and **scutellumis black**.

Damage :- Both **nymphs** and **adult** **suck the cell sap** from **leaves** and **green bolls** of cotton. **Lint is of poor quality**. The **seed** produced may also have **low germination** and **less oil**. The bug **stains the lint** with their **excreta** or **body juice** as they are **crushed in the ginning factories**. A **bacterium *Nematosporagossypi*** the site of injury and **stain the fibre**.



Life cycle:-

- It **passes winter as adult stage**.
- It lay **eggs in moist soil** or in crevices in ground
- The predaceous bugs like ***Herpactorcostalis*** **feed on nymph and adult**.

Management:-

- **Field sanitation**
- Remove **alternate hosts**
- Follow **crop rotation**
- **Judicious use of fertilizer**
- Spray 750 ml of **oxydemeton methyl 25 EC** or 625 ml of **dimethoate 30 EC** in 250 liters of water /ha

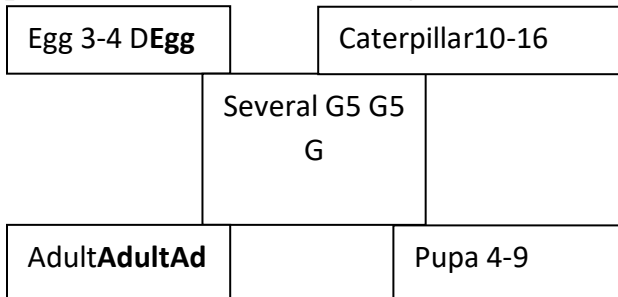
**Spotted bollworms, *Eariasinsulana* (Boisduval) and *E. Vittella* (Fabricius)
(Lepidoptera: Noctuidae)**

Mark of Identification :- Moth of *E.insulana* has **yellowish green** fore wings , while *E. vitella* has **green fore wings with white streak** on each of fore wings.

Caterpillar, dullgreen caterpillar has **bristle** and series of **black spot on the body**.

Damage :-

- Early in the season the **larvabore into shoots** of young plants, which **wither away and dry up**. With the onset of flowering the **larvae damages buds, flowers and bolls**. The infested **bolls open prematurely and drop off**.
- . When cotton plants are young, the larvae bore into the terminal portions of the shoots, which wither away and dry up. Later on, they cause **shedding of the fruiting bodies**. The green bolls attacked by spotted bollworm are often **infected by fungi which causes bolls to rot and dry up without opening**.The infested bolls called aborted bolls open prematurely and produce **poor lint**, resulting in **lower market value**.



Life Cycle :-

- The female moths **lay eggs singly on flower buds, brackets and tender leaves of cotton plants**.
- They **pupate either on plants or on ground among the fallen leaves**.
- The eggs **hatch in 3-4 days** and the caterpillars pass through **6 stages**, becoming full-grown in **10-16 days(caterpillar)**. They **pupate** either on the plants or on the ground (during **November December**) among fallen leaves and the **moths emerge in 4-9 days**. The life cycle is completed (usually August to October) in **17-29days**. **Several overlapping generations** are completed in a year.

Management :-

1. **ETL 10% Damage on flowering parts** either on plants fallen on **ground**
2. Use **egg parasitoid**. Eg. *Trichogrammachilonis* , *T brasilensis*, ,and *Brachymerianephantidis* pupa of *Erias sp.*
3. **Mechanical control**: - Attacked **stem, buds, flowers and bolls** must be **removed** and ultimately **destroyed**.
4. For monitoring **5-10 pheromone trap/ha**
5. Use **Trichogramma 40000/ Bigha**
6. Use *Chrysoperla cornea* **12000/ Bigha**
7. Spray following Insecticides for control of *Erias sp.*
 - i. Fenvelrate 20 EC - 1 ml/lit
 - ii. Deltamethrin 2.8 EC - 1 ml/lit
 - iii. Monocrotophos 36 SL - 2.0 ml/lit
 - iv. Malathion 50 EC – 2 ml/lit
 - v. Chloropyriphos 20EC –5 ml/lit
 - vi. Quinolphos 25 EC – 2 ml/lit
 - vii. Indaxocarb 14.5 SC 1 ml/lit
 - viii. Spinosad 45 SC – .33 ml/lit
 - ix. Flubendiamide 480 SC. 0.4 ml/lit

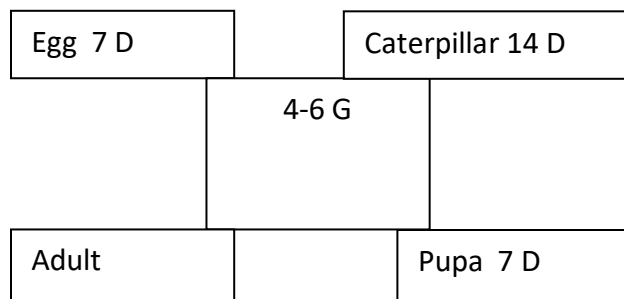
Pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera - Gelechiidae)

Mark of Identification :-The adult is a **deep brown moth**, measuring **8-9 mm** across the spread wings. There are **blackish Spots on the fore wings**, and the margins of the **hind wings are deeply fringed**. Caterpillars, are **white on emergence**, and **turn pink as they grow older**. The **head** of caterpillar is **dark brown**.

Damage :- Soon after emergence, the **larvae enter the flower-buds, the flowers or the bolls**. The holes of entry **close down**, but the larvae continue feeding inside the seed kernels. The attacked squares, buds, flowers (called rosetted flowers) and young bolls fall off pre-maturely. **The infested flowers spun together by larval silks to form a rosette shaped bloom whose bolls fails to open**. Infestation causes **premature opening of bolls** leading to invasion of **saprophytic and other fungi**. The damaged seed-cotton is difficult to pick, discolored and gives a **lower ginning percentage, lower oil extraction** and inferior spinning quality. **The last**

generation do not, however, pupate. They cut window hole in the two adjacent seeds and join them together forming double seed and keep feeding inside the bolls.

Life cycle :-



- The females lay **whitish, flat eggs singly** on the underside of the young leaves, new shoots, flower buds and the young green bolls.
- The last life-cycle is very long covering **5-10 months**.
- **Pupation** on the ground, among fallen leaves, debris.

Management:-

- Parasitoids
 - Trichogramma achaeae* in egg parasite of pink bollworm use **150000 /ha**
 - Apanteles angaleti* parasitizes larvae of this pest other larval parasites are
 - Bracon greeni*
 - Chelonus pectinophorae*
 - Elasmus johnstoni*
 - Gonizus spp., Bracon lefroyi*

Destruction of off season cotton sprout, **alternate host** plants and **burning of plant debris**.

ETL :- 10% Damage on fruiting bodies

Sow the seed between 15th April to 15th may will reduce the infestation

5 pheromone trap/ ha to destroy male moth.

Destroy rosette flower in which larvae of pink boll worm is there.

Spray following Insecticides for control of *Earias* sp.

- Cypermethrin 10 EC – 1 ml/lit
- Cypermethrin 25 EC – 0.4 ml/lit
- Carbaryl 50WP – 4.5 gm/lit
- Triazophos 40 EC - 2.5 ml/lit
- Malathion 50 EC – 2 ml/lit
- Deltamethrin 2.8 EC 1.0 ml/lit
- Flubendiamide 480 SC. 0.4 ml/lit

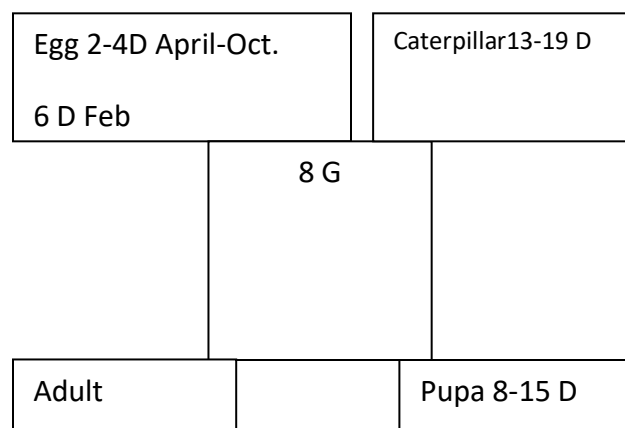
Gram Pod borer or American bollworm, *Helicoverpa armigera* (Hubner)
(Lepidoptera: Noctuidae)

Mark of Identification:-The moth is **stoutly built** and is **yellowish brown** with a **V shaped speck on fore wing**. **Hind wings** are **whitish and lighter in color** with **broad blackish band along outer margin**.

Caterpillar :- **greenish with dark broken grey lines along the side of the body (35 cm long)**.

Damage:-**Small puncture** may be seen on bolls .Larva seen feeding on the bolls by thrusting the head in boll and **half body hanging outside**. The **larvae first feed on the leaves than on the bolls**.

Life cycle:-



1. Moth lays eggs on tender parts of plant
2. They pupate in soil
3. **ETL 5 % damage** in fruiting bodies or **3-4 male moth / pheromone trap/ week 2-3 times**

Management:-

1. **Avoid mono and continuous cropping**
2. **Deep summer ploughing**
3. **Avoid mono cropping** by growing Of less preferred crops like **greengram, blackgram, castor, soyabean** along with cotton as inter crops, border crop or alternate crop.
4. **Remove and destroy crop residue** to avoid the carryover of the pest
5. **Avoid the excessive use of nitrogen fertilizers**
6. **Water management** to prevent excessive vegetative growth and larval harborage
7. **Monitoring** the pest through **light and pheromone** traps
8. Inundative release of **egg parasites Trichogrammaspp @1.5 lac/ha**
9. **Destroy the larvae** by hand collection
10. **10-12 thousand chrysoperla/ Bigha**
11. Apply **NPV @ 0.75ml/l** of water
12. **Neem insecticide** 300 ppm/5.0ml/lit water
13. Spray following Insecticides for control
 - Quinolphos 25 EC – 2 ml/lit
 - Malathion 50 EC – 2 ml/lit
 - Deltamethrin 2.8 EC 1.0 ml/lit
 - Thiodicarb 75 SP – 1.75 gm/lit
 - Ethion 50 EC – 3.0 ml/ lit
 - Indaxocarb 14.5 SC 1 ml/lit
 - Spinosad 45 SC –.33 ml/lit
 - Alphamethrin 10 EC - 0.5 ml/ lit
 - Chlozopyriphos 20EC - 5 ml/lit

Chapter-11.

Pests of Mango (mangifera indica : family : anacardiacea)

Mango is considered to be the **king of all fruits** in south Asia. India is the largest producer and exporter of mango in the world. Mango is rich source of vitamin A and vitamin C. There are a number of insect pests of this fruit and over **175 species** of insects have been reported damaging mango tree but the most abundant and destructive at the flowering stage are the mango hoppers. Important pests of mango are as follows;

1. Mango-hoppers, *Idioscopus clypealis*, *Amritodus atkinsoni* and *Idioscopus niveosparus* : Hemiptera : cicadellidae.

2. Mango mealybug, *Drosicha mangiferae* (Hemiptera) : Margarodidae

3. Mango stem borer, *Batocera rufomaculata* (Coleoptera : Cerambycidae)

3. *Batocera rubus* (Coleoptera : Cerambycidae)

4. Mangofruit fly, *Bactrocera dorsalis* (Diptera : Tephritidae)

5. Mango stone weevil, *Sternochetus mangiferae* (coleopteran : curculionidae)

6. mango shoot borer, *Chlumetia transversa* (Lepidoptera : Noctuidae)

7. Mango gall psyllid *Apsylla cistella* (hemiptera : psyllidae)

8. Mango bud mite, *Acerya mangiferae* (Acarina : Eriophidae)

9. Bark eating caterpillar, *Inderbella quadrinotata* (Lepidoptera : Meterbelidae)

10. Red tree ant, *Oecophylla smaragdina*, (Hymenoptera : formicidae)

11. Mango scale, *Chloropulvinaria psidi*, (Hemiptera : Coccidae)

12. Mango leaf mining weevil, *Rhynchaenus mangiferae*, (coleopteran : Curculionidae)

1. Mango-hoppers, *Idioscopus clypealis*, *Amritodus atkinsoni* and *Idioscopus niveosparus* : Hemiptera : cicadellidae.

Mark of identification : The newly hatched **nymph** are **yellow** and become active in the beginning of February. The **nymphs of *I. clypealis* are dull yellow or dust yellow**, whereas those of *A. atkinsoni* are **pale yellow**, elongated and more active. This insect is **triangular** in shape being **broader at anterior end narrower towards the posterior**. Adults of the larger mango hopper *I. clypealis* measure **6.3 mm** length are **grayish**. There are three dark brown spots on the head, a median band and two black spots on the pronotum. The black triangular marking in scutellum and a central longitudinal dark streak dilated anteriorly and posteriorly, are the characteristic of this species. *A. atkinsoni* adult is about 5.1 mm long. It differ from the larger species by the absence of a central longitudinal dark streak on the scutellum. **Adults of**

mango hoppers are light greenish-brown with black and yellow markings.

Life-cycle. This pest is **active** practically **throughout the year** but during the hot months of May-June and the cold month of October-January, only the adults are found sitting in thounds on the bark of trunk, branches etc. The adult surviving winter **emerge in February from underneath the bark of tree and othe places of shelter.** They **cluster on the floral buds and start sucking the cell- sap .** When the **inflorence appears, they start laying eggs in them** in the **second or third week of February** and continue to do so for some weeks. The eggs are **deposited singly** and since they are **embedded in plant tissues**, it is extremely difficult to observe them under natural conditions. A female deposits on an everage,**200 eggs.** Within **4-7 days in south and 8-10 days in north, the egg hatch.** The **nymphal period lasts 8-13 days in south and 17-19 days in north.**They commence feeding on inflorescence, quickly suck the cell sap and **excrete honeydew** ,which serve as a medium for the development of **shooty mould,Chaetothyrium mangiferae.** This gives **dull blakish look to the mango trees.** The **smoky black appearance persists for many months** until the fruits are mature and the crop is almost over. The full fed nymph then moult and give rise to winged hoppers. The **life cycle is complicated in 15-19 days** during the flowering season, *Idioscopus clypealis (1 generation)*, *Amritodus atkinsoni(3 generation)*per year.

Damage:Mango hoppers are the **most destructive pests** of fruit tree. Injury to the inflorescence and young shoots is caused by egg laying and feeding.The voracious feeding **nymphs are particularly harmful.** They cause the **inflorescence to wither and turn brown.** Even if the flowers are fertilized, the subsequent development and **fruit setting may ceases.** A **sooty mould develops on patches of honey dew exuded by the nymphs.** As the wind blows, the young fruits and **dried inflorescence break of the axil and fall to the ground.** The growth of the young

trees is much retard and the older tree does not bear much fruits. Damage to mango crop may be as high as **60 per cent**.

Management : (1) **do not go for high density planting** as it provides favourable habitat for hopper multiplication.

(2) **do not give regular irrigation** and split doses of nitrogenous fertilizers.

(3) **avoid water logged** and or damp condition.

(4) **pruning of branches** may be done in the **winter** to have better light interception.

(5) spray **2. liters of malathion 50 EC** or **Carbaryl 50 Wp 2.5 kg** in 1250 liters of water.

Mango mealybug, *Drosicha mangiferae* (Hemiptera) : Margarodidae.

