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ENTOMOLOGY

Insect Pests and their Management

DR. A. V. Navarajan Paul
Principal Scientist & National Fellow
Biological Control Laboratory
Division of Entomology
Indian Agricultural Research Institute
New Delhi – 110012

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Introduction

Insects are found in all types of environment and they occupy little more than two thirds of the known species of animals in the world. Insects affect human beings in a number of ways. Many of them fed on all kinds of plants including crop plants, forest trees, medicinal plants and weeds. They also infest the food and other stored products in godowns, bins, storage structures and packages causing huge amount of loss to the stored food and also deterioration of food quality. Insects inflict injury to plants and stored products either directly or indirectly in their attempts to secure food. Insects that cause less than 5 % damage are not considered as pests. The insects which cause damage between 5 - 10% are called minor pests and those that cause damage above 10% are considered as major pests. Insects that cause injury to plants and stored products are grouped into two major groups namely chewing insects and sucking insects. The former group chews off plant parts and swallow them thereby causing damage to the crops. Sucking insects pierce through the epidermis and suck the sap. Many of the sucking insects serve as vectors of plant diseases and also inject their salivary secretions containing toxins that cause severe damage to the crop.

Introduction of high yielding varieties, expansion in irrigation facilities and indiscriminate use of increased rates of agrochemicals such as fertilizers and pesticides in recent years with a view to increase productivity has resulted in heavy crop losses due to insect pests in certain crops. This situation has risen mainly due to elimination of natural enemies, resurgence of pests, development of insecticide resistance and out-break of secondary pests. Distribution, nature of damage, life history of important key pests of crops and their management strategies are outlined hereunder:

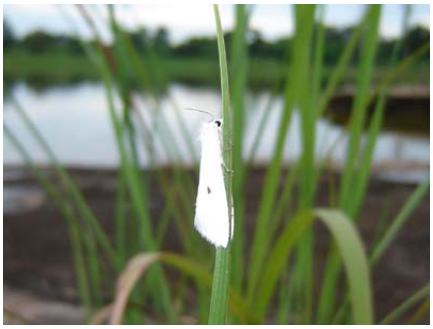
I. Insect Pests of Rice (*Oryza sativa*)

1. Rice stem borer *Scirpophaga incertulas* (Walker) (Pyraustidae: Lepidoptera)

Distribution: The yellow stem borer of rice attacks only rice and has wide distribution in all Asian countries.

Nature of damage: Larva feeds inside the stem causing drying of the central shoot called ‘dead heart’ in young plant or drying of the panicle called ‘white ear’ in older plants. October-December has been found conducive for the multiplication of the insect.

Life history: The female lays 15 - 18 eggs in a mass near the tip on the upper surface of tender leaf blade and covers them with buff coloured hairs and scales. A female lays about 2 - 3 egg masses and the incubation period ranges from 5 - 8 days. The newly hatched pale white larva enters the leaf sheath and feeds for 2 – 3 days and bores into the stem near the nodal region. Usually only one larva is found inside a stem but occasionally 2 - 4 larvae may also be noticed. The larva becomes full grown in 33 - 41 days and measures about 20 mm long. It is white or yellowish white with a well developed prothoracic shield. Before pupation it covers the exit hole with thin webbing and then forms a white silken cocoon in which it pupates. The pupa is dark brown and measures 12 mm long. The pupal period varies from 6 -10 days and may get prolonged depending on the weather conditions. The entire life-cycle is completed in 50 - 70 days.

Rice stem Borer

Source: www.knowledgebank.irri.org/ **www.savebutterfly.com/**

Management Strategies:

(i) Removal and destruction of rice stubbles from field and also collection and destruction of egg masses.

(ii)) Clipping the tip of the seedlings prior to transplantation to eliminate egg masses.

(iii) Collection and destruction of moths using light traps.

(iv) Spraying of fenthion or fenitrothion or endosulfan or phosalone or monocrotophos or etofenprox or cartap hydrochloride or chlorpyriphos or phenthoate at 0.5 kg a.i./ha or fipronil 5% SC at 1 litre/ha if the economic threshold level of 10% dead heart is crossed in the nursery a week prior to pulling out the seedlings and the second after 15 days of transplantation.

(v) An economic threshold level of 10% dead heart in vegetative stage and presence of 1 moth or 1 egg mass/sq.m. in the ear-head bearing stage has been suggested for adoption of chemical method of control by giving a third spray with one of the above chemical pesticides.

(vi) Seedlings root dip treatment for 12 or 14 hours before transplanting in 0.02% chlorpyriphos gives protection upto 30 days against stem borer.

2. Rice gall midge *Orseolia oryzae* (Wood-Mason) Mani (Cecidomyiidae :Diptera)

Distribution: It is distributed throughout India. Five biotypes of gall midge have been observed. It is destructive in some parts of Kerala, Orissa, Andhra Pradesh, Madhya Pradesh and Bihar. It also breeds on a number of grasses such as *Paspaladium geminatum*, *Paspalum scrobiculatum*, *Panicum* spp., *Ischaeum ciliare*, *Cynodon dactylon* and *Eleusine indica*.

Nature of damage : The gall formed by this fly is popularly known as ‘silver shoot’ or ‘onion shoot’ or ‘anaikomban’ because of the formation of hollow pink or purple, dirty white or pale green cylindrical tubes bearing at their tips a green reduced leaf blade complete with ligules and auricles. It infests the rice even in the nursery but usually tillers are preferred. The loss in yield in a heavily infested crop may be up to 50 %.

Life history: The yellowish brown fly, which is active at night, lays 100 - 300 reddish elongate tubular eggs singly or in groups of 2 - 6 on just below or above the ligules of leaf blade. The maggots hatch out in 3 or 4 days move down to shoot primordia in 6 – 12 hrs. The maggot feeds on the shoot primordia resulting in the suppression of the apical meristem and formation of radial ridges. Only one larva develops in a shoot apex and throughout its development it remains inside the tubular gall formed due to its feeding. Gall is the modified leaf sheath. The pale red coloured maggot feeds on growing point for 15 - 20 days and pupates inside the gall. The pupal

stage lasts for 2 - 8 days and at the time of emergence of the adult the pupa wriggles upto the tip and projects half way out. The life cycle occupies 19 – 21 days but during winter it takes 32 – 39 days.

Rice Gall midge
(Source: www.agridept.gov.lk/)

Management Strategies:

(i) Seed treatment with chlorpyriphos 0.2% emulsion for 3 hours or seed mixing with either chlorpyriphos (0.75 kg a.i./100 kg seeds) or imidacloprid (0.5 kg a.i./100 kg seeds) provide protection for 30 days in the nursery.

(ii) Seedling root dip in 0.02% chlorpyriphos emulsion before transplanting for 12 - 14 hours gives protection for 30 days.

(iii) Removal and destruction of weeds that serve as alternate host plants.

3. Green rice leaf hoppers *Nephotettix nigropictus* (Stal.) and *N. virescens* (Distant) (Cicadellidae: Homoptera)

Distribution: These insects are found distributed in all rice growing areas in Asia and Africa. The insect is active during July – November in different regions.

Nature of damage: Both nymphs and adults suck the plant sap and cause browning of leaves. Both the species are known to be vectors of virus diseases of rice such as rice transitory yellowing and rice yellow dwarf.

Life history: The female of *N. nigropictus* is green and the male has two black spots extending upto the black distal portion on the fore wings. It has a black tinge along the anterior margin of pronotum and a submarginal black band on the crown of the head. In *N. virescens* black submarginal band on the crown is absent and the black spots on forewings do not extend upto the black distal portion.

They also breed on some grasses. The female inserts the eggs in rows under the epidermis of leaf sheath and may lay upto 53 eggs. The life-cycle occupies about 25 days, the egg and nymphal periods being 6 – 7 and 18 days, respectively.

Management Strategies:

(i) Spray application of phosalone or etofenprox or cartap hydrochloride or monocrotophos or acephate or chlorpyriphos or carbaryl, at 0.5 kg a.i./ha or fipronil at 50 g a.i./ha or application of granular insecticides such as phorate or sevidol or cartap hydrochloride or carbofuran at 1 kg a.i./ha or fipronil 0.3% G at 25 kg/ha.

4. Brown plant hopper *Nilaparvata lugens* (Stal.) (Delphacidae: Homoptera)

Distribution: Distributed throughout South and South East Asia where rice is grown. It is known only to feed on rice and the weed *Leersia hexandra* Sw., Poaceae.

Nature of damage: It infests the rice crop at all stages of plant growth. Due to feeding by both nymphs and adults at the base of the tillers, plants turn yellow and dry up rapidly. At early infestation, round yellow patches appear which soon turn brownish due to the drying up of the plants and this condition is called 'hopperburn'. *N. lugens* is a phloem feeder. Very high infestation causes lodging of the crop resulting in yield loss ranging from 10 - 70 %.

Life history: Two forms *viz*., macropterous (long-winged) and brachypterous (short-winged) are noticed and they are ochraceous brown dorsally and brown ventrally. The female inserts the eggs in two rows on either side of the midrib of the leaf sheath. The average member of eggs laid varies from 250 - 350. The incubation period is 6 - 9 days and the nymphal period is 10 – 18 days. The total life-cycle occupies 16 – 27 days.

Management Strategies:
(i) Spraying carbaryl (0.75 kg a.i./ha) or etofenprox, moncrotophos*****, phosalone***** or chlorpyrifos***** @ 0.5 kg a.i./ha or lindane 20 EC at 1 litre/ha in the early stages of the crop.
(ii) Application of granules of carbofuran at 0.75 kg a.i./ha or phorate at 1.25 kg a.i./ha.

***** Application should be restricted to early stage of the crop.

5. Rice leaf folder *Cnaphalocrocis medinalis* Guen. (Pyraustidae: Lepidoptera)

Distribution: Occurs in all rice growing areas of our country. It is active from October to January.

Nature of damage: The larva rolls the leaf blade by fastening its edges and sometimes even fastening the leaf tip to the basal part of the leaf blade and feeds from inside by scraping. In a severely infested field the whole crop gives a sickly appearance with white patches. The infestation at boot leaf stage of the crop sometimes results in heavy loss of grain yield.

Life history: The brownish – orange coloured moth is small and has two and one distinct dark wavy lines on the brownish fore and hind wings respectively. Both wings have a dark brown to grey band on their outer margin. The eggs are laid singly or in pairs on the under surface of tender leaf blades. The incubation period is 4 - 7 days. The pale yellowish green larva becomes full grown in 15 - 27 days and pupates inside the leaf roll. Pupal period is 6 - 8 days. Total life-cycle varies from 25 - 42 days.

Management strategies:
(i) Removal of grass from field bunds.
(ii) Need based spraying of phosalone or carbaryl or monocrotophos or etofenprox or cartap hydrochloride or quinalphos or fenthion at 0.5 kg a.i./ha or spray of fipronil 5 SC at 1 litre/ha.

6. Rice earhead bug *Leptocorisa acuta* (Thunberg) (Alydidae=Coreidae): Hemiptera)

Distribution: This is one of the important pests of rice throughout India generally appearing before the flowering stage and continuing upto the milky stage. Apart from rice it also breeds on a variety of grasses.

Nature of damage: Both the nymphs and adults feed on the sap of peduncle, tender stem and milky grains making them turn chaffy.

Life history: The female lays 250 - 300 eggs on leaf blade in long rows of 10 - 25 eggs and the incubation period is about a week. The slender greenish nymphs become adults in about two weeks. The longevity of the adults is 3 - 4 months.

Management Strategies:
(i) Dusting carbaryl 10 %, and repeat it depending upon the severity of infestation.

7. Whorl maggot *Hydrellia philippina* Ferino (Ephydridae: Diptera)

Distribution: It occurs in many rice growing countries in Asia. It occurs in severe form in certain high yielding varieties in Andhra Pradesh, Tamil Nadu and Orissa. It also breeds in *Cynodon dactylon*, *Echinochloa crusgalli*, *E. colona*, *Fimbristylis miliacea*, *Eleusine indica* and *Paspalum scrobiculatum*.

Nature of damage: The maggots attack the leaf blades even before unfurling and the initial damage is characterised by the presence of narrow stripes of whitish area in the blade margins. The tillers become stunted. Damaged leaves become distorted and may break off in the wind.

Life history: A female lays in 3 - 7 batches of about 100 cigar-shaped eggs singly on either side of leaves. Incubation period is 2 - 6 days. The larva undergoes 3 instars and the larval period is 8 - 17 days. Pupation take place in between the leaf sheath and the pupal period lasts for 5 - 9 days. There are 10 - 15 overlapping generations.

Management Strategies:
(i) Spraying of endosulfan or quinalphos or fenthion at 0.5 kg a.i./ha
(ii) Alternatively, application of granules of carbofuran or fenthion at 0.75 kg a.i./ha.

II. Pests of Wheat and Barley

1. Brown Wheat Mite *Petrobia lateens* (Muller) (Arachnida: Tetranychidae)

Distribution: It occurs on wheat in the summer rainfall regions and expected to be severe where drought conditions are frequently encountered.

Nature of damage: The brown wheat mite feeds on sap from leaves by inserting two needle-like stylets into the leaf thereby withdrawing nutrients from the plant. During high mite populations the leaves may have a bronze appearance with some leaves even dying off as a result of intense feeding. They have a tendency to feed on the tips of the leaves, causing them to dry out and die. Heavily infested fields present a scorched withered appearance. Showers of 12mm or more may lead to the eradication of the mite population, but eggs present in the soil may start a new generation.

Life history: The mites are very small measuring about 0.5 mm in length, metallic brown to black with pale yellow legs and their forelegs are distinctively longer than the other three pair of legs. Eggs are generally laid beneath clods and are either active i.e. red in colour and not visible to the naked eye or dormant i.e. white eggs

clearly visible on the underside of clods. Under favourable environmental conditions eggs hatch within 9 - 11 days. Dormant eggs may remain in the soil for long periods and hatch during July/August following light rainfalls. Dry conditions favour larval development and adulthood can be attained within 8 - 11 days. Only females occur and eggs are laid within 2 days after reaching adulthood. Subsequently, mite populations often reach pest status under dry conditions. The total life cycle is completed in 25.5 days.

Management strategies:
(i) Spraying formothion or oxydemeton methyl or phosphomidon @ 250 g a.i./ha. Spraying may be repeated after 15 days in case of severe infestation.
(ii) Growing of tolerant wheat variety such as C-306.

2. Grain aphid *Sitobion avenae* (F.) (Aphididae : Homoptera)

Distribution: This pest is found distributed worldwide in parts of Europe, Asia, Africa, North America, Central America and Caribbean and South America. In India it is reported from Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh and West Bengal.