The mango mealybug , besides mango, attacks **62 other plants**, including such trees as **jack-fruit, the banyan, guava, citrus spp. and jamun.**

Mark of identification: The **wingless females** are oval, flattened and have body covered with a white mealy powder. The male have **one pair of black wings** and are **crimson red in colour.**

Life cycle: The eggs are generally **deposited in April-May in soil up to 15 cm within silken pores.** The **dead body of the female is often found sticking to them.** They **hatch at the end of December or in January (hatching period 7-9 month)** and, in a given locality, continue to hatch for about one month. Thus, the nymph appears before the fresh growth of flowers on mango trees and nymphal period of female lasts for 77-135 days with 3 instars and male nymphal period lasts 76-134 days with 4 instar and a pupal period as well. The adult duration is 22-27 days. The young **nymphs ascend and congregate on the panicles** where they **feed on cell-sap** and pass through **three stages.** At the time of moulting the young nymphs wander away from the original feeding places in search of suitable shelters such as cracks and crevices in trunk . After moulting, they again seek suitable feeding-sites. The third stage nymphs, however, stick to their original feeding places and destined to be females, continue feeding. The mating takes place soon after emergence of the males at a time when the females are not fully developed. The males fly about large numbers, apparently in search of their mates. They have a very strong sex instinct and during the life span of about one week they mate frequently. The **female** mature after **15-35 days** and lay eggs for 22-47 days during April-May.

Damage: The **nymphs and adult females are destructive** and they **suck plant juice**, causing **tender shoots and flowers to dry up**. The young fruits also become juiceless and drop off. The pest is responsible for causing considerable loss to the mango growers and when there is a serious attack, the **tree retains no fruit at all**.

Management: (1) **remove weeds** from orchards which acts as additional hosts for mealybug
(2) **ploughing of orchards** during summer exposes eggs to natural enemies and extreme sun heat.

(3) nymphs should be prevented from crawling up the tree by applying **8 cm wide sticky bands with alkathene or plastic sheets** around the trunk about one meter above the ground level during second week of December .

(4) The nymphs found **congregating below the lower edges of alkathene band should be killed mechanically or by spraying them with 500 ml of methyl parathion 50 EC in 1250 l of water per ha**.

3. Mango stem borer, *Batocera rufomaculata* *Batocera rubus* (Coleoptera : Cerambycidae)

Mango stem bore is a pest of mango, fig and other tree in north –western part of the india.

Mark of identification : The adults are **5 cm long and 2 cm breath, yellowish brown longicorn beetles**, well built, and large. The beetle is provided with long legs and antennae and a dirty white band, extending from the head to tip of the body on each side. A number of **dirty yellowish spots are present on the elytra**. The full grown larva is a **stout, yellowish- white, fleshy grub, measuring about 6cm in length**.

Life cycle : The adult deposit eggs under the loose bark in a wounded or diseased portion of the trunk or branch. The **eggs hatch in 7-14 days**. The grub are equipped with strong biting mouth parts and they penetrate into the stem or even the roots, feeding on woody tissues. Winter is passed in the grub stage in that very burrow. They make large galleries for feeding. The full grown larva then hollow out a cell for pupation. The **larval stage probably lasts more than a year and the pupal stage last about one month**. The **life cycle may be completed in 1-2 year**.

Damage : Although the borer is not very common, yet whenever it appears in the **main trunk or a branch**, it invariably kill the host. Though the external symptoms of attack are not always visible, the site can be located from the **sap or frass that come out of the hole**.

Management :

(1) **cut and destroy** the infested branches with grub and pupa within.

(2) **remove frass near** the hole on main stem and inject 4 ml of methyl parathion 50 EC mixed in one litre of water into the hole and plug it with mud.

Mangofruit fly, *Bactrocera dorsalis* (Diptera : Tephritidae)

The mango fruit fly or **Oriental fruit-fly** is the most serious of all fruit flies, it attacks on mango, guava, peach, apricot, cherry, pear, chiku, ber, citrus and other more than 250 plants.

Mark of identification : The adult is stout, a little larger than the housefly, is **brown or dark brown** fly and has **transparent or hyaline wings and yellow legs**. The legless maggots are **yellow and opaque**. The other fruit flies damaging mango fruits are *Dacus zonatus*, *D. correctus*, *D. diversus* and *D. hageni*. Which, though less common than *D. dorsalis*, cause similar damage.

Life cycle : The adult flies **emerge in April** and start laying eggs under the rind of the ripening fruits and vegetables of the season such as guava, laquat, apricot, plum, brinjal, and later shift to mango. They lay 2-15 eggs at a time in clusters. A female lays on an average, **50 eggs** but under favourable conditions, 150 eggs are laid in one month the **eggs hatch in 2-3 days in march april and 1-1.5 days in the summer and 10 days in winter**. As the maggot develop they pass through **3 stages** in the ripening pulp and are full grown in **6-29 days**. They leave the fruit and move away by jumping in little hope. On reaching a suitable place, they burry themselves into the soil and pupate 8-13 cm below the soil surface. In 6-44 days, they emerge as flies and reach the ripe fruit for further multiplication. The **life cycle** is completed in **2-13 weeks** and **many generations** are completed in a year.

Damage. The damage is caused **both by maggot and adults**. The adults feed on exudation of ripe fruits and honeydew of various insects. The punctures for egg laying made by the females attract fermenting microorganisms. The maggot destroy the pulp making it **foul smelling and discoloured**. The fruit develop brown rotten patches on them and **fall to the ground** ultimately. The infested fruits become **unmarketable** and at times almost all of them contain maggots.

Management : (1) Avoid infestation of fruit flies **by early harvesting** of mature fruits.

(2) To prevent the carryover of the pests, **collect and destroy all fallen infested fruits** twice in a week.

(3) **Plough round the tree** during winter to expose and kill the pupae.

(4) Monitor the fruit fly population in orchards by using **methyl eugenol traps**.

(5) Spray **1.25 litres of malathion 50 EC + 12.5 kg gur or sugar in 1250 litres of water** per ha and repeat spray at 7-10 days intervals if infestation continues.

(6) After harvest dip the fruit in 5 per cent sodium chloride solution for 60 minutes to kill the eggs, if any and also to decontaminate them of insecticide residue if at all present.

Guava (*Psidium guajava* Family : Myrtaceae)

Guava fruit fly, *Bactrocera dorsalis* (Diptera : Tephritidae)

The guava fruits are attacked by five species of flies, viz., *Bactrocera dorsalis*, *B. diversus*, *B. curcubita*, *B. nigrotibialis* and *B. zonata*, however, among these, the former two are most common and serious pests of guava.

Management : (1) a thorough clean cultivation/ sanitation of orchard is essential in reducing the pests infested fruits and bury them in at least 60 cm deep pit. The pit may be covered with clay after every 2-3 days and should not be allowed uncovered for a longer period.

(2) Avoid taking rainy season crop which may get heavily infested by the pest.

(3) plough and stir the soil well before June- July to expose and kill pupae.

(4) harvest the fruit when slightly hard and green in colour.

(5) Fix methyl eugenol based PAU fruit fly traps @ 40/ ha in the first week of July and recharge the same if required.

(6) in orchards spray 3.15 liters of fenvalrate 20 EC in 1250 litres of water/ ha at weekly intervals on ripening fruits from July onwards till the rainy season crop is over, fruit should be harvested at least after 3 days of spray.

Pests of Mango (*Mangifera indica* : family : anacardiaceae)

Mango is considered to be the **king of all fruits** in south Asia. India is one of the largest producer and exporter of mango in the world. Mango is rich source of **vitamin A and vitamin C**. Mango is attacked over **175 species** of insects. The most abundant and destructive at the **flowering stage** are the **mango hoppers**. Important pests of mango are as follows ;

1. Mango-hoppers, *Idioscopus clypealis*, *Amritodus atkinsoni* and *Idioscopus niveosparus* : Hemiptera : cicadellidae.

2. Mango mealybug, *Drosicha mangiferae* (Hemiptera) : Margarodidae

3. Mango stem borer, *Batocera rufomaculata* (Coleoptera : Cerambycidae)
3. *Batocera rubus* (Coleoptera : Cerambycidae)
4. Mangofruit fly, *Bactrocera dorsalis* (Diptera : Tephritidae)
5. Mango stone weevil, *Sternochetus mangiferae* (coleopteran : curculionidae)
6. mango shoot borer, *Chlumetia transversa* (Lepidoptera : Noctuidae)
7. Mango gall psyllid *Apsylla cistella* (hemiptera : psyllidae)
8. Mango bud mite, *Acerya mangiferae* (Acarina : Eriophidae)
9. Bark eating caterpillar, *Inderbella quadrinotata* (Lepidoptera : Meterbelidae)
10. Red tree ant, *Oecophylla smaragdina*, (Hymenoptera : formicidae)
11. Mango scale, *Chloropulvinaria psidi*, (Hemiptera : Coccidae)
12. Mango leaf mining weevil, *Rhynchaenus mangiferae*, (coleopteran : Curculionidae)

Chapter-12

Pests of Citrus (citrus spp, family: Rutaceae)

Citrus psylla, *Diaphorina citri* (Hemiptera: Aphalaridae)

Appearance: The insect is brown with its head lighter brown and pointed. The wings are membranous, semitransparent; with a brown band in the apical half of the fore wings. The hind wings are shorter and thinner than the fore wing. The nymphs are flat, louse like, orange yellow creatures, and are seen congregated in

large number on the young leaves and buds. The adult tail end body being turned upward.

Host plant: on all species of citrus and a number of other plant of the family Rutaceae. It is the most destructive pests of all the citrus pests.

Active period: Winter, February –March.

life cycle: The female lay ,on an average 500 almond- shaped, orange and stalked egg on tender leaves and shoots of citrus tree. The eggs hatch in 10-20 days in winter and 4-6 days in summer. There are five nymphal stsges and the development is complited in 10-11 days from April to September, 15-20 days in the spring and autumn,and 34-36 days in December-January.the female live longer than the males, and the duration may be as long as 190 days in winter and only 12-26 days in the summer. There are 8-9 overlapping generation in a year.

Damage: Damage is caused by nymph and adult. With the help of their sharp, piercing mouth parts, they suck the cell-sap in millions. The vitality of the plants deteriorates, and the young leaves and twigs stop growing further. The leaf-buds, flower, buds and leaves may wilt and die. The fruit formed in the spring fall off prematurely. Moreover, the nymph secrete drop of a sweet thick fluid in which a black fungus develops, adversely affecting photosynthesis. It is also thought that the insects produces a toxic substance in the plants as a result of which the fruit remain undersized and poor in juice and insipid din taste. This insect is also responsible for spreading the greening virus.

Managemnt: (1) tetrastichus radiates (Eulophidae)is an important parasitoid of nymphs. A number of lady bird beetles , viz. Coccinella septempunctata,C.transversalis, Menochil chilus sexmaculatus, , Brumoides suturalis and Chrysoperla carnea larvae also feeds on nymphs.

(2) spray 1.70 liters of dimethoate 30 EC or 1.50 liters of monocrotophos 36 SL in 1250 liters of water per ha during February- March (Spring flush) May- June (before rainy season) and July- August (after rainy season).

Citrus caterpillar, *Papilio demolleus* (Lepidoptera:papilionidae)

Appearance: Caterpillar is yellowish green, horn like structure in the dorsal side of the last body segment (40 mm L and 6.5mm W). the adult is a large beautiful butterfly with black and yellow marking on the fore wing, there being a creamy-yellow colouration on the underside of the abdomen.

Host plant: Feed and breed on all varieties of cultivated or wild citrus and various other species of family Rutaceae.

Active period: This pest is most active in September and October.

Life cycle: The butterfly appears in March and lays egg in tender shoots and fresh leaves mostly on the underside. The eggs are placed singly or in group of 2-5. The eggs are glued firmly on to the surface of the leaf and are pale or greenish yellow in colour. They hatch in 3-4 days during summer and 5-8 days in winter. The larval life lasts 8-16 days in the summer and about 8-16 weeks during November –December. The black or brown and white markings make the larvae look like bird droppings. The pupal stage lasts about 8 days in the summer, and 9-11 days in the spring autumn. The pest possesses three or four generations in a year. Since there is an overlapping generation in a year, all the stages of the pest are found throughout the year.

Damage: The young larvae feed only on fresh leaves and the terminal shoots. Habitually, they feed from the margin inwards to the midrib in later stages, they feed on mature leaves and sometimes the entire plant may be defoliated. This pest is particularly devastating in nurseries and its damage to foliage seems to synchronize

with fresh growth of citrus plants in April and August- September. Heavily attacked plants bear no fruit.

Management: (1)The egg parasitoids associated with this pests are Trichogramma evanescens and Telenomus sp while the larvae is parasitized by Brachymerria sp.

(2) hand picking of various stages of the pest in nurseries and field and their destruction will suppress their population.

(3) Spray Bacillus thuringiensis , DD-136 and neem seed extract (3%) give effective control.

(4) spray following insecticide%

(a) quinalfops 25 EC @ 2.0 liters

(b) Carbaryl 50 WP @ 2 kg per ha in 1250 Liters of water.

Bark eating caterpillar, *Indarbela quadrinotata*, Lepidoptera : Metarbelidae.

The bark-eating caterpillars feed on citrus, mango, guava , jamun, laquat, mulberry, pomegranate, ber, drumstick, litchi, amla, rose and a number of forest and ornamental trees.

Mark of identification: The adults are pale brown moths with rufous head and thorx. The fore wings are pale rufous with numerous dark rufous bands. Their hind wings are fuscous. The freshly larvae are dirty brown while the full grown caterpillars (50-60mm) have pale brown body with dark brown heads.

Life cycle: The female lays eggs in cluster of 15-25 eggs each, under the loose bark of the trees. As many as 2000 eggs may be laid by a single female. The egg hatch in 8-10 days and the freshly hatched larvae nibble at the bark and after 2-3 days bore inside. The larvae have the habit of making webs along the feeding galleries and the webs above them have a zig-zag shape and contain wooden frass and excreta. The larvae take as many as 9-11 months to complete development. Ehen full grown, they male hole into the wood and pupate inside. The pupal stage lasts 3-4 weeks. The moth emerges in summer and they are short lived. Only one generation is completed in a year.

Damage:Thick ribbon like, silken webs are seen running on the bark of the main stem especially near the forks. The larva also make holes as many as 16 may be seen in a tree, one caterpillar occupying each hole. A severe infestation may result in the death of the attacked stem but not of

the main trunk. There may be interference with the translocation of cell sap and thus arrestation of growth of the tree is noticed with the resultant reduction in its fruiting capacity.

Management: (1) Clean cultivation is essential to prevent infestation of these borers.

(2) As soon as infestation is noticed, kill the caterpillars mechanically by inserting an iron spike into the holes made by these caterpillars.

(3) During February – March insert into the borer holes insecticides-soaked cotton swab or plugs (with the help of metallic spike) and plaster on the outside with mud.

(4) The insecticides for 100 litres of water are 40g carbaryl 50 WP or 2 ml dichlorvos 76 EC or 5 ml methyl parathion or 10 ml monocrotophos 36 SL . These chemicals should be applied after removing webbing.

(5) Treat all alternate host plants in the vicinity of the orchard.

Chapter-13

Pomegranate

Anar Butterfly, *Virachola Isocrates* (Lepidoptera:lycaenidae)

Appearance: Butterfly: male is **bluish-violet** while , Female is **brownish violet** with an **orange patch** on fore wings .

Caterpillar, **dark brown** and have short hair and **whitish patches** all over the body.

Host plant(Polyphagous) Aonla, apple, ber, citrus, guava, litchi, loquat, mulberry, peach, pear, plum, sapota, tamarind and pomegranate.

Active period:

Life cycle: The female butterfly lays shiny white oval shaped eggs on the calyx of flower and on small fruits.

The eggs hatch in 7-10 days. The larval period lasts for 118

They pupate inside the fruit but occasionally may pupate outside even attaching themselves to the stalk of the fruit.

The pupal period lasts 7-34 days.

There are four overlapping generations in a year.

Damage: the caterpillar damage the fruit by feeding inside and riddling through the ripening seeds of pomegranate. As many as eight caterpillars may be found in a single fruit. The infested fruits are also attacked by bacteria and fungi which cause the fruit to rot. The affected fruits ultimately fall off and give an offensive smell. This pest causes 40 to 90 per cent damage.

Management:(1) Bagging of fruits before maturity will help in checking damage.
 (2) collection and destruction of fallen infested fruits prevent build up of the pest.
 (3) remove flowering weeds especially of compositae family.

Spray young fruits with 1.75 liters of quinalphos 25 EC in 1250 liters of water per ha during May-June at 15 days interval. 2-3 sprays are enough.

Pests of Ber (*Zizyphus mauritiana*:family:Rhamnaceae)

Ber fruitfly, *Carpomyia visuviana* (Dipteral: Tephritidae)

Appearance: Adult fly: **Brownish yellow**, with **brown longitudinal stripes on the thorax** surrounded by black spots on the side and back of the body. **Greyish brown** spots on the wings and **bristly hairs on the tip of the abdomen**.

Larvae: creamy white and slightly smaller than the other fruit flies.

Host plant: *Zizyphus mauritiana*, *Z. jujube* and *Z. sativa*.

Active period: August to mid November.

Life cycle: The flies lay eggs in skin of fruit. The egg hatch in two to three days. The larval period lasts for **7-10 days**. The **pupal stage** lasts for **14-30 days**. There are **2 to 3 brood** in a year. The pest is active in winter and hibernate in the soil from April to August in the pupal stage in the soil.

Egg	2-3 days	Larva
	2-3 G	7-10 daya
Adult	14-30 days	Pupa

Damage: The fly make cavities in the skin of fruit. The maggots feeds on the flesh of the fruit, making galleries toward the center. Such fruits rot near the stone. There are as many as 18 maggots have been recorded in a fruit. The fruit become deformed and there is no further growth of the fruit in the vicinity of this puncture. Fleshy varieties of ber are

more seriously damaged than the less fleshy ones. The attacked fruits are rotten near the stones and emit a strong smell.

Management: (1) collect and destroy the fallen infested fruits at alternate days.

(2) Rake the soil around the trees during the summer to expose the pupas to heat and natural enemies.

(3) To escape egg laying on fruits, do not allow the fruits to ripen on the tree, harvest at green and firm stage.

(4) Spray 1.25 liters of dimethoate 30EC in 750 liters of water ha⁻¹ during pea fruit stage.

Ber beetles, (*Adoretus pallens* and *Adoretus nitidus*) Coleoptera :Scarabaeidae)

Appearance: Beetle: the beetles are bright yellow colour and yellowish brown shiny wings. Their legs are deep red and 9-13 mm long.

Host plant: Ber and grapevine.

Active period: This pest is active during summer and passes the winter in larval stage.

Life cycle: It lays white, smooth, elongate eggs, singly in the soil near the host plant. Eggs hatch in 6-9 days during May to August. The whitish grubs feed on soil humus, roots of grasses and other vegetable matter found under or near the ber tree. The full grown grubs are creamy white and they make an earthen cell in the autumn and hibernate through the whole of winter. Pupation takes place sometimes during next April and the adult emerge after 11-12 days (pupa). There is only one generation in a year.

Damage: The damage is done by adult beetles by cutting round hole in the leaves during the night. The ber trees are sometimes so heavily damaged that the entire foliage may disappear and such trees do not bear any fruit. The attack starts early in the spring and continues up to August.

Management: (1) Light traps are quite effective in trapping the adult beetles.

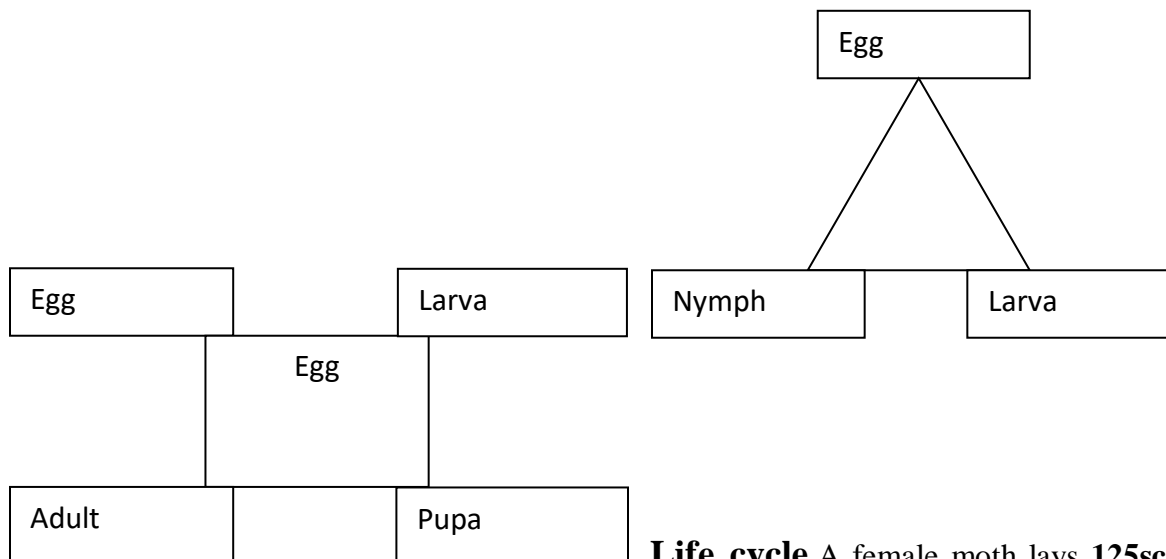
(2) Raking around the tree is useful in exposing the hibernating grubs and killing them.

(3) Spray quinalphos 25 EC @ 1.5 lit, Carbaryl 50 WP @ 2.5 kg or monocrotophos 36 SL @ 1.5 Lit in 750 Liters of water per ha¹ .

Chapter-14.

Black-headed caterpillar, *Opisina arenosella*, Lepidoptera : xyloryctidae.

This is one of the most important pests of coconut palm. The moth is **ash grey coloured**. It is medium sized, measuring **10-15 mm**, with wing expanse of **20-25 mm**.



Life cycle. A female moth lays **125 scale like eggs** in small batches on the **underside of tip of old leaves**. Freshly laid eggs are **creamy white and turn pink** on completion of embryonic development. The **incubation period** lasts about **3-5 days** in summer and **10 days in winter**. The larvae feed on green matter and simultaneously construct silken galleries in which it feeds and voids frass. When full grown in about **40 days**, the larva transformed itself into a brownish pupa inside the gallery. Within

about **12 days**, a whitish moth emerges and native parasitoids, *Goniozus nephantidis* and starts the life cycle all over again. The *Bracon brevicornis* at 3000 and 4500 per ha caterpillar is parasitized by *Apanteles* respectively have given encouraging results for *taragamae*, **Bracon brevicornis**, and management of black head caterpillar.

Elasmus nephantidis. Inundative release of

Damage: As a result of the **numerous galleries** made by the feeding caterpillars, the foliage dries up. infested tree can be located or recognize from the **dried up patches in the fronds**. In cases of severe attack due to large scale drying of leaflets, the whole plantation presents a **burnt up appearance** from a distance, results in a considerable reduction in yield.

Management: apply **2.5 liters of chloropyrifos 20 EC** in 625 litres of water per ha.

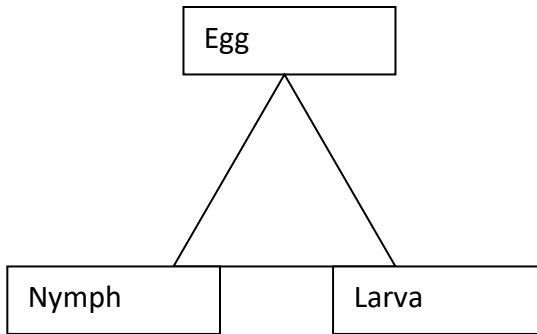
Pests of apple

San jose scale, *Quadraspidiotus perniciosus* (Hemiptera : Diaspididae)

Appearance: the scale which forms a covering on the body of the insect is **black or brown**. Underneath, a **lemon-yellow** insect is visible when the covering is lifted.

Host plant: prefer Rosaceae family plants such as **plum, pear, current, willow, hawthorn and rose**.

Active period: **March to December**



Life cycle: The San Jose scale gives birth to young ones, each female may give birth to 200-

400 nymphs. They become full-grown in 3-40 days and the females again start giving birth to young ones within the next 10-14 days. The gravid mothers live for about 50-53 days. The male hardly live for 24-32 hours. Four overlapping generations are completed in a year.

Damage: The nymph find a suitable place on the host, they insert their mouth parts in to the plant tissue and begin to feed by sucking the cell-sap. All the parts of the plant above the ground are attacked and the injury is due to loss of the cell-sap. At first, the growth of the infested plant is checked, when the scale increases in number, the infested plant may die.

Management: (1) Sanitation of orchard, infested pruned material should be collected and burnt.

(2) The parasite *Encarsia perniciosi* and *Aphytis sp.*

Proclia may be released to check the overwintering on the wild host plant.

(3) To check the plant in nursery, apply carbofuran granules @ 0.75-1.0 g a.i. per plant.

(4) Spray 625 ml of methyl parathion 25EC in 500 liters of water.

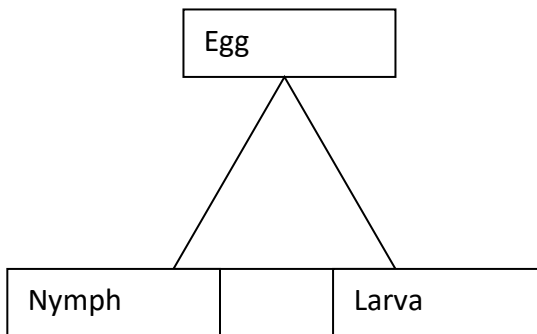
(5) Spray diesel oil emulsion+Bordeaux mixture (diesel oil 68 ltrs+ copper sulphate 15 kg +unslacked lime 3.37 kg) to be emulsified and diluted 5-6 times before spraying.

Woolly apple aphid, *Eriosoma lanigerum* (Hemiptera : Aphididae)

Appearance: Purplish aphid covered with white cottony mass.

Host plant: Apple, pear, crab-apple, hawthorn and mountain ash etc.

Active period: March to December.



Life cycle: The aphids reproduce parthenogenetically and the progeny thus produced, consists of females only. Each female may produce up to 116 young ones in her life time at the rate of 1-4 nymphs per

day. The total duration of nymphal period is 35-42 days in February, 29.5 days in August-November, and 10.5-19.5 days in April-july. There may be 13 generations in a year. There is a partial migration from aerial parts to the roots of infested plants (**December**) and the reverse migration from the roots to the aerial parts takes place in(**May**).

Damage: Both nymphs and adults suck the cell-sap from the bark of the twigs, fruit stalk, calyx and from the roots underground. Swelling or knots appear on

the roots which hinder the normal plant functions. Owing to the loss of cell-sap, the twigs also shrivel and the young nursery plants may die quickly.

Management: (1) Use of resistant root stock like **Golden Delicious and Northern Spy**.

(2) Release specific parasitoid *Aphelinus mali* which attacks the 4th and 5th stage nymph.

(3) Select healthy plants from nursery and treat them with **chloropyriphos 0.5 %** before planting.

(4) During **leaf fall** stage spray the plants with **methyl parathion 3.0** ltrs in 1250 ltrs of water per ha, spray **oxydemeton methyl 25 EC 3.0 ltrs in 1250** ltrs of water for **controlling root forms**. Spray the plants with **malathion 50 EC 2** ltrs in 1250 ltre of water during **summer**.

(5) Carry out fumigation against root forms with **paradichlorobenzene granules** in 15 cm deep trench dug around the infested tree, about 2 meters from

Chapter-7.

Pests of vegetables crops

Insect Pests of Brinjal (*Solanum melongena* ; family : solanaceae)

1. Brinjal fruit and shoot –Borer, *leucinodes orbonalis* (lepdoptera : pyralidae)

Appearance: : Moth , **white** but has **pale brown or black spot** on the dorsum of the thorax and abdomen (20-22mm).

Wings : **white with a pinkish or bluish tinge** and have small hairs along the apical and anal margin.

Caterpillar: **Creamy white** when young, but **light pink** when full grown.

Host plant: Solanaceous plants and green pods of pea also.

Active period: March-April.

Life cycle: egg, creamy white egg on under surface of leaves, stem, flower buds and calyces of fruit. Hatching period 3-6 days. Larval period 9-28 days. Pupal stage in the fallen leaves 6-17 days. 5 overlapping generation.

Damage: The young caterpillar bore into the tender shoot near the growing point into flower buds and into the fruits. The growing point of the plant killed. One caterpillar may destroy as many as 4-6 fruits. The damage to fruit particularly in autumn, is very severe.

Management: (1) Remove and destroy the infested fruit.

(2) Avoid continuous cropping of brinjal crop.

(3) do not ratoon the brinjal crop.

(4) spray carbaryl 50 wp @ 4 gm or formathion 50 EC @ 1 ml or Acephate 50 EC @ 0.5 gm quinalphos 25 EC, trizophos 40 EC and monocrotophos 36 SL @ 2 ml per litres of water.

2. Tomato Fruit Borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae)

Host plants: Peas, tomato, cotton, maize, tobacco, safflower, groundnut, chillies etc.

Marks of identification:

Adult: Moth is stout with dark yellow olive grey or brown wings crossed by a dark band near outer margin and a dark spot near costal margin of forewings and hindwings pale with a dark apical border.

Larva: Full grown caterpillar is cylindrical 40 – 48 mm in length with variable colour, dark green or reddish brown or brownish and marked with a white broken lines and a prominent white line along lower part of sides.

Life cycle:

Yellowish shiny, sculptured eggs are laid singly on tender parts of plants. Each female lays 300-400 eggs. Egg period is 2-4 days. Larval period 18-25 days. Full grown caterpillar drops down and pupates in soil. Pupa is dark brown and adult emerges in 6-21 days.

Damage:

- The larvae scrape the tomato foliage until early or late second instar stage.
- Thereafter, the larva bores into the fruit making it unfit for marketing.
- In severe cases of infestation, more than 80 per cent fruits get damaged

Management:

1. Deep ploughing after harvesting the crop to expose the pupae for natural killing affords good protection.

2. **Hand picking** of larvae in small area is also recommended.
3. Use of **African marigold** as a **trap crop** is useful for control of fruit borer.
4. Give three sprays at 2 week intervals starting from the initiation of flowers with any of the following insecticides using 250 litres of water/ha :

2.0 litres of endosulfan 35 EC

2.0 kg of **carbaryl 50WP**

250 ml of **fenvalerate 20 EC**

500 ml of cypermethrin 10 EC,

400 ml of **deltamethrin 2.8 EC**,

4.5 litres of **profenophos 50EC**

4.6

3.Spotted Bollworms, *Earias insulana* (Boisduval) and *E. vittella* (Fabricius) (Lepidoptera: Noctuidae)

The shoots infested with borer droop downwards and dry up. The infested **fruits have a varying number of holes.**

Management:

- (i) Plant resistant varieties, viz. **Vaishali Madhu and Sel-6-l.**
- (ii) Remove regularly the attacked fruits and **bury deep in the soil.**
- (iii) Uproot hollyhoek and the ratooned cotton, which are host plants for bollworms.
- (iv) Spray the crop when damage **20-30 per cent shoots show borer** with 1.0 litre of **monocrotophos 36SL** or 250 ml of **fenvalerate 20EC** or 400 ml of **deltamethrin 2.8EC** or **200 ml of cypermethrin 25EC** in **250-300 litres of water/ha.**

POTATO (*Solanum tuberosum*) and TOMATO (*Lycopersicon esculentum* Mill.)