Nature of damage: A major pest of cereal crops in the spring. Heavy infestations can cause a reduction of the number of grains per ear and thus a noticeable reduction of the yield. Sooty moulds develop on the honeydew which they secrete. This aphid is also a vector of the barley yellow dwarf virus (BYDV).

Life history: Primary hosts of this aphid belong to the genus *Pubus*. Secondary hosts mostly belong to the *Poaceae* (=*Gramineae*), including grasses like cocksfoot grass, and also cereals *viz*., oats, wheat, rye, barley. Winter eggs are laid on the straw of graminaceous plants and hatch in late winter, giving rise to several generations of apterous, virginoparous fundatrigeniae. Winged aphids emerge, spreading to other graminaceous plants and developing on the uppermost leaves before moving to ears as soon as these emerge. When populations are abundant or when the ripening grain hardens, winged aphids appear in a few days, leaving to create new colonies on *Poaceae* which are still green. During mild winters, this species survives parthenogenetically on new growth of winter cereals and other *Poaceae*.

Management strategies:
(i) Spraying formothion or oxydemeton methyl or phosphamidon @ 250ml a.i./ha.
(ii) Growing aphid resistant barley varieties DL117 or DL200.
(iii) Early sowing of barley by 1st fortnight of November usually reduces aphid attack.

3. Shootfly Atherigona *naqvii* (Muscidae: Diptera)

Distribution: Occurs in all wheat growing areas.

Nature of damage: The maggots bore into the shoot of young plants, a week after germination to about one month and as a result the central shoot dries up resulting in ‘dead hearts’. If it is a little later the mother plant may produce side tillers. But the tillers also may be attacked. The infestation often goes as high as 60%.

Life history: The adult is a small dark fly. It deposits whitish eggs singly on the central surface of the leaves. The eggs hatch in 1 - 3 days and the maggots which are yellow in colour migrate to the dorsal surface of the leaf, enter the space between the leaf sheath and the axis and make a clean cut at the base of the leaf. The growing

point of the plant dies and decays on which the maggots feed. The larval period lasts for 6 - 10 days. Pupation takes place inside the stem itself and the adults emerge in about a week. Each female fly is capable of laying 30 eggs during its life time. Life cycle occupies 17 - 20 days.

Management strategies:

(i). Early sowing of wheat will reduce the attack.

(ii). In late sown crops (end of December to 1st week of January) spraying of cypermethrin 0.002% twice at fortnightly intervals in seedling stage was found effective. The most vulnerable period of crop is being upto 60 days of germination.

III. Pest of Millets

A. Sorghum (*Sorghum vulgare*)

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

Distribution: Occurs throughout the country.

Nature of damage: The maggots bore into the shoot of young plants, a week after germination to about one month and as a result the central shoot dries up resulting in 'dead hearts'. If it is a little later the mother plant may produce side tillers. But the tillers also may be attacked. The infestation often goes as high as 60%.

Life history: The adult is a small dark fly. It deposits whitish eggs singly on the central surface of the leaves. The eggs hatch in 1 - 3 days and the maggots which are yellow in colour migrate to the dorsal surface of the leaf, enter the space between the leaf sheath and the axis and make a clean cut at the base of the leaf. The growing point of the plant dies and decays on which the maggots feed. The larval period lasts for 6 - 10 days. Pupation takes place inside the stem itself and the adults emerge in about a week. Each female fly is capable of laying 30 eggs during its life time. Life cycle occupies 17 - 20 days.

Alternate hosts: The fly infests wheat, maize, small millets and grasses, besides sorghum.

Management strategies:

(i) *****A higher seed rate is adopted and the affected seedlings are pulled out and destroyed.

(ii) Application of 10% phorate (Thimet) or carbofuran 3% granules at the time of sowing at the rate of 2.5 kg a.i./ha.

(iii) Spraying of endosulfan @ 0.07% or cypermethrin @ 0.005% or cartap hydrochloride 0.5 kg a.i. /ha or triazophos @ 0.5 kg a.i. /ha twice a week after sowing or during second week.

***** Seed rate of @ 12 kg/ha may be followed and the infected plants are removed.

2. Sorghum stem borer *Chilo partellus* (Swinhoe) (Crambidae: Lepidoptera)

Distribution: It is found in all places of India where sorghum is grown. It is also found to attack finger-millet, maize, pearl-millet, sugarcane and wild grasses.

Nature of damage: Presence of 'dead heart' in the early stages is the main symptom. The bore holes may be visible in contrast to the dead-heart caused by the stem fly. Later it acts as an internode borer and is found till the time of harvest. Yield is

affected much and the quality of the fodder is also reduced. The damage caused to the crop by this pest is estimated to range between 70 – 80 %.

Life history: The moth is medium sized and straw coloured. The female lays flat oval eggs, about 200 on the underside of the leaves, near the midrib. The eggs hatch in 2 - 6 days. The larva is pale white with black dots and brown head. It bores into the stem near the node and feeds upwards. The larvae remain dormant in winter and hibernate. The average number of caterpillars per plant is four. The larval period lasts from 28 – 50 days in summer to 193 days in winter. Pupation take place inside the stem and the adults emerge in 7 - 15 days depending upon the climatic conditions. Total life cycle is completed in 30 – 40 days.

Management strategies:

(i) Collection and destruction of the stubbles which are left in the field or heaped in one corner of the field since they act as a source of infestation, as the larvae hibernate in them.
(ii) Spraying of carbaryl 0.1 % or endosulfan 0.07% thrice at an interval of 15 days from a month after sowing.
(iii) Two whorl applications of 4 % endosulfan or 10 % carbaryl or 4% cartap hydrochloride granules, first at 5 kg /ha at 25 – 30 days after crop emergence and second at 10 kg/ha 10 - 15 days later. If infestation is severe, three applications at 5.0, 7.5 and 10.0 kg/ha are recommended.

3.Sorghum midge *Contarinia sorghicola* (Coq.) (Cecidomyiidae: Diptera)

Distribution: It has a world wide distribution and is considered to be one of the important pests of sorghum.

Nature of damage: The maggots feed on the developing grains and cause the developing grains to shrivel and severe infestation has a significant effect on the overall production of grains. The loss varies from 20 - 50 %.

Life history: The adult fly is very small, fragile and has a bright orange abdomen and a pair of transparent wings. The maggot feeds inside the developing grain and pupates there itself. It emerges between the tip of the glumes leaving the white pupal case attached to the tip in a characteristic manner. The life-cycle from egg to adult varies from 14 - 90 days.

Management strategies:

(i) Spraying of endosulfan 35 EC***** 1 litre, or phosalone 35 EC 1 litre, or Malathion 50 EC 1 litre, or carbaryl 50WP 2 kg per hectare at nearly 90% ear-head emergence and repeated after 4 or 5 days.
(ii) Phosalone 4% or endosulfan 4% or Malathion 5% or carbaryl 10% or quinalphos 1.5% dust at 12 kg/ha is also effective.
* EC = Emulsifiable Concentrate

IV. Pests of Sugarcane (*Saccharum officinarum*)

1. Early shoot borer *Chilo infuscatellus* Snellen (Crambidae: Lepidoptera)

Distribution: It is found to attack sugarcane in Tamil Nadu, Andhra Pradesh, Punjab, U.P., Bihar, West Bengal, Madhya Pradesh, Rajasthan and Maharashtra.

Nature of damage: The borer enters into young shoots and tunnels downwards. The upper portion of the central leaf whorl is thus cut off and dries up causing dead hearts

in shoots from about a month old to 2 - 3 months crop. If the attack is in early stages the mother shoot dies completely and late attack induces profuse tillering.

Life history: The eggs are white and flat, laid in batches on the under surface of the leaves by the side of the midrib in three or more rows, one overlapping the other. Eggs are laid on the leaf sheath also. A moth may lay more than 200 eggs at a time and in each cluster 8 - 60 eggs will be found. The oviposition is at peak during May in March - April planted crop. The eggs hatch in 3 - 4 days. The caterpillars cut a hole on the side near ground level and enter the shoot and feed downwards. The affected tiller will decay emitting a foul smell. The caterpillar is white with five violet stripes on the dorsal side of the body with a brownish head. The crochets in the proleg are crescentic or semi circular. Each caterpillar migrates and attacks a number of shoots. The larval stage lasts for about 35 days and pupates inside the stem. The pupa is light brown in colour and the pupal period lasts for 10 days. The adult moth is small, pale grayish brown, the forewings with darker markings especially along the outer edge and the hind wings whitish. Total life cycle occupies 44 - 49 days.

Management strategies:

(i) Light earthing up of the tillers at the early stages of the crop (month old) during May and June reduces the incidence. A second earthing a month later reduces the borer attack considerably.

(ii) Mulching with cane trash at the early stages also has been reported to reduce the incidence and help in conserving moisture.

(iii) Cutting the affected tillers as close to the ground as possible and destroying them.

(iv) Soil application of granules of cartap hydrochloride at 1 kg a.i./ha at planting followed by another application on 45^{th} day for late planted crop.

(v) Cartap hydrochloride 4G, sevidol 8G and chlorpyriphos 10G at 1 kg a.i./ha as whorl application at 35^{th} and 65^{th} day are also found effective.

(vi) Inundative releases of the egg parasitoid *Trichogramma chilonis* @ 50,000/ha from first month of planting at 7 - 10 days interval till one month prior to harvest.

(vii) At 30^{th}, 45^{th} and 60^{th} day of crop growth spray granulosis virus of *Chilo infuscatellus* (10^{-7} – 10^{-8} inclusion bodies/ml) at 500 l/ha.

(viii) Release of 125 gravid females of *Sturmiopsis inferens* (Tachinidae) per ha at 45^{th} day of crop growth.

2. Internode borer *Chilo sacchariphagus indicus* (Kapur) (Crambidae: Lepidoptera)

Distribution: The insect is found throughout India and usually occurs on sugarcane late in its growing phase during June – December. It is serious in Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Uttar Pradesh. The larva has been found feeding on Pearlmillet, sorghum, maize, paddy and wild plants like *Sorghum spontaneum*, *S. fusca* and *Pennisetum hoockenhackeri*.

Nature of damage: It infests the crop after the third month when internodes begin to form and continues till the time of harvest. Symptoms will be visible only on close examination. The affected node will be thinner than the other nodes. Mostly the attack is found on the first five internodes. It feeds on the internal tissue making it turn red. The bore hole is plugged with excreta. Due to the attack the quality of juice is reduced and in severe cases cane formation is affected resulting in loss of weight.

Life history: Oval flattish eggs are laid in rows on the leaf. Generally, two rows, one just overlapping the other are laid. Each row will contain 9 - 11 scale like eggs. Egg

period lasts about 3 days. The larva bores near nodes and feeds on the fibrous tissue by tunneling. It migrates and damages many nodes. The larva is white with dark spots on the body and four violet stripes on the dorsal surface. The dorsal median line is absent. The head is shiny yellowish brown. The crochets on the prolegs are circular. Larval period lasts about 30 days. Pupates in the leaf sheath and the pupal period lasts about a week. The adult is a pale brown moth with a white hind wing. Total life cycle lasts about 40 - 45 days.

Management strategies:
(i) Inundative release of the egg parasitoid *Trichogramma chilonis* @ 50,000 parasitoid/ha/week from the 4^{th} up to 11^{th} month after planting affords protection.
(ii) Use of resistant varieties are CO 285, 453, 513, 617, 853, 915, 1007, 1287, 6806 and COJ 46.

3. Top borer *Scirpophaga excerptalis* Walk. (Pyraustinae: Lepidoptera)

Distribution: The insect has a wide distribution in India but is more serious in North India. It occurs on sugarcane in the later stages of growth during June – December and may persist till harvest. Wild *Saccharum* sp. is also attacked by this pest.

Nature of damage: Tunneling of midrib in a leaf, small holes in a parallel line in the freshly appeared leaves, dead heart which is reddish brown in the young crop (2 - 4 months old) and a bunchy top in a grown up crop are the characteristic symptoms. Sprouting of the eye buds affects the quality of the juice. Since the growth is restricted, the yield is also affected. It accounts for 20 - 30 % reduction in yield resulting in low juice quality and early maturity of the crop. The sucrose per cent in juice decreases by 2 units.

Life history: There are 5 broods reported in a year. The moth lays oval shaped flattish eggs in groups of 35 - 40, generally on the lower surface of the leaf and covers with crimson coloured hairs. The new larva hatches in 6 - 11 days and it bores through the mid rib and slowly reaches the central region. It feeds through the leaf whorl, enters the growing shoot from the top and feeds downwards. The caterpillar is cream yellowish white, very slender and soft. After entering the shoot it does not move out. Larval period lasts from 25 - 41 days. Pupates inside the burrow and emerges after 12 - 21 days. The adult comes out through the hole made by the larva before pupation. Moth is uniformly creamy white in colour. The first pair of wings of certain moths bears a black spot on each wing. Females have a crimson hairy tuft at the anal end. The total life cycle lasts 45 – 75 days. Heavy rains are usually conducive for the multiplication of the pest.

Management strategies:
(i) The egg masses and also the infested portions of plants may be collected and destroyed during the brood emergence period.
(ii) Release of the ichneumonid parasitoid *Gambroides javensis* Rohw. has been found to be promising in Tamil Nadu.
(iii) Variety Co 419 is comparatively resistant to this borer. Other resistant varieties are CoS 767, CoJ 67 and Co 1158.
(iv) Soil application of carbofuran at 2 kg a.i. /ha or phorate at 1 kg a.i./ha for the third brood during first week of July is recommended.

4. Sugarcane Leaf hopper *Pyrilla perpusilla* Walker (Lophopidae: Homoptera)

Distribution: It is major pest of sugarcane in Punjab, Uttar Pradesh, Bihar and Maharashtra. Generally, it is a minor pest but sometimes assume a major form in different parts of India.

Nature of damage: Both the adults and nymphs are very active, jumping from leaf to leaf on slight disturbance. They suck the cell sap from the leaves and secrete honey dew which attracts the black fungus. Due to this feeding the leaves turns yellow and finally look withered and burnt with black encrustation.

Life history: The female bug lays greenish yellow eggs in clusters, generally on the undersurface of leaves and between the detached leaf sheaths and the stem. The eggs are covered with white cottony, waxy filaments. 10 - 15 eggs are found in a cluster and they hatch in about a week. The nymphs have two characteristic anal processes and feed on plant sap. They develop into adults in 50 – 60 days. The insects are generally found from August - September. The intermittent periods of drought during July - September, heavy manuring and irrigation and luxuriant growth help in its profuse multiplication. It is also found that broad and soft-leaved varieties are more susceptible to this pest.

Management strategies:
(i) Release of the lepidopteran ectoparasitoid *Epiricania melanoleuca* @ 4000 - 5000 cocoons or @ 4 - 6 lakh eggs/ha checks its multiplication.
(ii) In case of severe infestation without the occurrence of the ectoparasitoid, spraying of endosulfan 0.07 % is quite effective.

5. Whitefly *Aleurolobus barodensis* Mask. and *Neomaskellia bergii* (Sign.) (Aleyrodidae: Homoptera)

Distribution: *A. barodensis* in recent years has assumed serious proportions on sugarcane in Bihar, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Tamil Nadu and Uttar Pradesh and in a mild form in Andhra Pradesh. It is serious on ratoon crops under water-logged as well as drought conditions.

Nature of damage: The sap drainage by nymphs result in the leaf gradually turning yellow and pinkish and ultimately the leaf dries up. The nymphs excrete large quantities of honey dew which accumulates on the affected leaves and the leaves appear black due to development of sooty mould interfering with photosynthesis. High infestation causes stunted crop growth and reduces juice quality. Severe whitefly infestation may result in reduction in cane yield up to 24 % and loss in sugar up to 2.9 units.

Life history: The pale yellow adult female of *A. barodensis* lays about 80 eggs in linear masses on first and second top tender leaves. The eggs are fixed firmly on the leaf tissue on both the surfaces. The incubation period varies from 9 - 13 days. The nymphs feed by sucking the sap. The oval nymphs are black with fringes of wax and waxy deposit on body and the three nymphal instars last for respectively 4 – 7, 3 – 7 and 3 – 8 days. The fourth instar (pupal stage) lasts for 9 - 14 days. The last nymphal instar is the pupal stage from which through a T-shaped opening the adult emerges. The life-cycle is completed in 32 – 44 days.

Management strategies: (i) Discourage ratooning in low lying areas and avoid water logging. Remove lower leaves containing pupae periodically.

(ii) Spray imidacloprid 0.01% or monocrotophos 0.05% or acetamiprid @ 0.01% after removing infested lower leaves. At least two or more sprays will be required at fortnightly intervals.

6. Sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner (Pemphigidae: Homoptera)

Distribution: It was reported as a minor pest of sugarcane in Assam, Nagaland, Sikkim, Tripura, U.P. and Bengal in 1974. In July 2002 severe infestation of this pest in sugarcane crop was noticed in Maharashtra. Later this pest was found distributed in Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, Uttraranchal and Bihar. It is also reported to attack bamboo, *Miscanthus sinensis*.

Nature of damage: Nymphs and adults are found on the lower surface of the sugarcane leaves and suck the cell sap and excrete 'honey dew' which is dropped on the upper surface of the lower leaves. Honey dew encourages the growth of the fungus *Capnodium* spp. which results in black coating called 'sooty mould' on the upper surface of leaves affecting photosynthesis. Due to sap sucking, yellowish white spots develop on the leaves leading to drying of leaf edges and complete drying of leaves. Severe infestation causes mottling of leaves, stunted growth, and loss in sugarcane yield and sugar recovery. Losses up to 26% in sugarcane yield and 24% in sugar content have been reported.

Life history: Newly emerged nymphs are yellowish or greenish yellow in colour devoid of woolly filaments. Nymphs are found congregated at both the sides of the mid rib on the lower surface of the leaves. There are four instars observed after which they become adults. White coloured woolly filaments are observed on the dorsal side of the 3rd and 4th instar nymphs and not on the 1st and 2nd instars. Adults are black in colour and they possess two pairs of transparent wings and a pair of cornicles. Winged and wingless females are found to reproduce parthenogenetically throughout the year. Each female produced a maximum of 217 nymphs in 20 days. Nymphs completed four instars to become adults in 6 - 22 days. Overlapping generations are observed in the field.

Management strategies:
(i) Paired or wider row planting of sugarcane.
(ii) Release of the natural enemies *Dipha aphidivora* Meyr. or *Micromus igorotus* in shade net cages (5m x 5m) @ 50/cage and allow them to develop and disperse by removing the cages.
(iii) Release of *D. aphidivora* larvae @ 1000/ha and *M. igorotus* larvae @ 2500/ha.
(iv) Need based application of metasystox 0.0375% or endosulfan 0.05% or dimethoate 0.045% in case of severe infestation without the presence of natural enemies.

V. Pests of Oilseeds

A. Groundnut (*Arachis hypogaea* Linn.)

1. Red hairy caterpillars *Amsacta albistriga* Wlk. and *Amsacta moorei* Butler. (Arctiidae: Lepidoptera)

Distribution: This is a serious and devastating pest of rainfed groundnut crop. It is an endemic one and its seasonal outbreak in various areas is largely dependent on the climatic conditions and the local agricultural practices of the areas. Its outbreak takes

place generally during May - June in Coimbatore district, during June - July in South Arcot, North Arcot and Salem districts and during August - September in Madurai and Ramanathapuram districts. It also occurs in Andhra Pradesh, Maharashtra and Karnataka.

Nature of damage: The larvae that hatch out from the eggs feed gregariously by scarping the under surface of tender leaflets leaving the upper epidermal layer intact. As they grow they feed voraciously on leaves leaving behind the petiole and midribs of leaves and the main stem of plants and may be seen marching from one field to another in thousands. Severely damaged crop presents the appearance as though the entire area has been grazed by cattle. Often it results in total loss of pods. Though it is principally a major pest of groundnut it prefers cowpea to a great extent. Apart from these crops it also feeds on sorghum, cotton, *Pennisetum typhoideum* L., *Rhynchosia minima* (Fabaceae), finger-millet, castor, etc.

Life history: The adults are medium sized moths. In *A. albistriga* the fore wings are white with brownish streaks all over and yellowish streak along the anterior margin and the hind wings white with black markings. A yellow band is seen on the head. In *A. moorei* the anterior marginal streak of fore wings and the band on head are red in colour. Both species are found together.

After the receipt of heavy rains on the second evening at about 4 p.m. the moths emerge from their earthen cells in the soil. The moths mate and commence oviposition on the same day. The egg laying may last for 2 - 6 days. The creamy or bright yellow eggs are laid in groups mostly on the under surface of cowpea leaves usually sown along with groundnut as an inter crop and also on groundnut and occasionally on other vegetation, clods of earth, stones, dry twigs, etc. A female moth lays about 600 - 700 eggs but it has also been observed that as many as 2300 eggs have been laid by a moth. The incubation period ranges from 2 - 3 days. The larva becomes full grown in 40 - 50 days. It is about 5 cm long, reddish brown with hairs all over the body arising on warts. With the receipt of some showers, the grown up larvae burrow into the moist soil and pupate in earthen cells at a depth of 10 - 20 cm.

Management strategies: In view of the widespread out break of the pest, farmers need to adopt the control measures on a co-operative basis.

(i) The pupae may be collected at the time of summer ploughings and destroyed.
(ii) Setting bonfires or light traps to attract the moths up to 11.00 P.M.
(iii) Collection and destruction of egg masses should be carried out during the early stages of attack.
(iv) A week after mass emergence of moths, the field should be dusted with phosalone 4% or carbaryl 10% dust to kill the first instar larvae which are vulnerable at this stage.
(v) Grown up larvae are killed by spray application of phosalone 0.05 % or endosulfan 0.075%.
(vi) Stray grown up larvae found in the field may be collected and destroyed.
(vii) Nuclear polyhedrosis virus @ 250 LE/ha has been found promising in field scale control of the pest in Tamil Nadu.

2. Leaf miner *Aproaerema modicella* (Deventer) (Gelechiidae : Lepidoptera)

Distribution: The leaf miner is also one of the major pests of importance on groundnut crop all over India especially when raised under rainfed conditions. In the

rainfed crop, the peak of attack is during September and October. It also infects *Psoralea corylifolia*, *Cajanus cajan* and soybean.

Nature of damage: Bunch variety is generally severely infested. The larva mines into tender leaflets or it webs together adjacent leaflets and feeds on the tissue. The leaflets get distorted and due to feeding get dried up in course of time. In a very severely infested crop, the whole field presents a burnt up appearance and the small adults could be seen flying in large numbers when one walks through the crop. The loss in yield of pods is also considerable.

Life history: The moth is very small with dark brown wings and small distinct white spot on fore wings. It lays shining, sculptured eggs, singly on tender leaves. The incubation period is 3 days. A moth on an average lays up to 200 eggs. The larvae immediately after hatching mine into the leaves. Later they come out and web together the leaves and feed on the green matter. Larval period lasts for 9 – 17 days and the larvae pupate in the leaf folds. Pupal period is 3 – 7 days.

Management strategies:

(i) Dusting phosalone 4% or carbaryl 10% or spraying fenitrothion 0.025 % or phosalone 0.05% or monocrotophos 0.05 % or chlorpyriphos 0.05 %.

B. Mustard (*Brassica campestris*)

1. Mustard sawfly *Athalia lugens proxima* (Klang) (Tenthredinidae: Hymenoptera)

Distribution: This is one of the very few hymenopterous insects noticed to infest Cruciferous crops all over India. It is a pest of cold weather, generally active during October to March.

Nature of damage: The larvae feed voraciously on leaves. Apart from mustard it also attacks radish and allied plants. It feeds during mornings and evenings from the margin of the leaf towards the centre. During day time it prefers to stay in the soil.

Life history: The adult is black with yellowish femora and thorax. The female possesses a saw-like ovipositor and inserts the eggs very near the leaf margin. A female on an average lays about 60 eggs. The larva is cylindrical and dark gray with three pairs of thoracic legs and seven pairs of prolegs on abdominal segments 2 -8. Its body surface is hairless. Young larva is greenish grey in colour and its colour becomes darker in the later instar. It measures about 15 – 20 mm long and pupates in an earthen cocoon in the soil. The egg, larval and pupal periods occupy 4 – 5, 13 – 18 and 10 – 15 days, respectively. Parthenogenetic development is also observed.

Management strategies:

(i) Spray application of carbaryl 0.1 % or endosulfan 0.07 % or phosalone 0.05% or profenofos 0.05%

2. Mustard aphid *Lipaphis erysimi* Kaltenbach (Aphididae: Homoptera)

Distribution: The most serious pest of the mustard crop in India. Besides brassicas to which mustard belongs, this pest attacks a number of other economic plants, particularly those of the family Cruciferae. Like many other important aphid pests, this species has a very wide distribution in the world.

Nature of damage: These aphids are small (about 2 mm), generally globular with piercing and sucking mouth-parts. They possess a pair of small tubular structures at the posterior region of their body, called cornicles. It pierces its proboscis into the tender plant tissue and sucks the plant sap. It excretes honeydew that covers practically the whole surface of leaves and the tender shoots. A black mould develops on the honeydew which interferes with the photosynthetic activities of the plant.

Life history: The aphid population generally makes its appearance sometimes during winter and it continues to breed parthenogenetically till the end of spring when winged individuals are produced and large-scale dispersal takes place. The population, however, dwindles mostly due to climatic reasons and practically disappears for the whole of the summer and also most of the autumn.

Management strategies:
(i) Early sowing of mustard before 15th October will help to escape the attack of the pest and economic damage.
(ii) Spray application of metasystox 0.05% or imidacloprid 0.01% or acetamiprid @ 0.01%.

C. Coconut (*Cocos nucifera*)

1. *Rhinoceros* beetle *Oryctes rhinoceros* L. (Scarabaeidae: Coleoptera)

Distribution: It is widely distributed in India and persistent in all coconut growing areas. Pineapple, sugarcane, Aloe, African oil palm, palmyrah, date palm and talipot palm are also attacked by the beetle.

Nature of damage: The damage is inflicted by the adult beetle which burrows by remaining in between leaf sheaths near the crown and thus cut across the leaf in its folded condition. The damaged leaves show characteristic clipping or holes in the leaflets. Frequent infestation results in stunting of trees and death of growing point in young plantations. The infestation can be easily made out by the chewed fibrous material present near holes.

Life history: The adult beetle is stout, black or reddish black, about 5 cm long and has a long horn projecting dorsally from the head in male; in the female the horn is short. The female lays the oval, creamy white eggs in manure pits, decaying vegetable matter, undisturbed heaps of cattle excreta etc. to a depth of 5 - 15 cm. A female may lay up to 140 eggs and the incubation period is 8 – 18 days. The grub feeds on the decaying matter and the larval stage lasts for 99 - 182 days. It is stout, sluggish and white in colour with a pale brown head and is usually found at a depth of 5 - 30 cm. The grubs pupate in earthen cells at a depth of 0.3 - 1 meter and emerge as adults in 10 – 25 days. The total life-cycle from egg to adult ranges from 3.5 - 8 months and the adult longevity extends up to 290 days.

Management strategies:
(i) The grubs in their breeding places should be killed by spray application of carbaryl 0.1 % solution at least once in three months.
(ii) The beetles should be extracted from the crown with the help of iron hooks and a mixture of sand plus carbaryl 10% dust in equal proportions should be filled in the axils of innermost 2 – 3 leaves on the crown twice a year during pre and post monsoon periods.
(iii) The grubs are susceptible to the fungi *Metarrhizium anisopliae* and *Beauveria bassiana* and so application of these in breeding sites is recommended.

(iv) Pieces of tender coconut stem split longitudinally and treated with fresh toddy or 1 kg castor cake soaked in water in small mud pots when kept in coconut gardens are found to attract the beetles. And these could be used in poison baits.

2.Red palm weevil *Rhynchophorus ferrugineus* (Curculionidae : Coleoptera)

Distribution: This is one of the important pests of coconut in India in Kerala, Karnataka, Goa, Tamil Nadu and Andhra Pradesh and its attack often results in the death of the palm. In addition to coconut other palms are also attacked by the weevil.
Nature of damage: Few small holes with protruding chewed fibrous material and oozing out of a brown liquid from such holes, present in the tree trunk, indicate the early infestation by the pest. In the advanced stage of attack the central shoot shows sign of wilting and a large mass of grubs, pupae and adults of the insect could be seen inside the trunk at the affected portion. In the grown up trees the crown region alone is infested.

Life history: The reddish brown weevil has six dark spots on thorax and in the male the conspicuous long snout has a tuft of hairs. The female lays the eggs in scooped out small cavities on palms of up to 7 years and on older trees they may be deposited in the wounds and other cut injuries found on the trunk crown. A female lays as many as 276 eggs which are oval and white. The incubation period is 2 - 5 days. The apodous light yellowish grub with a red head becomes full grown in 36 - 78 days and pupates in a fibrous cocoon inside the trunk itself. It emerges as an adult in 12 - 33 days.