Family: Solanaceae

4. Potato Tuber Moth, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae)

This pest occurs especially in **hot and dry** climates. It is destructive to **potato** and also attacks **tobacco, tomato, brinjal and solanaceous weeds.** It is particularly **serious on potato in Himachal Pradesh.** The **larvae** cause the damage and are recognized as **pinkish-white or greenish caterpillars, with dark-brown heads.** They are about **20 mm** in length. The **adult** is **very small narrow-winged nocturnal** moth, about **13 mm** across the wings when spread, It is **greyish brown with mottling of dark brown.** Another species of tuber moth attacking potato is ***P. heliopa* (Lower)**

Life-cycle:

If food is available and the climatic conditions are favourable, this pest may breed throughout the year. In **cold weather**, the life-cycle is much **prolonged**. Early in the **spring**, the **moths escape** from **store-houses** and **start breeding in fields**. A female, on an average, **lays 150-200 eggs singly on the underside of leaves or on exposed tubers**. The larvae first produce **botch mines on leaves but subsequently, they work their way into the stems**. The **larval stage in summer lasts 2-3 weeks** and the **mature larva pupates in a grayish silken dirt-covered cocoon**, which is about 13 mm in length. The **moths emerge in 7-10 days**. They complete their life-cycle about **one month and there are usually 5-6 generations in a year**.

Damage:

- In **warm dry climates extensive damage** may be done to the crop; but the potato tubers kept in cold stores escape damage.
- Later generations in the field infest the **tubers** also.
- At the time of **digging, the moths may lay eggs on tubers**. The larvae, on hatching, may work their way just under the skin and, later, may make tunnels through the flesh, causing damage to the **tubers**.

Management:

1. All the **infested tubers should be removed** and destroyed.
2. **Cold storage of tubers also helps in suppressing the pest**.
3. The pest can be checked by spraying **2.5 kg of carbaryl 50 WP in 625 litres** of water per ha or by **dusting seed potato with 150 g of malathion 2 per cent per 100 kg**. Repeat spraying 2-3 times at fortnightly intervals and do not dust the edible potatoes.
4. If **potato tubers in the stores get infested**, fumigation with **carbon disulphide @ 2-3 litres per 100 m³** should be done.

5. Pea Stem Fly, *Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae)

It is **sporadic pest**.

Hosts: Peas, *Phaseolus mungo* L., *Phaseolus aconitifolius* Jacq., soybean, *Glycine max* Mer., cowpeas, *Vigna catjans* Walp. and *Lablab niger* L.

Marks of identification:

Larva : Yellowish maggots and are leaf-and stem-miners.

Adult : The adult flies are metallic black.

Life-cycle:

The flies are **active in summer** and mate 2-6 days after emergence. The female **lays 14-64 elongate, oval and white eggs into the leaf tissue** with the help of its elongated ovipositor. The **eggs hatch in 2-4 days** and the **maggots on emergence feed on leaf tissue** at first but later on move to the

terminal stems. They pass through three instars and the larval development is completed in 6-7 days in March-April and 9-12 days in November and December. The larva pupates within its gallery and the pupal period lasts 5-9 days in March and April, and 18-19 days in November and December. The female flies live for 8-22 days and the males for 11 days. The pest completes 8-9 generations from July to April and shifts from one host plant to the other in various seasons. It passes winter as larva or as pupa.

Damage:

- ✓ The maggots bore into the stem thereby causing withering and ultimate drying of the affected shoots, thus reducing the bearing capacity of the host plants.
- ✓ The adults also cause damage by puncturing the leaves, and the injured parts turn yellow. The damage is more severe on seedlings than on the grown up plants.

Management:

- (1) Avoid sowing of the crop earlier than mid-October to check the attack of the pest.
- (2) Remove and destroy all the affected branches during the initial stages of attack.
- (3) Sow the crop in the second fortnight of October to escape the damage of the pest.
- (4) Apply 7.5 kg of phorate 10G or 25 kg of carbofuran 3 G per ha in furrows at the time of sowing.
- (5) On the crop, spray three times 750 ml of oxydemeton methyl 25EC in 250 litres of water per ha. The first application should be just after germination and the other two at an interval of 2 weeks each.

Chapter-8.

Onion

Botanical name : *Allium cepa* L.

Family : *Alliaceae*

S.No	Pest	Scientific name	Order	Family
	Onion Thrips	<i>Thrips tabaci</i>	Thysanoptera	Thripidae
	Onion Maggot	<i>Delia antiqua</i>	Diptera	Anthomyiidae

1. Onion Thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae)

Onion thrips is world-wide and is found throughout India as a major pest of onion and garlic.

Other Hosts: Cotton, cabbage, cauliflower, potato, tobacco, tomato, cucumber etc.

Marks of Identification:

Adult: The adults are slender, yellowish brown and measure about 1 mm in length. The males are wingless whereas the females have long, narrow strap-like wings, which are furnished with long hair along the hind margins.

Nymph: The nymphs resemble the adults but are wingless and slightly smaller.

Life-cycle:

This pest is active throughout the year and **breeds on onion and garlic from November to May** when it migrates to cotton and other summer host plants and breeds there till September. In **October**, it is found on **cabbage and cauliflower**.

The adult female lives for 2-4 weeks and lays **50-60 kidney-shaped eggs singly in slits which are made in leaf tissue with its sharp ovipositors**. The eggs **hatch in 4-9 days** and the **nymphs start feeding on plant juices by lacerating the leaf tissues**. On onion and garlic, they are usually **congregated at the base of a leaf or in the flower**. On cotton, cabbage and cauliflower, they generally feed on the lower surface of leaves. The **nymphs pass through four stages and are full-fed in 4-6 days**, after which they descend to the ground and **pupate at a depth of about 25 mm**. The **pre-pupal and pupal stages last 1-2 and 2-4 days**, respectively. **Several generations** are completed in a year.

Damage:

- **Damage** is done by **adults as well as by nymphs**.
- In onion and garlic, the **leaves of attacked plants become curled, wrinkled and gradually dry up. The plants do not form bulbs nor do the flowers set seed**.
- In cotton, the leaves become wrinkled and fall off and the plants bear very few bolls.
- In Hawaii, *T. tabaci* is known to act as a vector of streak -virus disease of peas and yellow-spot of pineapple.

Management:

- ✓ **Spray 625 ml of Malathion 50 EC in 250 litres of water per ha as soon as the pest appears**. A waiting period of 7 days should be observed before harvest.

Chapter-10.

CUCURBITACEOUS VEGETABLES(SUMMER VEGETABLES)

Cucurbits are attacked by several species of insect pests, among which fruit flies and pumpkin beetles are important.

S.No	Pest	Scientific name	Order	Family
	<i>Melon Fruit-fly</i>	<i>Bactrocera cucurbitae</i>	<i>Diptera</i>	<i>Tephritidae</i>
	<i>Red Pumpkin-</i>	<i>Aulacophora</i>	<i>Coleoptera</i>	<i>Chrysomelidae</i>

	<i>beetle</i>	<i>foveicollis</i>		
	<i>Red vegetable mite</i>	<i>Tetranychus telarius</i>	<i>Acarina</i>	Tetranychidae

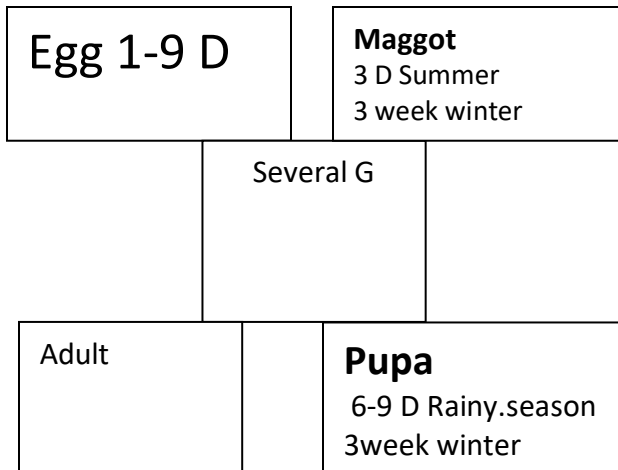
Melon Fruit-fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae)

This is the commonest and **most destructive fruit-fly of musk melon** and other cucurbits.

Host Plant: Tomato, chillies, guava, citrus, pear, fig, cauliflower, etc. In north-western India, it is very common on **late-sown melons** that ripen after the monsoon rains begin. Two other allied species common in India are *Dacus ciliatis* Loew and *Bactrocera dorsalis* (Hendel).

Marks of identification:

Larva: Maggots are legless and appear as headless, dirty-white wriggling creatures, thicker at one end and tapering to a point at the other. A full-grown maggot is 9-10 mm long and 2 mm broad in the middle. **Adult :** The adult flies are reddish brown with lemon-yellow markings on the thorax and have fuscous areas on the outer margins of their wings.



Life-cycle:

This pest is active throughout the year, but the **life cycle is prolonged during winter**. The adult **flies emerge from pupae in the morning hours and mate at dusk**. It takes a few days for the eggs to mature inside the body of a female which starts laying them within 14 days. During winter, the pre-oviposition period is prolonged. They oviposit in comparatively soft fruits avoiding those with hard rind. The selection of a suitable site and the actual laying of eggs take about 6-8 minutes. A cavity is made by the sharp ovipositor and about a dozen **white cylindrical eggs are laid, mostly in the evening hours**.

After laying the eggs, the female releases a gummy secretion which cements the tissues surrounding the puncture and makes the entrance water proof. The **secretion solidifies to form a shiny brown resinous material**. The **female, on all average, lays 58-95 eggs in 14-54 days**.

The eggs hatch in 1-9 days and the maggots bore into the pulp, forming galleries. The attacked fruits decay because of secondary bacterial infection. The larvae are full-grown in 3 days during summer and 3 weeks during winter. The mature larvae come out of the rotten fruits and move away in jumps of 12-20 cm. these are made possible by folding and unfolding the two ends of the elongated body. After reaching a suitable place, they **bury themselves about 5 mm deep in**

the soil and pupate. The **pupa are barrel-shaped**, light brown and they transform themselves into winged **adults in 6- 9 days** in the rainy season and **3- 4 weeks** in the winter. There are several generations in a year.

Pupae are parasitized by *Opius fletcheri* Silvestri, *O. compensatus* Silvestri and *O. insisus* Silv. (Braconidae), *Spalangia philippinensis* Full. and *Pachycephoides debrius* (Pteromalidae), *Dirhinus giffardi* Silvestri and *D. Izonensis* Rohw. (Chalcididae)

Damage:

- ✓ The maggots pollute and **destroy fruits by feeding on the pulp.**
- ✓ The damage caused by this fruit-fly is most serious in melons and after the first **shower of the monsoon, the infestation often reaches 100 per cent.** Other cucurbitaceous fruits may also be infested up to 50 per cent.

Management:

1. The regular **removal and destruction of the infested fruits** helps in the suppression of this pest.
2. **Frequent raking of the soil** under the vine or **ploughing the infested field** after the crop is harvested can help in killing the pupae.
3. Apply the bait spray containing 50 ml of malathion 50 EC + 0.5 kg of gur /sugar in 50 litres of water per ha. When the attack is serious, it should be repeated at weekly intervals.
4. Spraying the bait on the lower surface of the leaves of maize plants grown at distance of 8- 10 cm as trap crop has been found to be effective as the flies have the habit of resting on such tall plants.

Red Pumpkin-beetle, *Aulacophora foveicollis* (Lucas) (Coleoptera: Chrysomelidae)

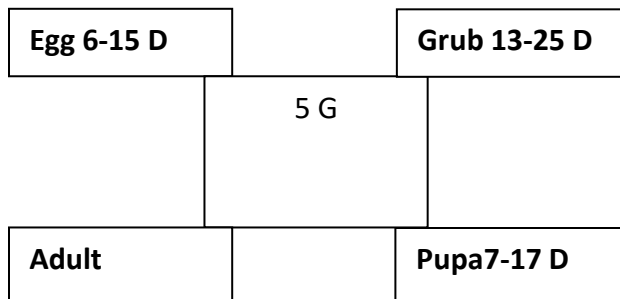
The two species, red pumpkin-beetle, *A .foveicollis* and blue pumpkin-beetle, *A. atripennis* Fabricius are common in North-western India, the former being more important. Damage is caused by grubs as well as by beetles.

Marks of identification:

Larva: The **grubs** lead a subterranean life and when full-grown, they measure about **12 mm** in length and **3.5 mm** across the mesothorax. They are **creamy white**, with a slightly darker oval **shield at the back**.

Adult: The **beetles feed** on those parts of the plant which **are above the ground**

d. They are oblong and **5-8 mm long**. Their dorsal body surface is brilliant **orange red** and **ventral surface is black**, being clothed in short white hair.



Life-cycle:

The **beetles are found concealed in groups under dry weeds, bushes and plant remains or in the crevices of soil**. They resume activity as soon as the season warms up and in their **life span of 60-85 days**, they lay **about 300 oval yellow eggs** singly or in **batches of 8-9** in moist soil, near the base of the plants.

The eggs **hatch in 6-15 days** and the grubs remain below the soil surface **feeding on roots, underground stems** of creepers and on **fruits lying in contact with the soil**. They are full-grown in **13- 25 days** and **pupate in thick-walled earthen chambers in the soil**, at a depth of about **20-25 cm**.

The **pupal stage lasts 7-17 days** and the beetles, on emergence, begin to feed and breed. The life-cycle is completed in 26-37 days and the pest **breeds five times from March to October.**

Damage:

- ✓ The beetles are very **destructive** to cucurbitaceous vegetables, particularly during **March-April when the creepers are very young.**
- ✓ The **grubs damage the plants by boring into the roots**, underground stems and sometime into the fruits touching the soil.
- ✓ The beetles **injure the cotyledons, flowers and foliage by biting holes into them.**
- ✓ The **early sown cucurbits are so severely damaged** that they have to be resown.