Management strategies:
(i) The dying and already damaged palms should be destroyed and as far as possible inflicting mechanical injuries on trees should be avoided.
(ii) The infested portion should be scooped out and dressed with tar. A solution of 1 % pyrocone E (a mixture of pyrethrin 1 part + piperonyl butoxide 10 parts) i.e. 1 part in 100 parts of water, or 1 % carbaryl or monocrotophos 36 WSC 5 ml + DDVP 76 WSC 5ml when injected through a hole on the crown at 1000 - 1500 ml per grown up tree brings about appreciable control of the pest.

3. Black-headed caterpillar *Opisina arenosella* (Wlk.) (Cryptophasidae: Lepidoptera)

Distribution: One of the pests of importance on coconut all over peninsular India but more injurious along the east and west coasts.

Nature of damage: The larvae live on the under surface of leaflets within galleries of silk and frassy material and feed by scraping the green matter. In case of severe attack due to large scale drying of leaflets the whole plantation presents a burnt up appearance from a distance.

Life history: The grayish white small moth lays about 130 eggs in groups on leaves and the larvae hatch out from the eggs in about 5 days. The larval period lasts about 40 days and the caterpillar is greenish brown with dark brown head and prothorax, and a reddish mesothorax. It pupates inside the web itself in a thin silken cocoon and after about 12 days emerges as adult.

Management strategies:
(i) The infested fronds should be cut and burnt.
(ii) In the case of young trees carbaryl 0.1% may be sprayed.

(iii) Trunk injection of monocrotophos 36 WSC at 5 ml/palm is also effective.
(iv) Root feeding with monocrotophos is suggested. For this select a mature dark brown root, cut with a sharp knife and immerse the cut end in an emulsion containing 20 ml of 1:1 monocrotophos 36 WSC and water in a well secured small polythene bag (15 cm x 10 cm). To avoid residues in the tender coconuts, this treatment is not suggested for fruiting trees.
(v) Periodically releasing of its parasitoids such as *Goniozus nephantidis*, *Bracon brevicornis*, *Elasmus nephantidis* and *Trichospilus pupivora* is recommended.

D. Sunflower (*Helianthus annuus* L.)

1. Sucking pest, *Amrasca biguttula biguttula* Ishida (Cicadellidae: Homoptera)

Distribution: This pest is of economic importance in Maharashtra, Tamil Nadu and Karnataka causing crop loss up to 46 %. Though it may appear on the crop round the year, it is serious during certain months at different places. Summer crops are likely to suffer more with this pest than kharif crop.

Nature of damage: The incidence would start from seedling stage and prevail right through entire plant life. Stunted growth of plant, cupped and crinkled leaves, burnt appearance of leaf margins are symptoms of damage.

Life history: The female lays on an average 15 eggs into the spongy parenehymatous tissue between the vascular bundles and the epidermis and they hatch in 4 - 11 days. The nymphs moult five times and the whole life cycle is completed in two weeks to more than a month and a half depending upon the temperature and humidity prevailing in the field.

Management strategies:
(i) Insecticides like phosphamidon (0.03%) or dimethoate (0.03%) or monocrotophos (0.05%) or imidacloprid (0.01%) may be sprayed @ 650-700 litre spray solution per hectare if the pest build up is very high.
(ii) Seed treatment with imidacloprid @ 5g and 7.5 g/kg of sunflower seed protects from jassid up to 35 - 40 days after sowing.

2. Capitulum borer, *Helicoverpa armigera* (Hubner) (Noctuidae : Lepidoptera)

Distribution : The capitulum borer, *H. armigera* is highly polyphagous with about 181 host plants including important crop plants such as pulses, cotton, vegetables, oilseeds etc. and the pest is prevalent throughout India.

Nature of damage: The larva is capable of developing on foliage which is rather less common in field's situations. On a bloom, usually, larvae on hatching would get into the bottom of the preripheral florets and feed on ovaries. During pre-anthesis stage they feed scraping the bracts first and later feed through ray-florets which cover disc florets and finally find access to immature ovaries. The larval growth is better supported by developing seeds.

Life history: *H. armigera* passes through four generations in Punjab and seven to eight generations in Andhra Pradesh. Several crops like maize, sorghum, cotton, sunflower, tomato, pigeonpea, chickpea etc., are found to support large populations of *H. armigera*.

Emergence of *H. armigera* moth has been observed evening any time after 1600 hrs. the peak emergence being between 20.00 and 22.00 hr. Pre-oviposition period ranged from 1 - 4 days, oviposition period 2 - 5 days, and post oviposition period 1 - 2 days. Each female moth can lay on an average 700 - 1000 eggs. The incubation period ranges from 2 - 5 days. There are normally six instars, but exceptionally seven instars are found in cold season. The larval period ranges from 8 to 33.6 days with 8 to 12 days on tomato, 21 - 28 days on chickpea, 21 - 28 days on maize, 33.6 days on sunflower and 20 - 21 days on cotton. The full grown larvae pupate in earthen cocoons in the soil. Pupal period vary from 5 - 8 days in India.

Management strategies:

(i) A significant reduction in pest density is achieved with the spray of NPV @250 LE*****/ha.

(ii) NSKE (5%) and many neem origin pesticides are found effective in reducing damage due to *H. armigera*.

(iii) Endosulfan (0.05%) on 25 and 45 DAS is ideal for management of this pest in a short duration variety like Morden.

(iv) Endosulfan (0.05%), cypermethrin (0.005%), fenvalerate (0.005%) and deltamethrin (0.002%) spray @ 650 – 700 litre/ha against the head borer are found to be effective.

* LC = Larval Equivalent

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

Distribution: It is cosmopolitan, highly polyphagous and is reported on sunflower in all sunflower growing areas.

Nature of damage : Early instar larvae (gregarious phase) scrape on green matter that give a mesh like appearance to damaged leaves which can be spotted easily from a distance. Older larvae cause total defoliation.

Life history: Adult moth has dull brown forewings with white markings, hind wings are hyaline. Eggs are laid underneath the leaves in clusters (200 - 300 eggs) covered with cream coloured hairs and scales. Egg period is 3 - 4 days. Larvae are gregarious when young, later disperse having 5-6 instars. Larval duration ranges from 15 - 28 days. They feed on foliage at night, hide in soil and debris during day. The larvae pupate in the soil in an earthen cell. Pupal period is 7 - 10 days.

Management strategies:

(i) Monitoring of moth activity through pheromone traps.

(ii) Collection and destruction of egg masses and gregarious early instars present on undersurface of leaves.

(iii) Spray of monocrotophos 0.05% or dichlorvos 0.05% or cypermethrin 0.005% in 500 litre water/ha in case of severe incidence.

(iv) Use of poisoned bran bait (125 ml monocrotophos + 1 kg jaggery + 10 kg rice bran) is effective against later instars.

4. Bihar hairy caterpillar *Spilosoma oblique* Walker (Arctiidae: Lepidoptera)

Distribution: It is highly polyphagous and mainly a pest of rabi-summer sunflower in Maharashtra.

Nature of damage: The larvae are foliage feeders. Early instars feed on chlorophyll and later instars defoliate the crop. Drying up of infested leaves is a characteristic symptom.

Life history: Adult moth lays eggs in clusters. Larvae are hairy, gregarious in early instars and disperse later. Larval period varies from 14 - 21 days. Pupal diapause is noticed. Generation time is 38 - 164 days

Management strategies:
(i) Collection of infested leaves which show characteristic drying symptoms will reduce the population to a great extent because of the gregarious nature of young larvae.
(ii) Spraying contact insecticides endosulfan or quinalphos or carbaryl at 0.05 – 0.1 %.

5. Green semiloopers *Trichoplusia ni, Thysanoplusia orichalcea* (Fabr.) (*Plusia orichalcea*) (Noctuidae: Lepidoptera)

Distribution: Regular pest of sunflower in Maharashtra, Karnataka during August and September. It is also found to attack cotton, legumes, solanaceus plants, sweet potato and some cucurbits.

Nature of damage : Early instars feed on chlorophyll of tender leaves causing transparent leaf spots, later feed from leaf margin and defoliate leaving midribs in case of severe incidence.

Life history: Larvae are green in colour with a thin white lateral line and two white lines on the back, active and form loop in motion; swollen at posterior end and tapers anteriorly. Pupate in white transparent silken cocoons in leaf litter or crop debris. Life cycle takes 30 days.

Management strategies:
(i) Spray quinalphos 0.05% in case of severe incidence.

E. Gingelly

1. Leaf webber *Antigastra catalaunalis* Duponchel (Pyraustidae: Lepidoptera)

Distribution: This is one of the most common and important pests of gingelly in India in all gingelly growing areas.

Nature of damage: The larvae web together the top leaves or bore into tender shoots and capsules and feed on them. A severe infestation of the pest will contribute to low yield of gingelly seeds.

Life history: The pale brownish small moth with yellowish brown elongate wings lays about 100 - 130 shining flat eggs on the tender parts of plants. The incubation period is 4 - 5 days. The full grown larva is pale green with black head and tubercles having thin hairs on the body. It measures about 20 mm long. The larval period ranges from 11 - 16 days. It pupates in the leaf fold itself in a white silken cocoon and emerges as adult in 4 - 7 days.

Management strategies: (i) Collection and destruction of attacked parts of plants may minimize further damage.

(ii) Spray application of phosalone 0.07 % or carbaryl 0.1 % or dusting carbaryl 5% controls the pests.

2. Gall fly *Asphondylia sesami* Felt. (Cecidomyiidae: Diptera)

Distribution: The gallfly is found in all gingelly growing areas.

Nature of damage: The gallfly attacks the flowers and pods of gingelly and causes malformation.

Life cycle: It is one of the important and specific pests of gingelly. The small mosquito-like fly inserts the eggs into the ovaries of flower buds. The small whitish maggots feed on the ovary which results in the malformation of pod without proper setting of seeds. The yield of gingelly seeds gets reduced considerably if there is severe infestation. Pupation takes place inside the malformed pod itself and the adult fly emerges in a week.

Management strategies:
(i) Dusting carbaryl 10 % dust on the 25^{th}, 50^{th} and 65^{th} day from sowing has been reported to minimize incidence of the pest.

VI. Pests of Fibre Crops

A. Cotton (*Gossypium hirsutum, G. herbaceum, G. barbadense* and *G. arboreum*):

1. Cotton aphid *Aphis gossypii* Glover (Aphididae: Homoptera)

Distribution: It has a world wide distribution. It also attacks Lady's finger, brinjal, guava, gingelly etc.

Nature of damage: The greenish brown soft bodied small aphids infest the tender shoots and the under surface of leaves in very large numbers and suck the 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 lower leaves affecting photosynthetic activity. The Economic Threshold Level (ETL) is 10% affected plants counted randomly.

Life history: The alate as well as apterous females multiply parthenogenetically and viviparously. In a day a female may give birth to 8 – 22 nymphs which become adults in 7 – 9 days.

Management strategies:

(i) Spray application of dimethoate 0.03 % or methyl demeton 0.025 % or monocrotophos 0.04 % or imidacloprid 0.01 % affords protection.
(ii) Include also imidacloprid seed treatment for sucking pests @ 3 – 5g /kg seed that protects the crop around 30 – 45 days or so.

2. Cotton leaf hopper *Amrasca biguttula biguttula* Ishida (Cicadellidae: Homoptera)

Distribution: It is distributed in all cotton growing areas. It is also found to breed on brinjal, potato, lady's finger and sunflower.

Nature of damage: Both the nymphs and adults suck up the plant sap from the under surface of leaves. The leaves show symptoms of "hopper burn" such as yellowing, curling, bronzing and sometimes drying up, and these symptoms are expressed differently depending on how the different varieties react to the toxic saliva of the insect. The vigour of the plants is impaired to a great extent. The ETL is 2 Jassids or nymphs per leaf or yellowing in the margins of the leaves.

Life history: The female leaf hopper inserts about 15 eggs inside leaf veins and the incubation period ranges from 4 to 11 days. The nymphal period occupies 7 - 21 days depending on the weather conditions.

Management strategies:
(i) Spray application of dimethoate 0.03 % or methyl demeton 0.025 % or monocrotophos 0.04 % or imidacloprid 0.01 % affords protection.
(ii) Include also imidacloprid seed treatment for sucking pests @ 3 – 5g /kg seed that protects the crop around 30 – 45 days or so.

3. Cotton whitefly *Bemisia tabaci* (Gennadius) (Aleyrodidae: Homoptera)

Distribution: It is widely distributed in India and particularly serious on cotton and brinjal. It is very important as a vector of leaf curl virus disease of crops like tobacco, cotton, etc. and vein clearing disease of lady's finger. It also breeds on a variety of plants such as hollyhock, lady's finger, tobacco, safflower, *Achyranthes aspera*, Lab – lab niger, topioca.

Nature of damage: In cotton the nymphs are found in large numbers on the under surface of leaves and drain of sap due to sucking. Severe infestation results in premature defoliation, development of sooty mould on honey dew excreted, and shedding of buds and bolls and bad boll opening. The ETL is 5- 10 nymphs or adults per leaf before 9 A.M.

Life history: The female whitefly lays the eggs on the under surface of tender leaves. The egg and nymphal periods occupy respectively 3 - 5 and 9 - 14 days during summer and 5 - 33 and 17 - 73 days in winter. The pupal period is 2 - 8 days. The total life-cycle ranges from 14 - 107 days depending upon the weather conditions.

Management strategies:
(i) Spray application of acephate 0.075 % or imidacloprid 0.01 % or acetamiprid 0.01% or neem oil 0.3 % brings about control of the pest.

4. Spotted bollworms *Earias insulana* Boisd. and *E. vittella* (Noctuidae : Lepidoptera)

Distribution: Widely distributed in India, Myanmar. It is also found to attack Bhindi.

Nature of damage: The initial infestation takes place on 6 week old crop in which the larva causes detopping (drooping and drying of the shoot) due to its feeding by boring into it. In the later stages of the crop, the buds, flowers and bolls are damaged and a larva may migrate and attack fresh parts. Heavy shedding of early formed flower buds due to the pest is a common feature in cotton fields. The lint from attacked bolls will not be clean. The ETL for this pest is 5% damaged fruiting bodies or 1 larva per plant or total 3 damaged squares / plant taken from 20 randomly selected plants.

Life history: The moth of E. *vittella* has green fore wings with a white streak on each of them whereas that of E. *insulana* is completely green. The female moth deposits 2 or 3 eggs on bracts, leaf axils and veins on the under surface of leaf. The egg is crown-shaped, sculptured and deep sky blue in colour. A female may lay about 385 eggs and the incubation period is about 3 days. The larva becomes full grown in 10 – 12 days. The larva of *E. vittella* is brownish with a longitudinal white stripe on the dorsal side and without finger-shaped processes on its cream coloured body and orange dots on prothroax. The boat shaped tough silken cocoon is dirty white brownish and may be found on plants or on fallen buds and bolls. The pupal period is 7 – 10 days. The total life cycle ranges from 20 to 22 days.