Management:

- (i) After harvesting the infested fields, **plough deep to kill the grubs in the soil.**
- (ii) **Sow the crop in November** to avoid damage by this pest.
- (iii) **Apply 7.0 kg of carbofuran 3G per ha 3-4 cm deep in the soil near the base of the plants just after germination and irrigate or spray 375 g of carbaryl 50 WP in 250 litres of water per ha.**

Red Vegetable Mite, *Tetranychus telarius* Linnaeus (Acari: Tetranychidae)

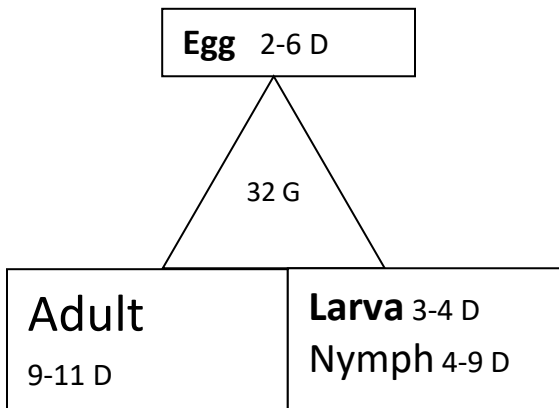
The red vegetable mite, also called the two-spotted spider mite, is world-wide. The large scale use of chlorinated hydrocarbon insecticides for the control of various other pests leads to the **multiplication of mites**, since they are less toxic to mites and especially since they kill large number of the natural enemies of mites.

Host plants: The mite is a **polyphagous pest** and is known to feed on **183 species** of plants including **cucurbits, brinjal and okra** on which it is occasionally very serious.

Marks of identification:

Nymph: A fully developed **nymph** is **microscopic and measures about 0.33 mm in length**. It is light brown and **has two eye-spots, four pairs of legs** and is quite active.

Adult: The **adult** male measures about **0.52 mm** in length and **0.30 mm** in breadth. The body of the female is **oval, pyriform and variable in colour**. It may be **ferruginous red, greenish amber or rusty green**. **Two large pigmented Spots are present on the body**.



Life-cycle:

The **mite is active from March to October** and passes the winter as a gravid female. As the season warms up in March, it **spins webs on the undersurface of leaves** of various host plants and **lays 60-80 eggs**. The eggs are **spherical and hatch in 2-6 days**. The emerging **larvae are light brown** and have **three pairs of legs**. They feed underneath the **webs** and, within **3-4 days, change into nymphs** which have **four pairs of legs**. The nymphs grow to maturity in **two stages within 4-9 days** and the **adults live for 9-11 days**. The life-cycle during the

active period is completed in 9-19 days. In Punjab, this mite is believed to complete 32 generations in a year.

Damage:

- ✓ The **damage is caused both by the nymphs and adults.**
- ✓ All the active stages usually **feed on the underside of the leaves by sucking cell sap.**
- ✓ Gradually, the infested leaves dry up and the webbing interferes with plant growth. There is a poor setting of the fruits and the yield is considerably reduced.

Management. Spray 625 ml of **dimethoate 30EC** or **oxydemeton methyl 25EC** in 250 litres of water per ha and repeat spray at 10-day interval.

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Chapter-9.

Cruciferous vegetable

Cabbage (*Brassica oleracea var. capitata* L.); Cauliflower (*Brassica oleracea var. botrytis* L.); Knol-khol (*Brassica oleracea var. gongylodes*); and Radish (*Raphanus sativus* L.)

Family : Brassicaceae

S.No	Pest	Scientific name	Order	Family
	Cabbage Caterpillar	<i>Pieris brassicae</i>	Lepidoptera	Pieridae
	Diamond-back Moth	<i>Plutella xylostella</i>	Lepidoptera	Yponomeutidae
	Cabbage Semi-looper	<i>Thysanopulsia orichalcea</i> and <i>Autographa nigrisigna</i>	Lepidoptera	Noctuidae
	Tobacco Caterpillar	<i>Spodoptera litura</i>	Lepidoptera	Noctuidae
	Crucifer Leaf-webber	<i>Crocidolomia binotalis</i>	Lepidoptera	Pyralidae
	Cabbage Borer	<i>Hellula undalis</i>	Lepidoptera	Pyralidae
	Cabbage Flea Beetles	<i>Phyllotreta cruciferae</i> , <i>P. chotanica</i> , <i>P. birmanica</i> , <i>P. oncera</i> , <i>P. downesi</i>	Coleoptera	Chrysomelidae

Cabbage Caterpillar, *Pieris brassicae* (Linnaeus) (Lepidoptera: Pieridae)

Hosts: It is a serious pest of **cabbage, cauliflower, knol-khol** and it may also attack **turnip, radish, sarson, toria** and other cruciferous plants.

Marks of identification:

Larva : The full-grown larva measure **40-50 mm** in length. The young larvae are **pale yellow**, and become **greenish yellow** later on. The head is **black** and the dorsum is marked with **black spots**. The body is decorated with short hair.

Adult : The butterflies are **pale white** and have a **smoky shade** on the dorsal side of the body. The wings are **pale white**, with a **black patch** on the apical angle of each fore wing and a **black spot** on the costal margin of each hind wing. The females measure **6.5 cm** across the spread wings and have two conspicuous black circular dots on the dorsal side of each fore wing. **Males are smaller than the females** and have **black spots** on the underside of each fore wing.

Life-cycle:

In the Indo-Gangetic plains, this pest appears on **cruciferous vegetables** at the beginning of **October** and remains active up to the end of **April**. From May to September the pest is not found in the plains but breeding takes place in the mountains. The butterflies are very active in the field and lay, on an average, **164 yellowish conical eggs** in clusters of **50-90** on the upper or the lower side of a leaf. The eggs hatch in **11-17 days** in November-February and **3-7 days** in March-May. The caterpillars feed

gregarious y during the early instars and disperse as they approach maturity. They pass through five stages and are full-fed in 15-22 days during March-April and 30-40 days during November-February. The larvae pupate at some distance from the food plants, often in barns or on trees. The pupal stage lasts 7.7-14.4 days in March- April and 20-28 days in November-February. The butterflies live for 25-125 days and the pest breeds four times during October-April.

The larvae of this insect are parasitized by *Apanteles glomeratus* (Linnaeus) (Braconidae) in the natural populations.

Damage:

- The caterpillars alone cause damage.
- The first instar caterpillars just scrape the leaf surface, whereas the subsequent instars eat up leaves from the margins inwards, leaving intact the main veins. Often, entire plants are eaten up.

Management.

- (1) Hand picking and mechanical destruction of caterpillars during early stage of attack can reduce infestation.
- (2) Spray one litre of Malathion 50EC or 925 ml of endosulfan 35EC in 250 litres of water per ha. Repeat spraying at 10 day intervals if necessary. Do not spray the crop at least one week before the harvest.

Diamond-back Moth, *Plutella xylostella* (Linnaeus) (Lepidoptera: Yponomeutidae)

This world-wide moth is a serious pest of cauliflower and cabbage, but also feeds on many other cruciferous, solanaceous and liliaceous plants, all over India.

Marks of identification:

Larva : When full-grown, the larvae measure about 8 mm in length and are pale yellowish green with fine black hair scattered all over the body.

Adult : The moths measure about 8-12 mm in length and are brown or grey, with conspicuous white spots on the fore wings, which appear like diamond patterns when the wings lie flat over the body.

Life-cycle:

This insect is active throughout the year. Yellowish eggs of the size of pinheads are laid singly or in batches of 2-40 on the underside of leaves. A female may lay 18-356 eggs in her life-time. The eggs hatch in 9.1, 3.7 and 2.5 days at 13.9, 17.9 and 23.4° C, respectively. The newly hatched caterpillars bore into the tissue from the underside of leaves and feed in these tunnels. At first, their presence is detected only from the blackish excreta that appears at the mouth of each tunnel, but in the second instar, the mines become more prominent. In the third instar, the caterpillars usually feed

outside the tunnels. The larvae of the **fourth instar feed from the underside of leaves**, leaving intact a parchment-like transparent cuticular layer on the dorsal surface. The **larvae are very sensitive to touch, wind or other physical disturbances** and readily feign death. **They become full-grown in 16.6, 14.3 and 8.6 days at 17, 20 and 25°C, respectively.** **Before pupating, the larva constructs a barrel-shaped silken cocoon which is open at both ends and is attached to the leaf surface.** The pupa stage lasts **4-5 days at 17-25°C and the moths may live for as long as 20 days.** The life-cycle is completed in **15-18 days** during September-October and there are **several generations in a year.**

Larval stage is parasitized by *Voria ruratis* Fab, *Itoplectis* sp. (Ichneumonidae), *Apanteles sicarius* (Braconidae) and *Tetrasticus sokolowskii* (Eulophidae), *Brachymeria excarinata* Gahan (Chalcididae) is associated with pupa. A larval-pupal parasitoid, *Diadrumus collaris* (Gravenhorst) (Ichneumonidae) is also found to be associated with this pest. *Apanteles plutellae* (Kurdyumov) **effectively checks the population of diamondback moth** on cabbage in Gujarat and Karnataka under favourable environmental conditions. In the hill regions of Tamil Nadu, *Diadegma semiclausum* Hellen exercises 70 per cent parasitization of diamondback moth in winter months.

Damage:

- **Damage is caused by the caterpillars which, in the earlier stages, feed in mines on are lower side of cabbage leaves and, in the later stages, feed exposed on the leaves.**
- Caterpillars damage the leaves of cauliflower, cabbage and rape-seed particularly in the heart of the first two.
- **Central leaves of cabbage or cauliflower may be riddled and the vegetables rendered unfit for human consumption.**
- **The pest is most serious when it appears on the early crop in August-September.**

Management:

- (i) **Remove and destroy all the remnants, stubble, debris, etc. after the harvest of the crop and plough the fields.**
- (ii) **Tomato, when intercropped with cabbage, inhibits or reduces egg laying by diamond-back moth.**
- (iii) **Indian mustard, which attracts 80-90 per cent diamond-back moths for colonisation, can be used as a trap crop.**
- (iv) **Spray 625 ml of diazinon 20EC or 1.0 litre or endosulfan 35EC or quinalphos 35EC or trichlorphon 50EC or 250 ml of fenvalerate 20EC in 250 litres of water per ha. Repeat sprays at one week intervals.**

Cabbage Semi-looper, *Thysanopulsia orichalcea* (Fabricius) and *Autographa nigrisigna* (Walker) (Lepidoptera: Noctuidae)

Hosts : this is **polyphagous** pest.: **Cabbage, cauliflower and other winter vegetables, groundnut and sunflower** are the host plant.

Marks of identification:

Larva :The caterpillars are **plump and palish green**. They cause damage by **biting round holes into cabbage leaves. On walking, they form characteristic half-loops and are often seen mixed with cabbage caterpillars.**

Adult :The adults of *T. orichalcea* are **light palish brown with a large golden patch on fore wing. They measure about 42 mm across the spread wings. The adults of *A. nigrisigna* are darker and have dark brown and dirty-white patches on the fore wings.**

Life-cycle:

These insects are active during the winter and it is not known how they survive the heat of summer. During the active period, they lay eggs on leaves of host plants and the caterpillars feed individually, biting holes of varying size according to the stage of their active development. When full-grown, they pupate in the debris lying on the ground. The moths are very active at dusk on flowers in gardens and public parks, where they are seen in hundreds during the spring season.

Management:Same as in case of cabbage caterpillar.

Tobacco Caterpillar, *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae)

Other hosts: Besides tobacco, feeds on **castor, groundnut, tomato, sunflower, cabbage** and various other cruciferous crops.

Marks of identification:

Larva :**Larva** measure **35- 40 mm** in length, at maturity. They are **velvety black with yellowish-green dorsal stripes and lateral white bands.**

Adult :The **moth** are about **22 mm long** and measure **40 mm across the spread wings**. The fore wings have beautiful **golden and greyish brown patterns.**

Life-cycle:

This pest breeds throughout the year, although its development is considerably **retarded during winter**. The moths are active at night when they mate and the female lays about **300 eggs in clusters**. These clusters are covered over by brown hair and they **hatch in about 3-5 days**. The larvae feed gregariously for the first few days and then disperse to feed individually. They

pass through **6 stages** and are full-fed in **15-30 days**. The full-grown larvae enter the **soil** where they **pupate**. The pupal stage lasts **7- 15 days** and the moths, on emergence, live for **7- 10 days**. The **life cycle is completed in 32-60 days** and the pest completes **eight generations** in a year.

The natural enemies, *Compoletis sp.*, *Eriborus sp.*, *Rogas sp.* (**Braconidae**) and *Strobliomyia orbata* W. (Anthomyiidae) are associated with larvae of this pest.

Damage:

- The **damage** is done only by the **caterpillars**.
- The **larvae feed on leaves and fresh growth**. They are mostly active at night and cause extensive damage, particularly in tobacco nurseries.

Management:

- (i) **Remove the egg masses** and clusters of larvae and destroy them.
- (ii) Spray **625 ml of diazinon 20EC or 1.0 litre or endosulfan 35EC or quinalphos 35EC or trichlorphon 50EC or 250 ml of fenvalerate 20EC in 250 litres of water per ha. Repeat sprays at one week intervals.**

LOCUSTS

The larger grasshoppers which form swarms are called locusts and there are three species of the family Acrididae found in India. (i) Desert locust, *Schistocerca gregaria* (Forsk.) (ii) Bombay-locust, *Patanga succincta* Linnaeus (iii) Migratory locust, *Locusta migratoria* (Linnaeus).

Of these, the desert locust is the most important. There are very few records of swarms involving other locusts, particularly of the migratory locusts. The first and second species are important in Maharashtra, Gujarat and Rajasthan but the desert locust is of all India importance. In fact, it is an international pest and efforts are being made constantly to control it through the International Locust Control Organization of the Food and Agriculture Organization.

Desert locust, *Schistocerca gregaria* (Forsk.) (Orthoptera : Acrididae)

The desert locust is found in two phases, i.e. the solitary phase and the gregarious phase. Individuals having characteristics in between the two are often placed under the transient phase. The nymphs of the gregarious phase are yellow or pink, with distinct black markings, whereas the color of the solitary hoppers varies according to the color of the surrounding vegetation. The gregarious adults are pink on emergence, gradually turning grey and ultimately yellow, when sexually mature. The adults of the solitary phase remain greenish grey throughout their life.

Life cycle: A single female may lay up to 11 egg-pods, each pod containing up to 120 eggs. A female normally lays 500 eggs in about 5 pods. Before egg laying the female, with the help of her ovipositor, bores a hole into the loose sandy soil, 5-10 cm deep. Having laid a pod, she secretes a frothy material over. The eggs, which hardens on drying and makes the pod water-proof while laying eggs, the females may be sitting very close to one another and as many as 5,000 eggs may be laid one square meter.

The egg, resembling grain of rice, is lightly curved and 79 mm long. The duration of the egg stage depends upon the soil conditions, temperature and moisture. The eggs laid in February and March hatch in 34 weeks and those laid in May-September hatch in 12-15 days.

The nymphs, at the time of emerging, break the egg-shell and creep out of the holes. The duration of the nymphal (hopper) stage lasts 6-8 weeks in spring and 3-4 weeks in summer.

Damage:

The locust is harmful in both the hopper and the adult stages. These gregarious and voracious feeders eat almost any vegetation, except a few plant species such as vegetation, except a few plant species such as ak (*Calotropis procera*), dharek (*Melia azedarch*), neem (*Azadirachta indica*), dhatura (*Datum stramonium*), etc. When in swarms, they can consume all the green vegetation and cause a famine. In addition to the damage to crops, orchards, forests, etc., the locust can be nuisance in houses, as these creatures climb over the walls, invade kitchens, storerooms and even enter into the beds. They fall into wells by the million and thus make water unfit for drinking. If an army of hoppers or adults marches on to the railway lines, all traffic is suspended because the crushed hoppers cause slippery rails.

Management: Management operation can be carried out against all stages of the locust, the most practicable and effective measures are against the nymphs.