Management strategies:

(i) The infested portions as well as shed buds and bolls should be removed and destroyed.
(ii) Periodical spray application of compounds like phosalone 35 EC @ 1.5 to 2.5 l/ha or carbaryl 50 WP @ 2.5 to 3.0 kg./ha or endosulfan 35 EC @ 1.5 to 2.0 l/ha or monocrotophos 40 SC @ 1.0 to 1.25 l/ha or profenofos 50 EC@ 0.75 to 1.0 kg /ha or thiodicarb 75 WP@ 625 g/ha etc. has been reported to be effective.
(ii) The synthetic pyrethroids fenvalerate and permethrin @ 100 - 150 g a.i./ha, cypermethrin @ 80 g a.i./ha, and deltamethrin @ 12.5 to 15 g a.i./ha are very effective in controlling the bollworms of cotton which may be alternated with other groups of insecticides.

5. Pink bollworm *Pectinophora gossypiella* Saund. (Gelechiidae: Lepidoptera):

Distribution: This is a well known pest of cotton found distributed all over the world. Alternate host plants of this pest are Lady's finger, hollyhock and *Thespesia populnea*, etc.

Nature of damage: The larva enters the developing boll through the tip portion and the entrance hole gets closed up as the boll matures. It feeds on the seeds and moves to adjacent locule by making a hole through the septum. The infested flower buds shed prematurely. A typical rosette-shaped bloom when examined will contain the larva. The infestation results in the seeds being destroyed in addition to retardation of lint development and weakened lint and staining of the lint both inside the boll and in the gin. Further, infested bolls open prematurely and expose it to invasion by saprophytic fungi. The seeds from damaged bolls show lower germination. The infestation ranges from 40 to 85 %. The ETL for pink bollworm is 8 months / trap per day for 3 consecutive days and the traps are to be installed @ 5/ha. or 10% infested flowers or bolls with live larvae.

Life history: The adult is a small dark brown moth and a female lays flattened and striated eggs on the bolls or in between bracts or on buds and flowers, the average being 125 eggs. The egg period varies from 4 - 25 days. The 15 mm long pinkish larva with dark brown head and prothoracic shield becomes full grown in 25 - 35 days and pupates in a thin silken cocoon among the lint, inside a seed or in double seeds, in between bracts or in cracks in the soil. The pupal period is about 6 – 20 days. Both short – cycle larvae and long-cycle larvae occur in Northern India and hibernation during winter takes place in the larval stage. In South India the insect is not known to hibernate in any stage of its development.

Management strategies:
(i) Need based spray application of carbaryl 50 WP @ 2.5 kg/ha or quinalphos 25 EC @ 2 - 3 l/ha or profenofos 50 EC @ 1.5 - 2 l/ha based on ETL.
(ii) Fumigation of seeds with methyl bromide at 1.5 kg/100 cu. m. for 24 hours or with aluminum phosphide at 18 tablets/100 cu. m. or heat treatment for a few minutes at 60°C kills hibernating larvae in seeds.

B. Jute (*Corchorus olitorius* & *C. capsularis*)

1. Stem girdling beetle *Nupserha bicolor* postbrunnea Dutt (Lamiidae: Coleoptera)

Distribution: *Corchorus olitorius* and *C. capsularis* are the two species of Jute cultivated in Assam, West Bengal, Orissa, Tripura and Uttar Pradesh which are attacked by this pest. It is particularly serious on *C. olitorius*.

Nature of damage: The adult beetle girdles the stem at two levels before it starts oviposition. This causes withering, drooping and death of the portion above the lower girdle to a length varying from 5 - 50 cm thus resulting in loss of fibre yield.

Management strategies:

(i) Spray application of phosalone 0.07% or endosulfan 0.07 % at fortnightly interval.
(ii) Removal and destruction of drooping stem portions and stem casings containing the larvae in diapause.
(iii) Growing of *C. capsularis* jute which is not preferred by the insect.

2. Jute weevil *Apion corchori* Mshll. (Apionidae: Coleoptera)

Distribution: The insect occurs in a serious form on jute in Bihar and U.P.

Nature of damage: The adult weevil excavates a small hole on the stem and oviposits. The grubs tunnel into the pith. Due to damage a gall-like swelling is formed. *C. capsularis* is more susceptible to attack than *C. olitorius*.

Life history: The weevil is dull black or dark brown in colour and a female is capable of laying up to 675 eggs during an oviposition period of about 4 months. The egg, larval and pupal periods last for 3 – 5, 8 – 18 and 4 days respectively.

Management strategies:
(i) Spray application of phosalone 0.07% or endosulfan 0.07 or cypermethrin 0.005%.

3. *Spodoptera exigua* (Noctuidae: Lepidoptera)

Distribution: Has worldwide distribution which includes Europe, South Africa, America and the oriental region. In India, it is quite widespread, found attacking jute, indigo, Lucerne, lentil, cabbage, maize, cotton and gram.

Nature of damage: The caterpillars, on hatching, gather on the leaf surface, the epidermis of which they eat. At this young stage, they are also in the habit of webbing together either several leaflets or the margin of the same large leaf. At times, these webs give a shabby look to the crop. Within these webs the young larvae live gregariously only for two or three days and thereafter they separate and spread out.

The feeding activity of grown up larva is generally confined to a few morning hours i.e. 9 to 11 a.m. and then again after 4 p.m. or so. They are very voracious and quite large patches of foliages are quickly stripped.

Life history: The adult lays eggs on leaves in clusters of up to 200 eggs each. Each egg is spherical like a poppy-seed in shape and size but with radiating lines. These egg-clusters are often covered with buff-coloured hair which are also present in-between the eggs. The egg-period ranges between 24 - 36 hours. The adult stage is a typical small noctuid moth with dark –spotted forewings and white hind wings. The colour of the larva is very variable, depending on the crop on which it has been feeding. When full-grown and full fed the caterpillar seeks shelter usually on the soil surface at the base of the plant, under stones or among leaves and such other debris. Also when necessary, a small amount of webbing is produced as a covering and a very rough cocoon is formed with bits of leaf and other material. The larval period is completed in 12 – 14 days. Inside this cocoon the larva pupates and the chrysalis is of the usual noctuid type with a double spine at the tip of the abdomen. The pupal period may be as short as five days and the whole life-cycle can be completed in less than three weeks. But the life-cycle can be very much lengthened, depending upon the environmental temperature and humidity.

Management strategies:

(i) Collection and destruction of egg masses.
(ii) Spray application of phosalone 0.07% or endosulfan 0.07% or cypermethrin 0.005%.

VII. Pests of Pulses

1. Gram pod borer *Helicoverpa armigera* (Hb.) (Noctuidae: Lepidoptera)

Distribution: This polyphagous species is a well known important pest of pulses and cotton in India. It attacks pulse crops such as redgram, Bengal gram, *Lab-lab niger*, soybean, green gram, black gram and pea. Its other important food plants include safflower, chillies, sorghum, groundnut, tomato and cotton.

Nature of damage: The larvae feed on leaves and bore into pods. As the internal contents of pods are devoured the yield of pulses is considerably reduced.

Life history: The moth has a V-shaped speck on the light brownish fore wings and a dark border on the hind wings. It lays the spherical yellowish eggs singly on tender parts of plants. The full grown larva measures 35 – 45 mm long and is greenish with dark gray lines laterally on the body. While feeding it thrusts its head inside the pod leaving the rest of its body outside. It pupates in an earthen cocoon in the soil. The egg, larval and pupal periods respectively is 2 - 4, 18 - 25 and 6 – 21 days.

Management practices / strategy:

(i) Setting up of pheromone traps @ 5 traps/ha before the initiation of flowering and collection and destruction of moths caught in the traps.
(ii) Spray application of phosalone 0.07 % or endosulfan 0.07% or profenofos 0.05 % or cypermethrin 0.005% or the combination with *Bacillus thuringiensis* var. kurstaki three times at fortnightly interval commencing from flowering affords protection.
(iii) Dusting of endosulfan 4% or carbaryl 10% dust @ 25 kg/ha once at initiation of flowering controls the pest on Bengal gram.
(iv) Spray application of *Ha*NPV at dusk @ 250 larval equivalent /ha.

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

Distribution: It occurs in most of the regions in India where redgram is grown.

Nature of damage: The larva feed on flower buds and seeds of pods by remaining outside and is very characteristic. The pulse crops attacked are red gram and *Lab – lab niger*.

Life history: The adult is a small greenish-brown plume like moth. These moths lay eggs singly on the tender pods and these eggs hatch into tiny larvae about 1 mm in length within a few days. These young larvae at first scrap their food from the surface of the pod before they cut holes in it. At times they also bore into the unopened flower-buds and feed on the developing anthers. The larvae become full-grown within two to four weeks when they are about 7 mm long. The larva has numerous rosettes of capitate spines and hair all over the body. The pupal period lasts from three days to more than a week, depending on the prevailing temperature.

Management strategies:

(i) Spray application of phosalone 0.07% or endosulfan 0.07% or profenofos 0.05%.

VIII. Pests of Tuber Crops

1. Pests of Potato (*Solanum tuberosum*)

i. Cutworm *Agrotis ipsilon* (Hufn.) (Noctuidae: Lepidoptera)

Distribution: The cutworm is an important pest of potato which is widely distributed in India. The larvae are also known to feed on barley, oats, tobacco, pulses, cabbage, beetroot, peas, lady's finger, etc.

Nature of damage: The larvae, which hide during day time in cracks in the soil, become active at dusk, feed on leaves and also cut the tender stems of young and growing plants and thus cause reduction in yield of tubers upto 35 %.

Life history: The adult is a dark brown stout moth with a reddish tinge and has wavy lines and spots on the fore wings. The female lays about 300 eggs in groups of 30 on the under surface of leaves or on moist soil. The larva is dark brown with a red head and when full grown has a greasy appearance which pupates in an earthen cocoon. The egg, larval and pupal periods is respectively 2 – 13, 10 –30 and 10 – 30 days. The total life-cycle lasts from 30 - 68 days depending on weather conditions.

Management strategies:

(i). Hand picking and destruction of larvae.
(ii). Soil drenching with chlorpyriphos 0.1 emulsion before planting.

ii. Potato tuber moth *Phthorimaea operculella* Z. (Gelechiidae: Lepidoptera)

Distribution: This is a cosmopolitan pest distributed in different parts of India, which gained entry into India about 70 years ago from Italy. It is a pest of importance on potato both in the field and in storage.

Nature of damage: In storage 30 - 70 % of tubers are damaged by the larvae. In the field the larvae mine into leaves or bore into tender shoots and developing tubers.

Life history: The small dark brown moth lays from 100 - 150 eggs singly on the under surface of leaves or on exposed tubers. Egg period is 3 - 6 days. The yellowish

caterpillar with a brown head tunnels into the leaves, stem or tubers and when full grown pupates in a silken cocoon among trash, clods of earth, etc. on the ground or on seams of bags and in crevices in the floor or on walls in storage. Larval period lasts for 5 - 16 days. Hibernation takes place in the larval or pupal stage in some cooler areas of the country. Pupal period is 5 - 7 days.

Management strategies:
(i) Earthing up the crop to close the crevices helps in minimizing infestation and in godowns the tubers may be stored in sand.
(ii) Fumigation of tubers with methyl bromide at 2.5 - 5 kg/1000 cu.m. for 3 hours brings about control of the pest in storage.
(iii) Spray of phosalone @ 0.07% upon the initial occurrence of the pest in the field.
(iv) Release of the parasitoid *Copidosoma koehleri* @ 1.5 lakhs / ton of stored potato.

IX. Pests of Citrus Crops

1. Lemon butterfly, *Papilio demoleus* (Papilionidae: Lepidoptera)

Distribution: It is distributed all over India. The larvae are found feeding on Curry leaf also.

Nature of damage: The caterpillars feed on the leaves and especially young seedlings and trees are seriously affected. Complete defoliation occurs in severe attack. It is present throughout the year.

Life history: The butterfly lays yellow, spherical eggs, scattered singly on the tender foliage. They hatch in 4 or 5 days. The larva is dark brown with irregular whitish patches, resembling the excreta of birds. After about 10 days it turns green with white and pink lines. On disturbance the caterpillar everts out two orange coloured osmeteria with a characteristic smell. Full grown caterpillar is stout and about 40 mm in length. Larval period is 15 – 25 days. Pupate on the plant itself as green chrysalis attached to the leaf or twig by a silken girdle. Pupal period is 10 days.

Management strategies:
(i). Hand picking the larvae if the plants are few.
(ii). Spraying endosulfan 0.07% or phosalone 0.05% or application carbaryl 5% dust.

2. Leaf miner: *Phyllocnistis citrella* St. (Gracillaridae: Lepidoptera)

Distribution: It is found in all the states where *Citrus* spp. is grown.

Nature of damage: The minute caterpillars mine into the leaf tissues of tender leaves and feed on them leaving the outer tissue intact. Leaves become crinkled with whitish lines. In case of severe infestation leaves turn pale, curl badly and dry off.

Life history: The tiny moth lays the eggs singly on the undersurface of the leaves near the mid-rib. On hatching, the caterpillar enters tissue and starts mining between the two layers. It is thin and yellowish green in colour. In about one or two weeks caterpillars become full grown and pupate inside the mine. The pupal period is 5 – 7 days. The adult is a tiny moth, grayish in colour with a wing expanse of 5 mm only.

Management strategies:
(i) Spray application of dimethoate 0.03% or methyl demeton 0.025%. or imidacloprid 0.01%.
(ii) Neem cake soaked in water and the decantation when sprayed also controls the pest.

3. Whitefly: *Aleurocanthus spiniferus* Q. (Aleurodidae: Hemiptera)

Distribution: Distributed in all citrus growing areas.

Nature of damage: The leaves are crinkled and black oval puparia and nymphs can be seen on the undersurface of the leaves.

Life history: The adult is a minute delicate insect. Wings are white or grayish, body yellow and eyes red in colour. The nymphs are oval in shape, scale like, blackish with marginal bristle like fringes. Nymphs are stationary. Large number of yellowish eggs (150 - 200) is laid on the lower surface of leaves. They hatch in 10 days. The nymphs crawl about and fix themselves up on the under surface of the leaves and suck the sap. After 3 – 10 weeks they turn into a pupa. Pupal period lasts for 16 – 22 weeks. The life cycle lasts about 6 months.

Management strategies:
(i) Neem cake soaked in water and the decantation when sprayed controls the pest (given earlier).