Eggs. If eggs are laid in a well-defined area, a trench may be dug around it, so that the young nymphs on emerging drop into it and can be buried alive, filling the ditch with soil. If these trenches are heavily dusted with lindane, it may not be necessary to bury the nymphs.

Nymphs. The hopper stage is the most vulnerable and control measures are most effective before the second moult. The nymphs may be destroyed either with chemicals or by using mechanical methods: (i) The principal mechanical method of control lies in digging trenches in front of the moving army of nymphs and driving them into these trenches, with brooms or with twigs of trees and then, buried alive. The nymphs can also be guided to the trenches along metal or canvas barriers 45 cm high. Two barriers, one, on each side of the army of the marching hoppers are so fixed that they converge on a narrow gap that leads to a trench in which they drop. The trench should be deep enough to accommodate a large number of hoppers most of which would then die under the weight of their own fellow creatures. Later, the trench can be filled with earth. In the early stages, a trench 30-45 cm wide and 60 cm deep, is sufficient but when the hoppers are older, the width should be 57 cm and the depth more than 60 cm. (ii) At night when the hoppers rest on bushes, they can be burnt with flame-throwers. (iii) Poison baits such as the poisoned bran or sawdust, if scattered in the early morning or in the evening, are effective. During day, the bait dries quickly so the hoppers do not eat it. The poison used is a sodium fluosilicate or Paris

green. (iv) Lindane dust and lindane spray (0.2%) are very effective. (v) Lindane as a spray can also be applied shortly before the emergence of the hoppers, so that as soon as they come out, they come into contact with the insecticide and die. (vi) Spraying the crop with neem seed kernel powder suspension (1%) has been found to be very promising. (vii) A number of birds attack locusts and of these, the common mynah and the tiliar (starling) are the most important. During the locust cycle, if practicable, these birds should be protected.

Adults (i) The adults can be beaten to death with thorny sticks, brooms or can be swept together and buried underground in heaps. (ii) Lindane 2 per cent, if dusted on crops, trees and the ground, is very effective. (iii) Lindane (2%), in an oil medium, is also effective _ when sprayed with an aeroplane on top of a flying swarm. Lindane 20 EC in water suspension can also be sprayed on locusts, on the ground.

Anti-Locust Organization. The Anti-Locust Organisation in India consists of (a) The Central AntiLocust Organization, and (b) the State AntiLocust Organizations.

(a) Central AntiLocust Organization. This organization is handled by the Plant Protection Adviser to the Government of India, who is also the Director of Locust Control, having his headquarters at Faridabad (Haryana). The Directorate is required to:

- Record the weekly density of locusts per unit area in the breeding areas located in India and to carry out control operations there.
- Interpret the records and pass on the information on locust movements to the various State Locust Control and Warning Officers and to the revenue authorities of the concerned districts before the locust reaches there so that arrangements for control can be made in advance.
- Keep watch on the coming swarms of extra-Indian origin, their direction and size. * Give technical and material assistance to the various States.
- Coordinate the Anti locust work in India by issuing a fortnightly bulletin on the locust situation both in India and in foreign countries.

In India, the work of this organization extends both to the scheduled desert areas where locusts breed and to the cultivated areas where they do the damage.

In the scheduled desert areas, the Central Anti-Locust Organization operates over an area of 2,05,785 square kilometers in the States of Rajasthan, Haryana, Maharashtra and Gujarat. This area is divided into 10 zones which are grouped into 4 circles with headquarters at Bikaner,

Jodhpur, Barmer and Palanpur (Gujarat). The responsibility of the control work is entrusted to the Locust Entomologist in charge of the circle.

(b) State Anti-Locust Organization In the scheduled area of the desert as well as in the adjoining States where locusts cause damage; there are State Anti-Locust Organizations to take suitable measures against the swarms. The State organization is headed by the Locust Control and Warning Officer, who is well connected with the local revenue authorities, from the Deputy Commissioner to the Tehsildar and Patwari. When the latter official receives information from district headquarters warning him of a locust invasion; he alerts the villagers to be ready with machines and insecticides, kerosene, flamethrowers, spades, etc. When the swarm actually arrives, the farmers try to kill it as well as they can and then the Patwari intimates the Locust Control Officer and his own Deputy Commissioner of the extent of success achieved. In case the swarm settles down to lay eggs, the Locust Control Officer or his staff visits the place to devise suitable control measures.

TERMITES

The termites, commonly called white ants, are among the common insect pests belonging to the order Isoptera. They are found abundantly and widely in tropical and sub-tropical regions of the world. They live in large communities, mostly in underground nests and are familiar because of their depredations. They make small earthen mounds or earthen passages that are visible above the ground. On opening a portion of an earthen passage, grayish white; Wingless insects are seen moving towards or away from the center of their nest, where the queen of the colony resides. They belong to many families and their nesting behavior is characteristic of every group.

The following four families of the order, Isoptera, are economically important, (i) Kalotermitidae (exclusively inhabit dead, dying and living wood, have no connection with the soil e.g. Neotermes, (Cryptotermes); (ii) Hodotermitidae (live in arid zones of India, attack grasses and stored grains, live and breed wholly underground, e.g. Acanthotermes); (iii) Rhinotermitidae (largely subterranean, some invade wood works in buildings, e. g. Heterotermes, Rhinotermes, Captotermes, Reticulotermes); and (iv) Termitidae (largest and economically most important, both under and above ground dwellers, e.g. Odontotermes, Microtermes, Hypotermes, Nasutitermes).

The termites are social insects and their colony organization is based on a caste-system. In a colony, there are numerous workers, lots of soldiers, one queen, a king and a good number of complementary or the colonizing forms of true but immature males and females. The various castes and their duties are described as under.

A. Productive Castes

1. **Colonizing individuals.** These are winged individuals of both sexes and are produced in large numbers during the rainy season. When the temperature and moisture conditions are optimum, they emerge from the parent colony and hover over street lamps early in the evening, usually after a shower of rain. The wings are meant for the nuptial flight only and when they have mated, the wings usually drop off. Most of the winged insects are eaten up by frogs, lizards and snakes. A pair that happens to escape may start a new colony in a crevice in the soil as the queen and the king of a colony. To start with, they themselves attend to the foraging and other duties which, later on, are performed by the workers.

2. **Queen.** This is the only perfectly developed female in the colony. She develops either from colonizing individuals described above or from the Wingless forms (complementals) present in an established colony. She attains a much larger size when developed from the former caste. Her reproductive system occupies almost the entire abdomen. She is a phenomenal “egg-laying machine”, laying one egg per second or 70,000-80,000 eggs in 24 hours. There is only one queen in a colony and normally she lives from 5 to 10 years. The queen is fed by the workers on the choicest food, and is housed in a special area referred to as the ‘royal chamber’ which is situated in the centre of the nest, at depth of about 0.5 meter below the ground surface.

3. **King.** A king develops from an unfertilized egg and becomes fully developed by consuming a superior diet. He is the father of the colony and is a constant companion of the queen, living with her in the ‘royal chamber’. He is much smaller than the queen and is slightly bigger than the colonizing individuals. He mates with the queen from time to time and, thus, aids her in laying fertilized eggs from which the colonizing forms and workers develop. The king’s life is much shorter than that of the queen and, when he dies, he is replaced by a new one.

4. **Complementary castes.** They are short-winged or Wingless creatures of both sexes and lead a subterranean life. In the event of the untimely death of the king or queen in a colony, the complementary castes replace them they are induced by the workers to undergo sexual development.

B. Sterile Castes

5. **Workers.** The workers develop from the fertilized eggs but remain stunted as they are reared on ordinary food. Numerically, they are the most abundant in a colony but are smaller than the soldiers. Except for the reproduction and defense of the community, practically all other duties are performed by the workers they take care of the eggs and the young ones and remove them to safe places at the time of danger. They also tend and feed the queen, collect food and cultivate a fungus food (ambrosia) in underground gardens.

When a new colony is established, the earlier broods of workers construct a hemispherical chamber for the queen and it IS connected with innumerable galleries. In certain species, the workers also construct a high mound above the ground, which is known as the termitarium. Since the workers have to collect all provisions for the colony, they are notoriously destructive.

6. **Soldiers.** The soldiers develop from unfertilized eggs and remain comparatively underdeveloped. They are the most specialized members of the community and can be readily recognized by the large head and strongly characterised sickle-shaped mandibles.

Life-cycle. In the rainy season when atmospheric conditions are favorable, the colonizing forms leave their parent colony. As they are weak fliers, they do not travel a long distance unless aided by wind. As a rule, a particular species_ swarms at about the same time of season. The members of the swarm comprise individuals of both sexes. They are attracted to light where they mix with individuals of the neighboring swarms. A great majority of them fall prey to many types of predators and only a few individuals survive in the end. Sooner or later the survivors fall down and cast their wings and mate before or after shedding them. Both the male and female participate in the early operations of forming a nest by excavating small burrows or galleries or the nuptial chambers. In the beginning only a few eggs are laid and are looked after by them and the newly hatched nymphs are fed by the parents themselves. They develop into Workers and then take over all the brooding. During the first season, the reproductive castes are usually not produced. Gradually, the queen grows in size and the number of eggs laid increases.

The eggs hatch after one week during the summer and within 6 weeks the larvae develop to form soldiers or workers, as the case may be. The reproductive castes when produced, mature in 1-2 years. The queen is capable of laying many millions of eggs during her life, which is very difficult to estimate, but probably 6-9 years is the approximate span. The nests of many termites

grow fungus gardens in the center, near about the 'royal chamber'. The fungus grows into a comb like structure and is fed to the royal pair and the larvae.

Damage. The termites live on cellulose which they obtain from dead and living vegetable matter to obtain their food, they destroy wood-work, household articles, fences and wooden poles that come into contact with the soil. They also damage fruit and shade-trees, crops such as sugarcane, chillies, wheat and peas.

Management of Termites

1. When a colony is established, it is not so easy to eradicate the pest. The only sure method is to reach the center of the nest and kill the queen and the complementary forms. Since the termite tunnels run for hundreds of meters, it the wood and in the crevices is the only remedy. For a lasting relief the nests should be located in the vicinity and destroyed by flooding them with the insecticide emulsions.

2. To avoid the attack of white-ants in cultivated fields, care should be taken not to use green manure or raw farmyard manure.

3. Insecticidal control

(a) Fruit trees

(1) In new plantations, the pits should be treated with 0.2 per cent lindane emulsion or crude-oil emulsion before planting the trees. This is done by thoroughly mixing 0.25 kg of crude-oil emulsion and a little arsenic in about 4 baskets of subsoil taken from the pit. The treated soil is returned to the pit.

(2) To protect the tree trunks, spraying them with 1 per cent lindane is effective.

(3) To protect the roots, 0.5 per cent chlorpyrifos or lindane or 3 per cent sanitary fluid in the irrigation basin should be applied.

(b) Field crops

(i) For protecting chillies in small plots, 3 per cent sanitary fluid should be applied to the soil. When large areas are to be treated, the sanitary fluid is put in a canvas bag at the rate of 25-35 liters per hectare. The bag is suspended in the irrigation channel.

(ii) Soaking the sugarcane setts in 0.5 per cent lindane/chlorpyrifos suspension or 0.25 per cent lindane/chlorpyrifos emulsion in furrows at the time of planting, saves them from termite attack.

(iii), Wheat seed treatment before sowing, with 160 ml emulsion of chlorpyrifos in one liter of water spraying on thinly spread out 40 kg seeds with a water emulsion of chlorpyrifos 20EC remains effective for the crop season. Termite damage in standing wheat crop can be minimized by application of 5 liters of lindane 20EC per hectare into irrigation water or field spreading of one liter of lindane 20EC .mixed with sand or soil, followed by light irrigation.

(3) Buildings

(i) A galvanized sheet of iron with its outer edge turned downwards when placed just above the damp-proof layer makes the house white-ant-proof. Wooden structures such as doorframes should not directly touch the ground and should be raised on a cement layer.

(ii) An insecticidal barrier between the ground and woodwork in building should be made by treating the soil beneath the building and around foundations with 0.5 per cent chlorpyrifos or lindane. The solution should be applied at the rate of 5 liters per m².

4. To protect wood-work, paint it with solignum. The cupboards, almirahs, shelves, etc. should be sprayed with lindane or chlorpyrifos frequently. The place from where the galleries originate in the house should be either sprinkled over or injected with 0.5 per cent lindane or chlorpyrifos suspension in water. If wooden structures have already been attacked the injection of 0.5 per cent lindane or chlorpyrifos emulsions with a hypodermic needle into the wood and in the cervices is the only remedy.

5. Mounds of termite, if any, in the area should be treated with 0.5 per cent chlorpyrifos or lindane after breaking open the earthen structure, and making holes with an iron bar. The insecticidal emulsion should be used at the rate of 4 liters per m of the mound.

HAIRY CATERPILLARS

Red hairy caterpillar, *Amsacta moorei* (Butler) (Lepidoptera: Arctiidae)

The red hairy caterpillar or kutra is widely distributed in the Orient, including India. It is a *polyphagous* insect and feeds on all kinds of vegetation growing during the Kharif season. Its attack is particularly serious on sunhemp, maize, sorghum, glwra, mung, math and sesamum.

The moths are stoutly built and have white wings with black spots. The outer margins of the fore wings, the anterior margin of the thorax and the entire abdomen are scarlet red. There are black bands and dots on the abdomen. The full grown caterpillars are reddish-amber to olive green and the body is covered with numerous long hairs arising from the fleshy tubercles.

Lifecycle. The female moths lay light-yellow spherical eggs in clusters of 700-850 each on the under surface of the leaves of host plants. A single female may lay up to 1,500 eggs, which hatch in 2-3 days. The young caterpillars feed gregariously and, as they grow older, they march in bands destroying field after field of various kharif crops. The caterpillars grow through six stages and complete their development in 15-23 days. They enter the soil, shed their hair and make earthen cocoons at a depth of about 23 cm. Here they pupate and remain in this stage for many months till they emerge next year from the cocoons. In a given population, probably more than one generation is completed in a year.

Damage. The young kutra caterpillars prefer to eat the growing points of plants. The older ones have no such discrimination and they feed voraciously on all vegetation resulting in disaster. Field after field is devastated by the moving army of caterpillars.

Management. (i) The moths are strongly attracted to artificial light. Therefore, light traps of electric or petromax lamps placed just above a broad flat basin full of kerosenized water, should be put on the night following the first shower of the monsoon and continued throughout the period of emergence for about one month. (ii) Young larvae can be destroyed by pulling out the infested plants and burying them underground. (iii) The grown up caterpillars may be destroyed by crushing them under feet or picking and putting them into kerosenized water. (iv) In case of serious attack, spray 1.25 litres of endosulfan 35EC or quinalphos 25EC or 500 ml of dichlorvos 76EC in 500 litres of water per ha or dust 35 kg of trichlorphon 5% cent dust per ha.

2. Bihar hairy caterpillar, *Spilarctia obliqua* Walker (Lepidoptera: Arctiidae)

The Bihar hairy caterpillar is a sporadic pest and is widely distributed in the Orient. In India, it is very serious in Bihar, Madhya Pradesh, Uttar Pradesh and the Punjab as a polyphagous pest, particularly of sesamum, mash, mung, linseed, mustard, sunflower and some Vegetables. The full-grown caterpillars are profusely covered with long grayish hair. The moth measures about 50 mm across the Spread wing (F and is dull yellow.