4. Fruit sucking moths, *Othreis fullonica* Linn. and *O. materna* Linn. (Noctuidae: Lepidoptera)

Distribution: *O. fullonia* (Clerck) is widely distributed throughout Orient extending from Africa to New Guinea and Australia. The caterpillars of these are leaf defoliators on weed hosts *viz*., *Tinospora cardifolia*, *Cocculus pendulus* and *C. hirsutus*.

Nature of damage: The two species of moths attack the fruits during nights. They pierce the rind and suck the juice through the long proboscis. This puncture causes the fruit to rot. It is only the moths that are destructive to citrus fruits. The moths are distinguished by having particularly well developed proboscis with dentate tips with which they are able to pierce the ripening fruits. The moths are nocturnal in habit and may be seen flying about in orchards after dusk especially during rainy season. The damaged fruits soon start rotting as the punctured regions are easily infected with bacteria and fungi and ultimately the fruits drop prematurely.

Life history : The adults of *O. fullonica* has pale orange brown body with forewings dark grayish and the hind wings orange red with two black curved patches. The adults of *O. materna* has pale greenish gray upper wings with pale white markings and the lower wings with a marginal dark brown region mixed with white spots and a circular dark spot. The moth lays 200 – 300 eggs on a weed, *Tinospora cardifolia*. Egg period is 8 - 10 days. The caterpillar is a semilooper, dark brown with yellow and red spots. Full grown caterpillars are 50 - 60 mm long, stout, velvety-blue with yellow patterns on dorsal and lateral sides and having a hump at anal end. Pupation takes place in a transparent pale whitish silken cover enclosed in leaf fold. Larval period is 28 - 35 days. Pupal period is 14 - 18 days. Pupates on the leaves itself.

Management strategies:
(i). Systematic destruction of weed host plants on which the caterpillars feed in the vicinity of orchards helps to check the pest population.
(ii). Bagging of fruits has been suggested.
(iii). Creating smoke in the orchards after sunset may keep the pest at bay.
(iv). Spraying oil emulsions once in 10 days to act as a deterrent.

(v). Poison baiting (20 g malathion 50% W.P. + 200 g gur or molasses in 2 litres of water) has been found quite affective.
(vi). Growing tomato as a trap crop in the orchards to attract the moths.

X. Pests of Cole Crops

(A) Cruciferous Vegetables (Cabbage, Cauliflower, Radish, Beetroot and Knolkhol)

1. Diamond back moth *Plutella xylostella* (L.) (Plutellidae: Lepidoptera)

Distribution: It is a well known pest of cruciferous crops throughout the world.

Nature of damage: The larvae bite holes in leaves and cause serious damage. The larvae cause blisters on the leaves which dry away in course of time. It attacks cabbage, cauliflower, radish and knolkhol.

Life history: The moth is grayish brown with narrow wings having pale white markings anteriorly which from diamond-like white patches dorsally when wings are folded over back at rest. It lays up to 57 eggs singly on the under surface of leaves along the veins. Egg period is 4 – 5 days. The larva is greenish with short thin hairs on the body. The larval period is 13 – 21 days. It pupates in a thin loose mesh of silken cocoon and the pupal period is 7 – 9 days. The period from egg to adult occupies 24 - 35 days.

Management strategies:
(i) Mustard sown as trap crop twice i.e. 12 days preceding planting cabbage and again 40 days later controls DBM.
(ii). Spraying cypermethrin @ 30 g a.i. or fenvalerate @ 50 g a.i. or deltamethrin @ 10 g a.i. or cartap hydrochloride @ 175 g a.i./ha once at primordial initiation (22 days after planting) and repeated either thrice at 7 days interval or twice at 10 days interval.
(iii). Spray application of *Bacillus thuringiensis* var. kurstaki @ 1 kg/ha.

2. Leaf webber *Crocidolomia binotalis* Z. (Pyraustidae: Lepidoptera)

Distribution: Present in all localities where cabbage and cauliflower are grown.

Nature of damage: The leaves are skeletonized by the larvae which remain on the under surface of leaves in webs and feed on them. They also attack flower buds and pods. Often it assumes serious proportions. It attacks cabbage, cauliflower, radish, mustard and other crucifers and the weed *Gynandropsis pentaphylla*.

Life history: The small moth with light brownish fore wings lays the eggs in masses, each mass containing 40 - 100 overlapping flat eggs. The incubation period ranges from 5 – 15 days depending on weather. The larva with red head has brown longitudinal stripes and rows of tubercles with short hairs on its pale violaceous body. It becomes full grown in 24 – 27 days during summer and in 51 days during winter. It pupates in an earthen cocoon and emerges as adult in 14 - 20 days.

Management strategies:
(i). Mustard sown as trap crop twice i.e. 12 days preceding planting cabbage and again 40 days later controls DBM.
(ii). Spraying cypermethrin @ 30 g a.i./ha or fenvalerate @ 50 g a.i. /ha or

deltamethrin @ 10 g a.i. /ha or cartap hydrochloride @ 175 g a.i./ha once at primordial initiation (22 days after planting) and repeated either thrice at 7 days interval or twice at 10 days interval.

3. Cabbage butterfly *Pieris brassicae* (Linnaeus) (Pieriidae: Lepidoptera)

Distribution: In India, it is widely distributed along the entire Himalayan region. *P. brassicae* is comparatively more common and destructive. It causes severe damage to cabbage, cauliflower, radish, turnip as also mustard and rape. The pest passes winter in the plains and migrates to hilly regions during summer. During September to April, it breeds on rape and mustard.

Nature of damage: On hatching, the young caterpillars feed gregariously on leaves for a couple of days, then disperse, spreading infestation to the adjacent plants and fields. As a result of their feeding the leaves are skeletonized, sometimes the caterpillars bore into the heads of cabbage and cauliflower.

Life history: Eggs are laid in clusters under surface of the leaf. A single female lays only 2 - 3 egg-masses of 50 - 80 eggs each. Eggs are flask-shaped, about one mm long and yellowish in colour. Full grown caterpillars are 38 - 44 mm long, velvety bluish-green in colour with black dots and yellow dorsal and lateral stripes covered with white hair. Pupae are yellowish-green with black spots and dots. Adult butterflies have snow-white forewings with black distal margins more developed in females than in males; hind wings are also pure white with black apical spots. Wing expanse is 60 - 70 mm. Moths emerging in summer are larger in size than those of winter. Incubation, larval and pupal periods are on an average 3.2, 5.6 and 7.3 days during May extending upto 17.6, 40.7 and 28.8 days respectively in January. Generally there are two generations during winter (plains) and 4 - 5 in summer (hilly region).

Management strategies:

(i) Pest can be checked by handpicking and mechanical destruction of caterpillars during early stage of attack when the caterpillars feed gregariously.
(ii) In case of widespread infestation spray with 0.05% dichlorvos or 0.1% Malathion.

4. Cabbage aphid *Brevicoryne brassicae* (Aphididae: Homoptera)

Distribution: Cabbage aphid *Brevicoryne brassicae* was originally confined to Palaearctic or Holarctic regions but at present it has a very wide range of distribution.

Nature of damage : Colonies of these insects are often found on tender shoots and as a result of sucking of vital sap from the tissues, the plant remain stunted in growth resulting in poor head formation. In the case of severe infestation plants may completely dry up and die away. When infestation occurs on seedlings, they loose their vigour, get distorted and become unfit for transplanting. The aphids also produce copious quantity of honeydew which makes the plants sticky and favour the growth of sooty mould, as a result a black coating is formed on affected plant parts hindering the photosynthesis and adversely affecting the plant growth.

Life history: Reproduction is mostly viviparous parthenogenetic during summer and mild winter. However, during severe winter sexual reproduction may also occur. Eggs when present are pale yellow with greenish tinge. Nymphs are 1.0 - 1.5 mm long and yellowish-green in colour while adults are 1.8 - 2.0 mm long and darker in colour than nymphs. Eggs are laid during November – December. These hatch in 20 - 22 weeks.

The nymphs mature in about 2 weeks and immediately start producing young ones, without mating. A single female may produce 40 - 45 young ones during her life time. The life cycle is completed in 11 - 45 days and as many as 21 generations have been recorded during a year when provided with favourable conditions.

Management strategies:

(i) As soon as aphid infestation appears, cut and destroy the infested shoots mechanically.

(ii) When more than 5% plants are infested, spray with 0.025% phosphamidon or methyl demeton or 0.01% imidacloprid. Repeat the spraying after a fortnight if still 5% infestation is there.

5. Mustard Sawfly, *Athalia lugens proxima* Kulg (Tenthredinidae: Hymenoptera)

Distribution: Mustard sawfly is one of the very few hymenopterous insects reported as crop pests, and that too with chewing and biting habits. It is a cold weather pest found all over the Indian sub-continent. It is a major pest of not only cole crops but of almost all cruciferous plants, including rape and mustard. The peak period of activity is during September to December after which the activity declines; the pest is hardly noticed from March to July and appears on radish by the end of July.

Nature of damage: Eggs are laid singly, mostly during day time and inserted into leaf tissues near the periphery of leaves. On hatching the grubs nibble the margins of tender leaves but later on bite holes in the leaves. Grubs are diurnal in habit and feed generally during early morning and evening hours. With slight disturbance they fall on the soil and feign death.

Life history: A female lays on an average 35 eggs (20 - 150). Egg period is 6 - 8 days. Newly hatched grubs are 2 - 3 mm long, smooth, cylindrical and greenish-grey in colour; full grown ones are cylindrical in shape, 16 - 20 mm long and greenish-black in colour. They look and behave like caterpillars but have 8 pairs of prolegs. Grub development takes 21 - 31 days. Adults are 8 - 12 mm long, having dark head and thorax, orange coloured abdomen and translucent smoky wings with black veins. Females have a strong saw-like ovipositor – hence it has been given the popular name sawfly. They generally do not fly long distances but hop from leaf to leaf or fly from one plant to another plant. Their activity is pronounced during days while the insects remain practically motionless at night. Pre-pupal and pupal periods last for 3 - 4 and 7 - 10 days respectively. Severe winter is passed in pupal stage and lasts for about 14 weeks. In Northern India there are three generations during cold season. In South India where there is no severe winter, the pest undergoes as many as 10 overlapping generations in a year.

Management strategies:

(i) Hand-picking of grubs which are not active during dawn and dusk if the area under crop is limited.

(ii) Spraying with 0.05% endosulfan or 0.05% monocrotophos or 0.2% carbaryl.

(iii) Dusting with 5% Malathion or 10 % carbaryl is also effective.

6. Painted Bug *Bagrada cruciferarum* Kirkaldy (Pentatomidae: Hemiptera)

Distribution: Painted bug *Bagrada cruciferarum* and *B. hilaris* (Burmester) have been recorded as major pests of various *Brassica* spp. as also other cruciferous crops

and weeds. *B. cruciferarum* has been reported from East Africa, Afghanistan, Pakistan, Sri Lanka, India and South-east Asia while *B. hilaris* is found in East, West and South Africa, Italy, Iran, Iraq, Pakistan, India, Sri Lanka and USSR. The adults appear in field around October and their activity decreases with the onset of summer but is again accelerated in autumn.

Nature of damage : Both nymphs and adults suck cell sap from tender plant parts causing yellowing of leaves which gradually dry up and ultimately fall down exposing the plants to secondary invasion of bacteria and fungi. The plants wilt and wither affecting adversely the yield both quantitatively and qualitatively.

Life history: Eggs are laid singly or in batches of 2 - 12 on leaves, stems and flower buds. These are oval in shape about one mm long, pale yellow when freshly laid gradually becoming pinkish-orange. Nymphs are beautifully patterned with a mixture of black, white and orange colour, 1.5 - 4.5 mm long depending on their age. Adults are also black and orange colour bugs similar in colour pattern as nymphs – that's why they have earned the common name of painted bugs. Males are 6 - 7 mm long and females 7 - 8 mm. The mating takes place 2 - 6 days after the final nymphal moult and the oviposition commences a week after first mating and may continue intermittently throughout the life span of the female. A single female may lay as many as 230 eggs @ 15 - 20 eggs per day. Eggs and nymphal duration is recorded as 2 - 5 and 18 - 20 days respectively. A single life-cycle is completed in 3 - 4 weeks and adults live for 16 -18 days with 6 - 8 generations in a year.

Management strategies:

(i) Clean cultivation by removing weeds harbouring this pest is imperative for avoiding infestation of these bugs.
(ii) In case of heavy infestation, spray with 0.05% dichlorvos or 0.05% endosulfan or 0.05% phosalone. Atleast 7 - 10 days waiting period should be there between treatment and harvest.

(B) Solanaceous Vegetables

a). Brinjal *(Solanum melongena)*

1. Shoot and fruit borer *Leucinodes orbonalis* Guen. (Pyraustidae: Lepidoptera)

Distribution: This is the most serious pest of brinjal throughout the country. Its other host plants include potato, *Solanum xanthocarpum,* S. *indicum,* S. *nigrum* etc.

Nature of damage: The larva bores into tender shoots in the early stage and causes "dead hearts". It also bores into flower buds and developing fruits causing shedding of buds and making the fruits unfit for consumption and marketing. The infestation may go as high as 70 per cent on brinjal.

Life history: The moth has brownish and red markings on the whitish fore wings. The female lays about 250 eggs singly on tender shoots and developing fruits of brinjal. The pinkish larva with sparsely distributed hairs on warts on the body and a brownish head measures 16 - 20 mm long. It pupates in a tough grayish cocoon on the plant itself. The egg, larval and pupal periods occupy respectively 3 - 5, 15 and 6 - 8 days.

Management strategies :(i) The damaged portions of the plants and fruits should be removed and destroyed.

(ii) Need based spray application of phosalone 0.07 % or carbaryl 0.1% or profenofos 0.05 % or cypermethrin 0.025 % controls the pest.

2. Spotted leaf beetle (or Hadda Beetle) *Henosepilachna vigintioctopunctata* (Fabr.) (Coccinellidae: Coleoptera)

Distribution: It is found in different parts of South East Asia. The insect is considered to be one of the important pests of brinjal, sometimes becoming serious on it. It also breeds on brinjal, other solanaceous plants like *Solanum tuberosum,* S. *nigrum,* S. *xanthocarpum.* S. *torvum,* tomato, *Datura* sp., *Physalis* sp. and *Withania somnifera.*

Nature of damage: The grubs and adults scrape the leaves in a characteristic manner and feed. They feed on the epidermal layers of leaves which get skeletonized and gradually dry away. They affect the crop in all the stages.

Life history: The brownish hemispherical beetle has 12 - 28 black spots on the elytra. The female lays elongate, spindle-shaped yellowish eggs in groups of 10 - 20 on the under surface of leaves. About 120 - 180 eggs may be laid by a female. The egg period is 2 - 4 days. The yellowish spiny grubs become full grown in 10 -35 days and pupate on the leaf or stem. The pupa is hemispherical, yellowish with spines on the posterior part. The anterior portion being devoid of spines. Adults emerge in a week and live for a month feeding on leaves. The total life-history takes 17 - 50 days depending on weather conditions.