Life-cycle. The female lays 412-1241 light green, spherical eggs in clusters on the underside of leaves. The eggs hatch in 8-13 days and during the first two stages, the tiny caterpillars feed gregariously, but afterwards they disperse widely in search of food. They grow to maturity through 7 stages, within 4-8 weeks. When full-grown, larva spins a loose silken cocoon in which pupation takes place in plant debris or in the soil. The pupa] stage lasts 1-2 weeks in the active

period and the moths live for about a week. The life-cycle is completed in 6-12 weeks and the pest passes through 3 or 4 broods in a year.

Damage. The caterpillars eat leaves and soft portions of stems and branches. In severe infestation, the plants may be completely denuded of leaves.

Management. (i) The young caterpillars can be killed easily by dusting the infested crop with Malathion 5 per cent @ 25 kg/ha.(ii) When they are full-grown, it is difficult to kill them and very high doses of the pesticides are needed. The chemical control measures are same as in case of red hairy caterpillar.

CUTWORMS

The term cutworm or surface caterpillar is applied to the larvae of several species of noctuid moths which have, in common, the habit of biting through the stems of seedlings at ground level and eating the leaves or the entire seedlings. The various species of cutworms have a wide range of food plants, both cultivated and wild.

The majority of cutworms found in India fall under the genera *Agrotis* and *Euxoa*.of the recorded species, only four are widespread in the plains and have considerable economic importance. *Agrotis ipsilon* (Hufnagel) is the commonest and *Ochropleura flammata* (Denis & Schiffermuller) is occasionally abundant in India, the latter being particularly destructive in the north.

Gram cutworm, *Ochmpleura flammata* (Denis & Schifiermullerl (Lepidoptera: Noctuidae)

The gram cutworm is one of the most important pests of chickpea or gram in northern India particularly in the Punjab, Haryana and in the sub-Himalayan region. Its distribution extends to Europe, Syria, Iran, western Siberia and Pakistan. It is a polyphagous pest besides gram, it feeds on the seedlings of many vegetables and other plants such as potato, cucurbits, peas, okra, wheat, tobacco, opium, poppy, etc.

The adult is a heavy bodied, grayish-brown or wheat-colored insect which measures 5.0-6.2 cm in wing expanse. Its fore wings have characteristic markings and smoky patches. The caterpillars are dark grey or dull green and their skin is smooth and greasy.

Life-cycle. The female moths lay yellowish-white eggs on the under surface of leaves, shoots, stems, or in the soil, within 5-9 days of their short life span of 7-13 days. A female lays up to 980 eggs in its life time. The eggs hatch in 4-7 days during summer and 10-14 days during winter. The larvae remain hidden in soil during the daytime and feed at night on young shoots or underground tubers. They are full grown in 4-7 weeks and then make earthen cells in the soil for pupation. The pupal stage lasts 12-15 days but during winter it extends up to 5 weeks. The life cycle is completed in 7 -11 weeks and there are generally two generations in a year.

Damage. This cutworm is a sporadic pest of major importance. In some years, 50 per cent of the gram crop may be destroyed. The caterpillars spend the day hiding near and about the plant bases. They remain in the top 5-10 cm of the soil near the plants that might have been cut the night before. At night, they come out and become active, cutting down the young plants of gram, potato, vegetable seedlings, etc. just above or slightly below the surface of the soil they seem to be very voracious eaters and they cut more plants than they can consume.

Management. The pest can be controlled with lindane 2D @ 35 kg per ha or fenvalerate .4D @ 25 kg per ha or spray 80ml fenvalerate 20 EC or 50 ml cypermethrin 25 EC or 150 ml decamethrin 2.8EC in 100 litres of water per ha.

Greasy cutworm, *Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae)

This is a pest of worldwide occurrence and is found in America, Europe, North Africa, Syria, Japan, China, Indonesia, 'Australia, New Zealand, Hawaii, Sri Lanka, Myanmar and India. It has been reported from almost all the potato growing regions of northern India, forming a continuous belt from the Punjab in the west of Bengal in the east and Madhya Pradesh in the south it causes considerable damage to potato. In Punjab, it is not as common as *O.flammata*, but along with other cutworms it causes much damage to the crop.

Damage is caused by the caterpillars only. The slightly yellowish caterpillar, on emergence, is 1.5 mm long with a shiny, black head and a black shield on the prothorax. The full-grown larva is about 42-45 mm long and is dark or dark-brown with a plump and greasy body. The adult moth measures about 25 mm from the head to the tip of the abdomen and looks dark or blackish with some greyish patches on the back and dark streaks on the fore wings.

Life cycle. The pest is active from October to April and probably migrates to the mountains for further breeding during summer. The moths appear in the plains in october and come out at dusk and fly about until darkness sets in. They oviposit at night and lay creamy-white, dome-shaped

eggs in clusters of about 30 each, either on the undersurface of the leaves of food plants or in the soil. The number of eggs laid by a female varies from 199 to 344. Oviposition continues from 5 to 11 days and the duration of the egg stage varies from 2 days in summer to 8-13 days in winter. The newly hatched larvae feed on their eggshells and move like a semilooper. The larval stage varies from 30 to 34 days in February-April. The advanced-stage larvae may become cannibalistic. The caterpillars are found throughout the winter and become active at night when they cut off and fell the young plants. During the day, they hide in cracks and crevices in the soil. When full-grown, they make earthen chambers in the soil and pupate underground. The pupal stage varies from 10 days in summer to 30 days in winter. The moths usually emerge at night. The life cycle is completed in 48-77 days and generally three generations are completed in a year. It is a cold-weather pest and is active from October to March in the plains. It suddenly disappears with the onset of summer during April and is not traceable during the off-season, from April to August-September.

Damage. The young larvae feed on the epidermis of the leaves. As they grow, their habit changes. During the daytime they live in cracks and holes in the ground and come out at night and fell the plants by cutting their stems, either below the surface or above the ground. The cut branches are sometimes seen to have been dragged into the holes where the leaves are eaten at leisure. The larvae may also bore into cabbages. Damage to the rabi crops may go as high as 37 per cent and to the potato crop may be as high as 80 per cent.

Management. Same as in case of gram cutworm.

RICE GRASSHOPPERS

Hieroglyphus banian (Fabricius) and *H. nigrorepletus* Bolivar , Orthoptera: Acrididae) ,

Distribution. Rice grasshoppers are sporadic pests of rice distributed throughout India.

Identification. *H. banian* and *H. nigrorepletus* are somewhat like locusts but are smaller. The adults are 40-50 mm long and are shining greenish yellow, having three black lines running across the pronotum. Nymphs are yellowish, with many reddish brown spots in the early stages, but become greenish as they grow older.

Life-history. *Hieroglyphus* spp. have one generation in a year and pass the winter and dry part of summer in the egg stage. The eggs are found in the soil and they hatch in June or in early July, a

few days after the first shower, of the monsoon. On emergence, the nymphs start feeding actively and complete their development in seven stages, within 3 weeks. The adults are seen feeding voraciously during August and September. When they are two months old, they mate. The female starts laying eggs by inserting her abdomen in the soil. The eggs are laid 5-8 cm deep, in pods, each containing 30-40 eggs. The egg-laying continues from September to November and the adults die soon after, sometime in the winter.

Host plants. They are polyphagous and feed on leaves of rice, maize, mil-lets, sugarcane, grasses, sunhemp, arhar.

Damage. The greatest amount of damage .is caused during August-September When both adults and nymphs feed on paddy and other crops, causing defoliation. In certain years, they cause extensive damage, moving from field to field over large areas.

Management. Dust carbaryl 5 per cent or Malathion 5 percent @ 25 kg per ha.

PESTS OF PULSES

In India, the annual production of pulses was about 15.2 million tonnes on an area of 24.4 million ha in 2003-04. About 250 insects have been recorded feeding on pulse crop. Of these, about one dozen insects including pod borers, stem borers, leaf-miners, foliage caterpillars, cutworms, jassids, aphids and whiteflies are the most important. Some polyphagous insects also feed on these crops and cause considerable damage.

1. Gram pod borer

***Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae)**

The gram pod-borer or the gram caterpillar is cosmopolitan and is widely distributed in India. It is a serious pest of chickpea, pigeon pea, mungbean, urdbean, lentil soybean and cowpea. The insect has also been found damaging cotton, sorghum, okra, maize, tomato, berseem, sunflower and lately wheat also.

The moth is stoutly built and is yellowish brown. There is a dark speck and a dark area the outer margin of each fore wing. The forewings are marked with greyish wavy lines and black spots of varying size on the upper side and a black kidney shaped mark and a round spot on the underside. The hind wings are whitish and lighter in colour with a broad blackish band along the outer margin. The caterpillars when full-grown, are 3.5 cm in length, being greenish with dark broken grey lines along the sides of the body.

Life-cycle. The females lay eggs singly on tender parts of the plants. A single female may lay as many as 741 eggs in 4 days. The eggs are shining greenish yellow and are round. They hatch in 2-4 days in April to October and 6 days in February and the young larvae feed on the foliage for some time and later here into the pods and feed on the developing grains, with their bodies hanging outside. They move from pod to pod and are full-fed in 13-19 days and measure 35 mm in the last instar. The full-grown larvae come out of the pod and pupate in the soil. In the active season, the pupal period lasts 8-15 days, but in winter the duration is prolonged, particularly in northern India. Some of the pupae remain in a facultative diapause during November April in northern India. There may be as many as 8 overlapping generations in a year.

Campoletis chlorideae Uchida (Ichneumonidae) is a larval parasite of major importance. In vegetative phase, during the peak of its activity, it may parasitize 50-60 per cent of *H. armigera* larvae, whereas during podding phase, 30-40 per cent parasitization has been recorded.

Damage. Although they prefer food plants like gram and red gram, the larvae are polyphagous. They feed on the foliage, when young, and on the seed in later stages, and thus reduce yield. A single larva may destroy 30-40 pods before it reaches maturity.

Management. (i) Timely sowing, i.e. up to mid October or growing early maturing cultivars which complete podding by first week of March in northern region helps in escaping peak activity period of *H. armigera*. (ii) Use of Helicoverpa-tolerant varieties like JG 315 and JG 74 for central zone and ICCV 7 for southern zone is recommended. (iii) Mixed intercropping with non-preferred host plants like barley, wheat, mustard and linseed should be preferred over sole crop. (iv) Hand picking of the older larvae during early hours of the day is helpful as these are less susceptible to insecticides. (v) Apply nuclear polyhedrosis virus (NPV) @ 250-500 larval equivalents/ha alone or alongwith half dose of endosulfan 35EC (1.25 litrBS/ ha). Spraying should be carried out in the evening hours. (vi) The pod borer can be managed by spraying the insecticides at the economic threshold level of one larva per five plants at pod initiation stage. The recommended insecticides are 2.5 litres of endosulfan 35EC or 250 ml of fenvalerate 20EC or 200 ml of cypermethrin 25EC or 400 ml of deltamethrin 2.8EC in 625 liters of water per ha at the start of pod formation and repeat after two weeks, if necessary. Alternatively, Apply fenvalerate 0.4 per cent dust @ 20 kg/ha or Malathion 5 per cent Dust @ 25 kg/ha or endosulfan @ 25 kg/ha. For consuming any part of the raw gram plant observe waiting period of 20 days after application of the insecticide.

2.Plume moth, *Exelastis atomosa* (Walsingham) (Lepidoptera:Pterophoridae)

This insect is a specific pest of pigeon pea in many parts of India, particularly in Andhra Pradesh, Assam, Madhya Pradesh, Punjab, Tamilnadu, Haryana, Maharashtra and Karnataka. The full-grown caterpillar is greenish brown and measures 1.25 cm in length and has short hairs on the body.

Life-cycle. The female moths lay 17-19 eggs singly on tender parts of the plants. The eggs hatch in 2-5 days and the young larvae feed on the pods and become full-grown in 10-25 days. Pupation takes place outside the pod on its surface or in the entrance hole itself. The pupal period extends from 3 to 12 days. The life-cycle is completed in 17 -42 days.

Damage. The larvae first scrape the surface of the pods and finally make holes into them and feed on the seeds, reducing crop yield.

Management. Chemical control measures are same as in case of gram pod-borer.

3. Red gram pod fly, *Melanagromyza obtusa* (Diptera : Agromyzidae)

This pest occurs wherever pigeon pea is grown in India but is most common in northern India. It is a small metallic-black fly, whose tiny maggots bore into the pods and feed on seeds.

Life-cycle. The adult female fly thrusts its minute eggs into the shell of a tender pod. They hatch in 2-4 days. The maggots feed under the epidermis for some time and then enter the seed. They are full-grown in 5-10 days. Pupation takes place inside the damaged pods and the pupal period lasts 4-13 days. The adults emerge by cutting holes. The lifecycle is completed in 11- 27 days and several generations are produced in a year.

Damage. The maggots eat away only a part of the seed and the partially damaged seed becomes subject to bacterial and fungal infections. The damaged grains are thus unfit for human consumption.

Management. Spray 1.75 kg of carbaryl 50WP or one liter of endosulfan liters 35EC in 300 liter of water on dwarf varieties and 300 liters on tall varieties per ha at the time 50 percent flowering. Repeat the spray after 15 days.

5. PEA LEAF MINER *Chromatomyia horticola*(Goureau)(Diptera: Agromyzidae)

Distribution. This pest is widely distributed in northern India.

Identification. The adults are two-winged flies having grayish black mesonotum and yellowish frons.

Life-history. The pest is active from December to April or May and is believed to pass the rest of the year in soil, in the pupal stage. The adults emerge at the beginning of December and after mating, start laying eggs singly, in leaf tissues. The eggs hatch in 2-3 days and the larvae feed between the lower and upper epidermis by making zig-zag tunnels. They are full-grown in about 5 days and pupate within the galleries. The adults emerge from the pupae in 6 days and the life-cycle is completed in 13-14 days. The pest passes through several broods from December to April-May. Host plants. It feeds on a large number of cruciferous plants, antirrhinum, nasturtium, pea, linseed (*Linum usitatissimum* L.) and potato (*Solanum tuberosum* L.).

Damage. The large number of tunnels made by the larvae interfere with photosynthesis and proper growth of the plants, making them look unattractive.

Management. Spray one liter of dimethoate 30EC in 250 litres of water per ha and repeat spray at 15-day interval. A waiting period of 20 days should be observed for picking of pods.

5. GIRDLE BEETLE

***Obereopsis brevis* (Gahan) (Girdle beetle, Coleoptera : Cerambycidae)**

Identification. The adult is a small black beetle with hard shell-like exterior and rather on antennae. The freshly emerged adult is yellow, red, brown on the head thorax and bases of elytra. The larva is white, soft-bodied worm with a dark head.

Life-history. The ovipositing female beetle girdles the stem twice and makes it 3 punctures Just above the lower ring before inserting a single egg through the largest whole into the pith. This results in dropping of the upper part of the stem. A female beetle lays 7 -13 eggs and they hatch in 4-5 days. The larva tunnels upwards and downwards within the stem and a single larva can destroy the whole plant. The larval period lasts 34-47 days. Over-wintering takes place as the full-grown larva within the feeding tunnel in a gall-like chamber near the base of the plant in the girdled portion of the stem which has fallen out or under plant debris. The Pupal period is 8-11 days.

Host plants. This is an important pest of soybean and also attacks cowpea and lablab.

Damage. The attack of this insect begins initially in the last week of July to fortnight of August. The female of this insect feeds on the xylem of the stem. The larvae further damage the stem and make tunnels inside and fill these with excreta. The leaves and the growing points dry up. In later stages, the plant is cut at about 15-25 cm above the ground and broken stems can be seen in the field.