Management practices / strategy:
(i) In the initial stage, collection and destruction of affected leaves alongwith the eggs, grubs and adults.

(ii) Spray application of carbaryl 0.1% or cypermethrin 0.025% or profenofos 0.05%.

3. Grey weevil, *Myllocerus subfasciatus* G. or *M. maculosus* (Curculionidae: Coleoptera)

Distribution: It is a polyphagous pest occurring on a number of crops like cotton, sorghum, pearl millet and maize all over India.

Nature of damage: The adult beetles feed on leaves of brinjal and the grubs feed on roots and cause wilting and death of plants. Occasionally the insect assumes serious proportions on the crop.

Life history: The brownish weevil lays about 500 eggs in the soil about 80 - 100mm deep. The incubation period is 3 - 11 days. The grubs become full grown in 28 - 34 days and pupate in the soil-in earthen cocoons. The adults emerge in about 5 - 7 days. Total life cycle is completed in 6 - 8 weeks.

Management strategies:
(i) Application of 5% carbaryl dust.
(ii) Drenching 0.1% chlorpyriphos emulsion into the soil before transplanting.
(iii) Inter-culture of the crop regularly to prevent population build up and carry over of these weevils.

4. Aphid *Aphis gossypii* Glover and *Myzus persicae* (Sulzer) (Aphididae: Homoptera)

Distribution: Both the species occur in all places in all seasons. The incidence is

more in cool and humid seasons. Both are cosmopolitan in distribution and are absent only from colder parts of Asia and Canada. *A. gossypii* is also found attacking cotton, bhindi, chillies and guava.

Nature of damage: Both nymphs and adults are found in large number sucking the cell sap from leaves and tender apical shoots. The under surface of the leaves get crinkled and slightly curled backwards. The vitality of the plant is diminished and the plants turn yellow, get deformed and dry away. Besides this direct damage they also secrete copious quantity of honeydew on which sooty mould grows rapidly covering the affected parts with a thick black coating, which interferes with the photosynthetic activity of the plants. The infested plants become weak, pale and stunted in growth which consequently results in reduced fruit size.

Life History: Nymphs of *A. gossypii* are greenish-brown or yellowish in colour while adults are yellowish-green to dark green in colour, little over one mm in length and have a pair of siphunculi in the posterior side of abdomen. Wings when present are transparent with black veins. *A. gossypii* breeds during winter on a number of vegetables including brinjal from where it migrates in the month of April to melons and by June end return to cotton. Reproduction in case of *A. gossypii* is parthenogenetic viviparous and rate of multiplication is often phenomenal.

Adults of *M. persicae* are usually of green colour but may be pale brown to pinkish, 1.5 - 2.5 mm long with long clavate siphunculi. *M. persicae* reproduces by parthenogenetical viviparity during summer, monsoon and autumn seasons but sexually in cooler regions during winter. Adults normally perish due to severe cold and eggs overwinter in cracks and crevices on the bark of various temperate fruit trees. When the temperature rises, the eggs hatch and nymphs start feeding on blossoms. They mature in 3 - 4 days and reproduce parthenogenetically producing young ones which develop into wingless adults. After 2 - 3 generations when the temperature rises further or when there is too much crowding of these aphids, the winged forms are produced and these migrate to other crops including brinjal; again with fall in temperature, they migrate back to temperate fruit trees.

Management strategies:

(i) Two to three sprayings at 10 - 12 days interval with 0.05% dimethoate or monocrotophos or 0.01% imidacloprid.

(ii) Conservation of the coccinellids and syrphids that are found to feed on the aphids will reduce the numbers considerably without any insecticidal spray.

5. Leaf hopper *Amrasca biguttula biguttula* (= *Empoasca devastans* Dist.) (Cicadellidae: Homoptera)

Distribution: Distributed all over India; but particularly serious in Sind, Punjab and Tamil Nadu. It is a polyphagous pest attacking okra, brinjal, beans, castor, cucurbits, hollyhock, potato, sunflower and other malvaceous plants.

Nature of damage: The nymphs and adults remain on the under surface of the leaves and suck the cell sap and while feeding inject their toxic saliva. As a result the plant become stunted, the leaves crinkle, turn yellowish and become cup shaped. Brownish or reddish colour may develop along the edges of the leaves. This is called the 'hopper burn'. This pest is very active from September to January.

Life history: The adult is a slender green insect. Elongate, yellowish eggs are laid singly inside the leaf vein on the under surface of the leaves. A female lays 15 - 30 eggs, leaves of 35 – 40 days old are preferred for egg laying. Egg hatch in 4 -10 days. Nymphs are green and wedge shaped. The first and second instar nymphs feed mostly near the base of the leaf vein. Then they distribute themselves throughout the leaf and feed from the under surface. The nymphs develop into adults in 7 – 21 days. They breed throughout the year.

Management strategies:

(i) Spraying of 0.04 % phosphamidon or 0.05% monocrotophos or 0.01% imidacloprid.

(ii) Application of 5% dimethoate granules in seed furrows @ 20 kg/ha.

b). Tomato (*Lycopersicum esculentum* Milliere)

1. Whitefly – *Bemisia tabaci* (Aleyrodidae: Hemiptera)

Distribution: Commonly known as cotton whitefly is found in most of the countries in tropics and subtropics. Its main hosts are cotton, tobacco and some winter vegetables; including tomato, the infestation on these crops is sporadically severe.

Nature of damage : White, tiny, scale-like insects may be seen darting about near the plants or crowding in between the veins on ventral surface of leaves, sucking the sap from the infested parts. The pest is more active during the dry season and its activity decreases with the onset of rains. As a result of their feeding the affected parts become yellowish, the leaves wrinkle and curl downwards and are ultimately shed. Besides the feeding damage, these insects also exude honeydew which favours the development of sooty mould. In case of severe infestation, this black coating is so heavy that it interferes with the photosynthetic activity of the plant resulting in stunted growth. This whitefly also acts as a vector, transmitting the leaf curl virus.

Life history: Eggs are pear-shaped, light yellowish in colour, about 2 mm long and can be seen standing upright on leaves, being anchored by a tail-like appendage inserted into the stoma of leaves. On hatching, the nymphs crawl a little, settle down on a succulent spot on the same leaf and never move again during that stage. Nymphs are oval, scale-like and greenish-white in colour. Adults are minute insects, about one mm long, covered completely with a white waxy bloom. Incubation period is 3 - 5 days in summer extending up to 33 days during winter. Nymphal development takes 9 - 14 and 17 - 81 days in summer and winter, respectively and pupal period lasts for 2 - 8 days being longer during winter than in summer. A life-cycle may be completed in as little as 14 days or it may even be prolonged up to 107 days. There are about 12 overlapping generations in a year.

Management strategies:

(i) Spraying with 0.05% formothion or dimethoate or 0.01% imidacloprid or 0.1% acetamiprid.

(ii) In case of severe infestation, two sprayings at 10 - 12 days interval with 0.03% oxydemeton methyl or thiometon.

2. White Tailed Mealy Bug *Ferrisia virgata* (Cockerell) (Coccidae: Homoptera)

Distribution: It is pan - tropical in distribution and is found all over the Indian subcontinent and South-East Asia. It is polyphagous and has a very wide range of host

plants including, beans, cashew, cassava, coffee, cocoa, citrus, cotton, groundnut, guava, jute, sugarcane, sweet potato and tomato. It is found throughout the year, though it is less active during winter.

Nature of damage: Eggs are laid in clusters in cottony ovisac which remains concealed under the female. On hatching, the crawlers remain huddled together in cottony nest under the body of the mother. Later, these crawlers become active and wander about, moving swiftly till they find a succulent spot where they puncture the epidermis, inject their toxic saliva and start sucking the cell sap. The mechanical injury thus caused also serves as an entry for various disease producing organisms (bacteria and fungi). From 2nd instar onwards the nymphs secrete honeydew on which black sooty mould develop, which in turn hinders the photosynthetic activity of the plant resulting in stunted growth.

Life history: Eggs of this mealy bug are pale-yellow, cylindrical and about 0.3 mm long. A single female lays 100 - 400 eggs which remain concealed under the female. Freshly hatched crawlers are yellowish in colour and become pale white in 2 - 3 days. Adult females are apterous, long, slender, slightly oval (3.5 – 4.5 x 1.5 – 2.0 mm) covered with dusty white waxy secretion and having a pair of conspicuous long glossy wax tassels at the caudal end. Reproduction is sexual as well as parthenogenetic. Incubation period is 15 minutes to 4 hours and the immature stages may last for about 20 - 60 days in case of male and 19 - 47 days in case of females. Longevity of males is 1 - 3 days while the females live for 5 - 7 weeks.

Management strategies:

(i) Remove and destroy mechanically all the affected leaves and twigs in the early stages of infestation.
(ii) Spray application of 0.05% monocrotophos or 0.5% phosphamidon or phosalone.

3. Tomato fruit borer *Helicoverpa armigera* (Noctuidae: Lepidoptera)

Distribution: Gram pod borer is a major pest of tomato. It is widely distributed in the tropics, subtropics and warmer temperate regions of the world extending as far North as Japan and Germany. It is highly polyphagous attacking a number of host plants. It attacks a number of weeds and important plants like maize, sorghum, cotton, sunflower, pigeonpea, chickpea, field beans, roses etc.

Nature of damage: Eggs are laid singly, generally on leaves and flowers but sometimes on fruits as well. On hatching, the young larvae feed on tender foliage; advanced stage larvae attack the fruits. They bore circular holes and thrust only a part of their body inside the fruit and eat the inner contents. If the fruit is bigger in size, it is only partly damaged by the caterpillar but later it is invariably invaded by fungi and bacteria and spoiled completely. The larvae move from one fruit to another and a single caterpillar may eat and destroy 2 - 8 fruits.

Life history: The eggs are yellowish-white, ribbed and dome-shaped, 0.4 - 0.5 mm in diameter. Freshly hatched larvae are yellowish-white in colour but gradually change and acquire greenish tinge. Full grown caterpillars are 40 - 48 mm long, apple-green in colour with whitish and dark-grey broken longitudinal stripes. Full grown caterpillars drop down from the plants and burrow in the soil where they pupate. Pupae are dark-brown in colour, 11 - 14 mm long and have a sharp spine at the anal end. Moths are medium sized, stout, ochreous with olive grey forewings in male and reddish brown forewings in female with dark brown circular spot in the centre and

indistinct double waved antemedial lines. Hind wings are pale smoky-white with a broad blackish outer border. Fecundity of females is rather high ranging between 1200 - 1600 eggs. Incubation, larval and pupal stages last for 2 - 4, 15 - 24 and 10 - 14 days respectively and the entire life-cycle may be completed in 4 - 6 weeks.

Management strategies:

(i) Hand-picking of caterpillars and their mechanical destruction in the early stage of infestation can keep the population of this pest under check.
(ii) In case of severe attack, 5% dust or 0.2% spray of carbaryl or 0.05% endosulfan or 0.005% cypermethrin has been found to be effective.
(iii) Spray application of *Ha*NPV @250 LE/ha when the larval population reaches 1 larva / m^2.
(iv) Installation of pheromone traps @5/ha coinciding with the initiation of flowering and destruction of collected moths.
(v) Release of the egg parasitoid, *Trichogramma chilonis* or *T. brasiliensis* @ 1Lakh/ha coinciding with flower initiation at 15 days interval.

c). Chillies (*Capsicum annum* Linnaeus):

1. Chilli thrips, *Scirtothrips dorsalis* Hood (Thripidae: Thysanoptera)

Distribution: It is a polyphagous pest having a wide range of host plants distributed throughout India. It is also known to infest tea, grapevine, castor, cotton, *Prosopis juliflora*, etc.

Nature of damage: Eggs are laid on or just under leaf tissues. Both nymphs and adults lacerate the leaf tissues and imbibe the oozing sap; sometimes even the buds and flowers are attacked. Tender leaves and growing shoots are preferred. The infested leaves start curling and crumbling and is ultimately shed whereas buds become brittle and drop down. Yield loss due to thrips attack may range from 25-50 %.

Life history: Eggs are minute and dirty white in colour. Nymphs and adults are also tiny, slender, fragile, and yellowish-straw in colour; adults have heavily fringed wings that are uniformly grey in colour. Reproduction is both sexual and parthenogenetic. In case of sexual reproduction, oviposition period lasts for about a month during which a female lays on an average 100 eggs @ 2 - 4 eggs per day. A single life-cycle is completed in 2 -2½ weeks as many as 25 overlapping generations in a year.

Management strategies:
(i) Spray with 0.03% dimethoate or phosalone or monocrotophos or 0.2% carbaryl or 0.04% triazophos or 0.075% acephate.
(ii) The thrips *Franklinothrips vespiformis* (Crawford) and *Erythrothrips asiaticus* R. &. M. are predaceous on this thrips in nature and their population may be encouraged by avoiding chemical sprays.

d). Bhindi (Okra) (*Hibiscus esculentus* Moench)

1. Okra Shoot and Fruit borer *Earias vittella* (Fabricius) (Arctidae: Lepidoptera)

Distribution: It is widely distributed, recorded from Pakistan, India, Sri Lanka, Bangladesh, Burma, Indonesia, New Guinea, and Fiji. It is an oligophagous pest

having okra and cotton as its main hosts. It is also found feeding on a large number of malvaceous plants, both wild as well as cultivated.

Nature of damage: Eggs are usually laid singly on buds and flowers and occasionally on fruits as well, but in absence of these parts i.e. at early stage of crop growth, the eggs are laid on shoot tips. When the crop is only a few weeks old, the freshly hatched larvae bore into tender shoots and tunnel downwards, these shoots wither, droop down and ultimately the growing points are killed, side shoots may arise giving the plants a bushy appearance. With the formation of buds, flowers and fruits, the caterpillars bore inside these and feed on inner tissues. They move from bud to bud and fruit to fruit thus causing damage to a number of fruiting bodies. The damaged buds and flowers wither and fall down without bearing any fruit whereas the affected fruits become deformed in shape and remain stunted in growth.

Life history: Eggs are spherical in shape, about half mm in diameter, light bluish-green in colour and beautifully sculptured with 26 - 32 longitudinal ridges; the alternate ridges project upwards to form a crown. The moths emerge at dusk; mating takes place 2 - 3 days after emergence and oviposition commences after 1 - 5 days of mating. A female lays on an average 400 eggs (65 - 695). Incubation, larval and pupal periods last for 3 - 9, 9 - 20 (50 - 60 during winter) and 8 - 12 days respectively. A single life-cycle takes 22 - 25 days extending up to 74 days during winter and there may be 8 - 12 generations in a year. Another fruit borer, which is also known as spotted bollworm of cotton *Earias insulana* (Boisduval), is found damaging okra specially in drier regions.