Management. Same as in case of bean fly.

6. PEA APHID *Acyrtosiphon pisum* (Harris) (Pea aphid, Hemiptera : Aphididae)

Distribution. Pea aphid is cosmopolitan in distribution in both Palaearctic and Nearctic regions and has been recorded from practically all the areas where the peas are grown.

Identification. Adult aphids are soft-bodied, long legged, pear-shaped, green yellow or pink in colour with long conspicuous cornicles.

Life history. Both alate as well as apterous forms are present and these are generally females; males are rare. Winged and Wingless males have been reported from Europe and USA but not from India. Reproduction is parthenogenetic and viviparous it takes about a week to complete one generation and there are several overlapping generations in a year.

Damage. Both nymphs and adults suck the sap from young shoots, ventral surface of tender leaves, inflorescence and even on stems. There is curling of leaves, which become irregularly distorted, while the shoots become stunted and malformed. The leaves turn pale and dry. Honeydew secreted by the aphids encourages growth of sooty mould and this superficial black coating on leaves and stems hinders the photosynthetic activity of the plants, which become weak, thus affecting adversely the pod formation. Aphids are carriers of pea mosaic.

Host plant. Pea

Management. Spray 1-0 liter of dimethoate 20EC in 250 liters of water per ha when the attack starts and repeat after 15 days if necessary.

Birds

House crow, *Corvus splendens* (Passeriformes : Corvidae)

Mark of identification : the house crow is grey and has black and grey wings with a black area

Pests of stored grains:

(1) **Khapra beetle**(*Trogoderma granarium*: Coleoptera : Dermestidae):

Host: It is a serious pest of stored wheat. It also infest sorghum, gram, maize, poppy, pistachio, walnut, and other dried fruits.this pest is native to India.

Life history: The adult appear in april. All the stages of pests are present from May to October and there are 4-5 overlapping generation in a year. The pest over winter as full grown larvae (October to March). A newly emerged yellowish-white larvae is about 1.5 mm in length and has a brownish head. When larvae become full grown it attain brownish colour with yellowish brown transverse bands across the body, which has long hairy bristles. The adult male (2-3 mm in length) is oval and dark brown. It is stoutly built but incapable of flight. The females are about the twice the size of the males. They live for 10-30 days. The female lays up to 150 whit translucent eggs singly or rarely in cluster of 2-5 eggs among the grains. The eggs are rather cylindrical, round at one end and narrow at the other. A female may lay 13-35 eggs in 1-7 days. The incubation period varies from 3-5 days in June to 6-10 days in October. The male larvae is full fed in 20-30 days and the female larvae in 24-40 days. The pupation takes place in the last larval skin among the grain. This stage last 4-6 days. There are 4-5 generation in a year. The body of the grub is elongate and as broad at the tail end as at the head. The body is covered with long and redish brown hairs and a tuft of hair is present on the tail end.

Nature of damage: The grubs are destructive, whereas, the adult are harmless. The damage is confined to upper layer of the grain up to depth of 30-80 cm. The greatest damage is done in summer from July to October. The grub eat the grain near the embryo or any other weak point and from there proceed inwards. If the infestation is severe, the devastation is complete, reducing the grain to mere frass. Since the larvae are positively thigmotactic. They can be collected by merely placing the gunny bags on a heap of grain.

Pulse beetle: *Callosobruchus chinensis*, Coleoptera: Bruchidae

Host: Whole pulses Beans and Gram

Eggs: orange creamin colour and turn grayish white, singly, surface of pod or grain.

Grub: creamy white with black mouth parts, curved and fleshy.

Pupa: Under seedcoat , in pu;al cell.

Adult: Brownish grey coloured. Ivory spot on middle of dorsal surface. Adult is harmless.

Pygidium: elytera dose not cover the abdomen.

Nature of damage: grubs eat the grain by making cavity adult come out by making exit hole. The other species *callosobruchus maculates*.

Lesser grain borer: *Rhizopertha dominica*: Coleoptera: Bostrychidae.

Host: Paddy, Rice, Wheat, Maize.

Egg: On surface of grain, Singly or Cluster.

Grub: White, Brown head, Apodus (3 Instars).

Pupa: Grub enters the grain after 3rd instar for pupation in Grain.

Adult: Brown to blakish beetle.

Nature of damage: Grub+adult, holes, both feed inside the grain, Powder.

Rice weevil: *Sitophilus oryzae*: Coleoptera: Curculionidae.

Host: wheat, Rice, Maize, JOwer.

Egg: Translucent white, singly, plug the hole with gelatinous secretion.

Grub: White, brown head, apodus, curved, remain within the grain.

Pupa: Pupate inside the grain.

Adult: Redish brown to chocolate coloured, Snout is present.

Other species: *Sitophilus granarius*.

Angoumois Grain Moth: *Sitotroga cerealella*: Lepidoptera: Gelechiidae.

Host: Paddy, Maize, Jowar, Barley, Wheat.

Egg: White eggs, Surface of grain, Store or Field, become Red later.

Larva: white with yellow head.

Pupa: Pupate in cocoon inside the grain.

Adult: Yellowish Brown (dirty) wing, wings are narrow pointed and completely folded over back in sloping manner.

Nature of damage: Caterpillar, feed inside the grain and remain in a single grain only. Infestation remain to upper 30 cm depth only.

Red Rust Flour Beetle: *Tribolium castaneum*, *T. confusum* : Coleoptera: Tenebrionidae.

Host: Broken grain, flour, Maida.

Egg: White, translucent, sticky, slender.

Grub: Whitish, cream coloured, worm like.

Pupa: lying in grain or naked.

Adult: Brown in colour, Secondary pest.

Nature of damage: Grub: incapable of feeding on sound grain. Flour turn Greyish, mouldy and gives pungent odour, making unfit for human consumption.

Grain mite: *Acarus siro*: Acarina:

Host: Cereals, grain, flour etc.

Adult: Pale straw coloured to dark Reddish Brown.

Storage structures: The grain can be best protected by using improved insect proof receptacles of various types.

(A): **indoors bins**

(1): **Domestic metal bins:** Several types of domestic designs of metal bins have been developed, the capacity of which range from 3 to 27.5 quantals. These are indoor bins and may be kept in a room or varandha under a roof. The bins are made from galvanized iron sheets and are moisture, rodent and insect proof. These are found suitable for storage of wheat, paddy, maize, pulse and seed grains.

(2): **Gharelu theka:** this type of storage structure consists of rat-proof metal base, rubberized cloth containers and bamboo posts, having different storage capacities ranging from 2 to 3 metric tonnes.

(3): **Pucca kothi:** The improved structure called pucca kothi is constructed in two compartments with a capacity of 1 metric tonne.

(4): **Welded wire-mesh bin:** The bin is fabricated using wire-mesh with hessian cloth lining inside so that the air may circulate freely through it. The structure is mounted on prefabricated steel elevated base to prevent the entry of rodents. The storage capacity of bin is 2.8 metric tonnes. The food grains like maize and paddy can be stored in this bin even at slightly higher moisture level without destruction in quality.

(5): **Reinforced cement ring bins:** this design consists of pre-fabricated RCC rings placed one over the other with grippings joints at the edges.

(6): **Paddy straw-mud structure:** The improved paddy straw-mud structure of 400 kg capacity is made from paddy straw rope plastered on both side with specially prepared mud. Externally, the structure is further plastered with water proof mud to prevent the entry of moisture. The structure is mounted on a raised brick masonry platform to prevent the entry of rats. It is commonly used for paddy storage.

(B): **Outdoor bins**

(1) :**Flat and hopper bottom-metal bins:** these bins are fabricated using either steel or aluminium metal steels of different capacity ranging from 2.0 to 10.5 metric tonnes. The bins can be either erected on brick masonry base, brick masonry columns or pre fabricated steel elevated base. These bins are suitable for storage of wheat, pally and maize under different climatic conditions.

(2): **Composite bins:** these are the outdoor flat bottom storage bins fabricated with steel and timber in combination with varying storage capacity ranging from 3 to 14.5 metric tonnes.

(3): **Partly underground and above ground structures:** A prototype structure of 10 m³ or 7.5 metric tonnes capacity which is partly underground and partly aboveground has been constructed. The underground part of structure is of RCC or brick, while the above ground part of the structure is of galvanized iron sheet. This bin is suitable for construction in areas where water table is low.

(2): **Seed storage bin:** Quite popular in rural areas, these bins are either circular or square in shape with storage capacity ranging from 1 to 15 quintals.

(4): **Ferro-cement bins:** the bins are constructed by using rich cement mortar and closely spaced chicken wire-mesh. The bin is cylindrical in shape and has flat bottom and a dome shaped roof. It is treated on the out side with suitable moisture proofing paint like bituminous aluminium paint. The capacity of the ferro bins ranges from 0.6 to 3.0 metric tonnes. They are lighter in weight than the cement concrete structure.

(5): **Pusa bin:** This design consists of two brick walls of 10 cm thick each using sun dried bricks with polythene sheet sandwiched in between. The structure is constructed on a brick masonry platform plastered with cement mortar. A mud slab is provided as the top on a wooden frame structure. The polythene sheet is also provided at the top and the base to make the structure completely moisture proof and air tight.

(6): **Vacuum process storage:** The vacuum process storage (VPS) is a modern concept in storage system. Under the (VPS) system, the PVC containers manufactured for the purpose, are filled with food grains and air is sucked out of them instantly. Thus vacuumised containers could be operated like stone boxes and stacked like gunny bags in the open field. The food grains in such containers never get infected or catch fungus in the absence of air. Besides, the food grains thus stored never get discoloured and suffer damage in quality even though the stocks are kept for 3-4 years.

(7): **Bulk storage installations:** for bulk food storage, silo elevators have been installed in India at Hapur. The storage bin or silo have a capacity of 10,000 tonnes each and provided for bulk storage of

grains. The elevators are provided with mechanical operations for receiving and issuing out grains with the help of a mechanical system on scientific lines. The super structure consists of twenty cylindrical silos with a capacity of 500 tonnes each. The silo is about 6.7 meter in diameter and 23 metres in height. At the head of silos stands the head house which is 9.1 metres in diameter and 47.3 metres high. The auxiliary shipping tanks, grain cleaning and disinfecting equipments and automatic weighing machines are housed in the building. The grain handling authorities in the country like Food Corporation of India, Marketing Cooperative Federations, Central and State Warehousing Corporations are using these type of Bulk Storage Installations Structure in India.

The grains can be stored up to five years without destruction or loss. There is practically no access to insects or rodents. They are also provided with aeration and fumigation system whereby the grain can be periodically aerated and fumigated to maintain the good quality.

Principles of stored grain pest management:

It has been proved by experiments that the damage caused by the insect, mite and micro-organism depends upon the following three factors.

- (1) The moisture content of the grain.
- (2) Sources, availability and amount of oxygen in the storage.
- (3) The development of temperature gradient within the stored grain.

(i): **Moisture content**- for proper development each insect and mite species requires particular humidity. The minimum moisture content required by some storage insect-pests is given below:

1. <i>Trogoderma granarium</i>	0-1.9%
2. <i>Rhizopertha dominica</i>	9.0-10%
3. <i>Sitophilus oryzae</i>	9.5-11%
4. <i>Tribolium castaneum</i>	10%
5. <i>Corcyra cephalonica</i>	9%
6. <i>Cadra cautella</i>	10%

It is clear from the above that the moisture content of grains is mainly below 9 to 10 per cent, then the infestation of most of the pests can be avoided except that of khapra beetle. The initial moisture content before storage may be brought down by sun drying or by grain driers. The grain will be fit for storage if they are cut into pieces by teeth. Care should be taken that dried grain should always be stored in moisture proof godowns otherwise, it will soon adjust its moisture in accordance with atmospheric humidity which will invite the infestation of insect pests.

(ii): **Availability of oxygen**: Every insect species requires a certain percentage of oxygen for its development and survival. Therefore, in the absence of minimum oxygen percentage, the development of an insect ceases and it dies, for example, khapra beetle requires 16.8 % oxygen

content for the survival of eggs, therefore, its multiplication may be checked by lowering the oxygen content to this level.

(iii):**Temperature:** Temperature is the most important factor controlling the development and multiplication of insects. The insect survive and thrive within a certain limit of temperature beyond which their activity ceases. Certain insect form heat spots for their survival. The development of heat spots is due to excess heat produced either by insect multiplication or by microbial infection. Insect respiration produces both temperature and moisture increases, leading to favourable conditions for their multiplication. Therefore, efforts should be made to prevent the heat spots by way of cooling which may be done by forced aeration, turning of the grain and control of infestation by fumigation etc.

(A) Preventive Measures:

1. Godowns should be cleaned well and white washed, if possible moisture proof godowns should always be preferred.
2. All the cracks, crevices present in the floor, walls and ceiling of the store should be filled up with cement and levelled.
3. The walls of the store may be painted with coal-tar from the ground up to the height of 1.5 meter.
4. The dirt, broken infested grains and sweeping of the store should be removed and burnt before new grains is stored.
5. If the cracks, crevices and holes of the godowns are suspected to harbor insects, the godowns should be treated with the any of the following insecticides.
 - (a) The ceiling and walls of the godowns may be sprayed with 0.5% malathion @ 3lit/sq meter.

(B): Cleaning of bags:

1. Use new bags as far as possible.
2. If the old bags are to be used, these should be disinfected by the following ways:
 - (a) By dipping them in boiling water for about 15 minutes
 - (b) By drying them in hot sun heat for about 6 hours.
 - (c) By fumigating them with ED/CT mixture @ 1lit/10 bags.
 - (d) By dipping them in 1 % malathion solution for 10 minutes.
3. About 20 % of the room should be left free between the top layer of the bags and ceiling.

(c) Cleaning of grains and precautions:

1. Bullock carts, trucks or other vehicles used for the transport of grains should be cleaned and washed preferably with phenyl water
2. The grain should be thoroughly dried before storage, so that it does not have more than 9-10 per cent moisture.
3. The clean grain should be brought to the store direct from the threshing yard.
4. Only one kind of grain should be stored in a store as far as possible.
5. If the grain is stored in bags, a layer of bhusa should be sprayed at the floor and bags should be kept 50 cm away from the walls.
6. Dunnage materials must be free from insect pests.

Remedial measure:

- (1): Disinfect old gunny bags by dipping them in 0.0125 per cent fenvalrate 20 EC or cypermethrin 25 EC for 10 minutes and drying them in shade before filling the grains.
- (2): Disinfect empty godowns or receptacles by spraying 0.05 per cent malathion emulsion on the floor, walls and ceiling. Alternatively, fumigate the godowns using 25 tablets of aluminium phosphide per 100 m³ of empty space with an exposure period of 7 days.
- (3): The grain meant for seed can be protected by mixing of malathion 5 per cent dust @ 250 g per quintal of seed. The grain may also be treated with 25 ml of malathion 50 EC or 2 ml fenvalrate 20 EC or

1.5 ml of cypermethrin 25 EC or 14 ml of deltamethrin 2.8 EC per quintal of seed by diluting in 500 ml of water.

(4): Cover the pulses stored in bulk with 7 cm layer of sand or saw dust or dung ash, for protection against dhora.

(5): The fumigant, hydrogen phosphide (aluminium phosphide), is used for large scale fumigation of food grains in those storage structure which are away from living premises. It is available in tablet form and can be used at the rate of one tablet (3 g each) per metric tonnes or 25 tablet per 100 m³ of space with an exposure period of 7 days.