Management strategies:

(i) Remove debris and all the alternate host plants from field; collect and destroy all the infested shoots and fruits.

(ii) In case of wide spread infestation, give two to three fortnightly spraying with 0.05% endosulfan or 0.2% carbaryl or 0.005% cypermethrin.

2. Red spider mite *Tetranychus cinnabarinus* (Boisduval) (Tetranychidae: Arachnida)

Distribution: *Tetranychus cinnabarinus*, commonly called red spider mite, is the most common and destructive species attacking okra all over India. It has a world wide distribution and is highly polyphagous having a very wide range of host plants.

Nature of damage: Colonies of mites comprising of eggs, nymphs and adults are found feeding on ventral surface of leaves under protective cover of fine silken webs. As a result of their feeding innumerable yellow spots appear on the dorsal surface of leaves and the affected leaves gradually start curling and finally get wrinkled and crumpled. This in turn affects the growth and fruit formation capacity of the plants.

Life history: Eggs are globular in shape, about 0.1 mm in diameter and whitish in colour. Larvae are about 0.2 mm in length and pinkish in colour. Nymphs are greenish-red in colour and about 3 mm in length. Larvae and nymphs look alike in shape but can be easily distinguished as larvae have 3 pairs of legs while nymphs and adults have 4 pairs of legs. There are only two nymphal stages – protonymphal and deutonymphal. Adults are ovate in shape, reddish-brown in colour and 0.4 mm (male) - 0.5 mm (female) in length with four pairs of legs. Eggs hatch in 4 to 7 days; larval development takes 3 - 5 days; protonymphal and deutonymphal stages last for 3 - 4 days each. Longevity of adult males and females is 4 - 9 and 9 - 18 days respectively. The females that are active during summer in northern India become active with the

onset of monsoon and lay eggs parthenogenetically. These unfertilized eggs give rise to males only but the subsequent generations are sexual.

Management strategies:

(i) Dusting with sulphur dust or spray application with wettable sulphur powder.
(ii) Spraying dicofol (kelthane 18.5 EC) 0.0185%.

(C) Leafy Vegetables (*Amaranthus viridis*):

1. Leaf caterpillar *Hymenia recurvalis* (Fb.) (Pyraustidae: Lepidoptera)

Distribution: It infests *Amaranthus* spp., beetroot, soybean and *Trianthema portulacastrum* all over India.

Nature of damage: The larvae web the leaves and feed on the green matter. Severe attack results in complete skeletonising and ultimate drying of leaves.

Life history: The moth has white wavy lines on the dark wing. The female lays as many as 156 eggs on the leaves. The greenish larva with a brown head pupates in the soil in an earthen cocoon. The egg, larval and pupal periods respectively occupy 3 - 4, 12 – 15 and 8 – 11 days.

Management strategies:

(i) Spray application of profenofos 0.05 % or phosalone 0.07 % controls the pest.

(D) Cucurbitaceous Vegetables

I. Pests of Gourds

1. Fruitflies *Bactrocera cucurbitae* Coq. and *B. ciliatus* Loew (Tephritidae : Diptera)

Distribution: It is commonly called melon fruit fly. It is widely distributed and has been recorded from East Africa, some parts of USA, northern Australia, Taiwan, Okinowa in Japan, South China, South-east Asia and the Indian sub-continent. It is highly polyphagous having a wide range of host plants but its preferred hosts are musk melon, snap melon, bitter gourd and snake gourd.

Nature of damage: *B. cucurbitae* is slightly bigger with brown marking on wings and *B. ciliatus* is comparatively smaller and slender. The female flies puncture the soft and tender fruits with their stout and hard ovipositor and lay eggs below the epidermis @ 4 - 10 eggs per fruit each time. A single female can lay about 200 eggs in her life span of 8 - 10 weeks. A puncture made by one female is often used by others also for ovipositing and a single fruit may have more than one puncture made by one or more females. On hatching the maggots feed inside on the pulp of fruits and the infested fruits can be identified by the presence of brown resinous juice which oozes out of the punctures made by the flies for oviposition. These punctures also serve as an entry for various bacteria and fungi; as a result, the infested fruits start rotting, get distorted and malformed in shape and fall off from the plants pre-maturely.

Life history: In nature the population is generally low during dry weather and increases rapidly with adequate rainfall. Pre-oviposition, egg, maggot and pupal periods last for 9 - 21, 1 - 1½, 3 - 9 and 6 - 8 days respectively. During winter the larval and pupal stages are extended up to 3 and 4 weeks, respectively. A single life-cycle is completed in 10 - 18 days but it takes 12 - 13 weeks to complete a single life-cycle in winter. Adult longevity is 2 - 5 months; females live longer than males. Eggs

are 1.0 - 1.5 mm long, whitish in colour, elongate, cylindrical in shape, slightly curved and tapering at both ends. Full grown maggots are 5 - 10 mm long, cylindrical in shape, tapering anteriorly, blunt at posterior end and pale-white in colour. Pupae are 5 - 8 mm long, barrel shaped and brown to ochraceous in colour. The fully fed maggots come out of the fallen fruits and pupate 10 - 15 cm deep in the soil. Where the fruits do not fall, the maggots pupate inside the fruits (which are not common) or come out, drop down and pupate in the soil.

Management strategies:

(i) To avoid infestation by fruit flies, growing of resistant or early maturing varieties has been recommended.

(ii) To check the damage by these flies, fruits should be harvested before they start ripening.

(iii) All the fallen and infested fruits should be collected and destroyed to prevent the carry over of the pest.

(iv) The flies when they congregate and rest on the under surface of large leaves of ribbed gourd may be controlled by spray application of cypermethin 0.025 %.

(v) Spray application of three to five rounds of profenofos 0.05 % or fenthion 0.1 % or carbaryl 0.1 % at intervals of 15 days commencing from flowering may be useful.

(vi) Frequent raking of the soil under the vines or ploughing the infested fields after the crop is harvested can help in killing the pupae.

(vii) Baits prepared with 10% ripe banana, 10% jaggery mixed with 0.1% Malathion or 1g carbofuran used in bait traps was found effective or this bait mixture is to be applied as 200 spot splashes per hectare on the undersurface of cucurbit leaves.

(viii) Use of 0.4 ml methyl engenol with 1ml of dichlorvos in bait traps was also found effective.

2. Snake gourd semilooper *Anadevidia (=Plusia) peponis* F. (Noctuidae: Lepidoptera)

Distribution: Found to occur in all localities where snake gourd is grown.

Nature of damage: The caterpillar cut the leaf partly and rolls it and lives inside the roll. It is a specific pest of snake gourd and the larvae defoliate the plants considerably if infestation is serious.

Life history: The brownish moth has shiny brown fore wings. The female moth lays white spherical eggs on the under surface of leaves. The semilooper caterpillar with humped last abdominal segment measures 35 - 40mm long. Its body is greenish with white longitudinal lines and black tubercles with thin hairs arising on them. It pupates in a thin silken cocoon in leaf fold. The pupa is greenish but turns dark brown before the emergence of the adult moth. Egg, larval and pupal periods last for 4 - 5, 24 - 30 and 7 - 8 days respectively. Its life-history occupies about six weeks.

Management strategies:

(i) The larvae when found in small numbers may be hand-picked and destroyed.

(ii) Spray application of 0.02% carbaryl or 0.05% endosulfan or 0.05% monochrotophos.

3. Pumpkin beetle *Raphidopalpa foveicollis* (Lucas) (red beetle), *Aulacophora cincta* Fabr. (grey with black border) and *A. lewisii* (Baly) *(=A. intermedia* Jacoby) (blue beetle) (Galerucinae : Coleoptera)

Distribution: *R. foveicollis* is found in almost all states of India though it is more

abundant in northern states in association with *A. lewisii*. In South India *A. cincta* is more common.

Nature of damage: The beetles bite irregular holes on leaves and also feed on flowers. They prefer young seedlings and tender leaves and the damage at this stage may kill the seedlings. The roots as well as the stem and fruits that come in contact with the soil are damaged by the grubs. Pumpkin is preferred by *R. foveicollis* and sponge gourd by *A. lewisi.* Both the species feed also on snake gourd, pumpkin, cucumber, melon and ribbed gourd.

Life history: Adult beetles of R. *foevicollis* are 6 – 8 mm long having glistening yellowish red to yellowish brown elytra that are uniformly covered with fine punctures. Adults of *A. cincta* are similar in size and appearance except that the colour of elytra is greyish yellow to brownish grey with distinct palm margin all around. Adults of *A. lewisii* are slightly smaller (5 – 6 mm) with blackish blue elytra. They are active from March to October and the peak period of activity in April to June.

The yellowish pink spherical eggs are laid in the soil which turns orange after two days and a beetle may lay 150 - 300 eggs. The egg period is 5 - 8 days. The grubs become full grown in 13 - 25 days and pupate in the soil. The prepupal period is 2 - 5 days. The pupal period ranges from 7 - 17 days. Total life cycle occupies 32 - 65 days. In a year there may be 5 - 8 generations of the insect.

Management strategies:

(i) Cultural practices like clean cultivation and early sowing will reduce pest damage.
(ii) After harvesting deep ploughing of infested field to kill the grub in the soil.
(iii) Spray application of 0.2% carbaryl or 0.05% endosulfan or dusting 5% carbaryl dust or 4% endosulfan dust.

XI. Insect Pests of Fruit-Trees

(A). Mango *(Mangifera indica)*

1. Mango hoppers (Cicadellidae: Homoptera)

Three species of hoppers are found to feed on the inflorescence of mango *Amritodus atkinsoni* (Lethierry), I*dioscopus clypealis* (Lethierry) and *I. niveosparsus* (Lethierry).

Distribution: In India, these hoppers are widely distributed in all the mango growing regions. *A. atkinsoni* is more common in North India. *I. clypealis* is found all over India, more predominant in South Gujarat, Maharashtra and Karnataka. *I. niveosparsus* is recorded from peninsular India.

Nature of damage: The hoppers are found in abundance during November – February synchronizing with the flowering of mango trees. During the remaining part of the year they occur in small numbers inside barks or on leaves of mango. Both the nymphs and adults suck the sap from the inflorescence in large numbers causing withering and shedding of flower buds and flowers which result in heavy loss ranging from 25 - 60 per cent due to poor fruit setting. The honey dew excreted by them affords conditions for development of sooty mould. Egg laying also inflicts injury to the inflorescence.

Life history: *I. niveosparsus* (L.) is slightly smaller with three spots on the scutellum

and prominent white band across its light brown wings. *I. clypealis* (L.) is the smallest with two spots on the scutellum and dark spots on the vertex and is light brown in colour. *A. atkinsoni* (L.) is the largest and light brown having two spots on the scutellum. The female hopper inserts the eggs into flower buds and the inflorescence stalk. The nymphs hatch out in 4 to 7 days. Freshly hatched nymphs are wedge shaped and whitish in colour with two small red eyes. Gradually with each moulting, the colour changes to yellow, yellowish green, green and ultimately greenish brown. The period from egg to adult takes about 12 - 17 days and during a flowering season two or more broods of the pest may occur.

Management strategies:
(i) Three applications of carbaryl 0.1 % or phosalone 0.05 % at fortnightly interval, or, two sprays of phosphomidon or monocrotophos @ 0.03% at 13 to 18 days interval at flowering and 2 – 3 sprays in June – July.
(ii) Keeping the orchards clean, avoiding over crowding of trees and water logging keeps the pest at bay.

2. Flower webber *Eublemma versicolor* Wlk. (Noctuidae: Lepidoptera)

Distribution: Found distributed in all mango growing areas.

Nature of damage: The flowers in the inflorescence are webbed together by the larva and inside this silken gallery it remains and feeds causing considerable damage. The larvae also bore into the inflorescence stalk.

Life history: The female moth has purplish grey wings and the male has purplish pink or light orange wings with an apical patch. The female lays 8 - 10 reddish hemispherical eggs on sepals and the incubation period is 3 - 4 days. The full grown larva is smooth, greenish yellow with light brown head and prothoracic shield and measures about 20 mm long. The larval period is 18 – 20 days. It pupates inside the inflorescence and emerges as adult in 8 - 9 days. The life-cycle occupies 29 - 33 days. In Kerala *Eublemma angulifera* M. has been noticed to attack the inflorescence.

Management strategies:
(i) Two to three application of phosalone 0.05% at fortnightly interval at flowering.

3. Gall midges infesting mango inflorescence

Distribution: Three species of gall midges *viz*., *Procystiphora mangiferae* (Felt), *Dasineura amaramanjarae* Grover and *Erosomyia indica* Gr. & Pr. are found throughout India.

Nature of damage: Due to the attack of unopened flower buds, they fail to open and drop down. When the inflorescence stalk is attacked, the inflorescence becomes stunted and malformed.

Life history: (i) *Procystiphora mangiferae* (Felt): The light orange coloured fly lays the eggs inside immature blossoms. The maggots that hatch out from the eggs feed on stalks of stamens, anthers, ovary, etc. Only one maggot is found in each bud and it pupates inside the bud itself. The life-cycle from egg to adult occupies 12-14 days). (ii). *Dasineura amaramanjarae* Grover: The adult flies insert the eggs into unopened flower buds. The maggots feed inside the buds and they fail to open and drop down. The maggots hibernate in the soil and thus carry-over of the pest to the next year is accomplished. When favourable conditions set in they pupate and emerge as adults

(iii). *Erosomyia indica* Gr. & Pr.: The maggots attack the inflorescence stalk, flower buds and small developing fruits. The adult fly is yellowish and lays the eggs on the infloresence peduncle or at the base of' developing fruit. The maggots are yellowish and when full grown pupate in the soil.

Management strategies:

(i) Stem injection by making 5 – 10 cm deep holes in the main branches with dimethoate or monocrotophos @ 0.5 ml a.i./cm circumference gave effective control of the pest.

(ii) Single spray of 2, 4-D @150 mg/l in October resulted in opening of galls causing 90% autocidal mortality of the nymphs.

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

Distribution: It is widely distributed in the Orient region from Australia and Hawaii to Pakistan, hence it is also called Oriental fruit fly. The pest is active throughout the year in South India whereas in northern parts the pest hibernates during winter (November to March) in pupal stage. The flies appear late in spring on such of the fruits that are about to ripe and the population increases rapidly during summer.

Nature of damage: The female flies lay eggs just below the fruit epidermis (1 - 4 mm deep). On hatching the maggots feed on pulp of those fruits. As a result a brown patch appears around the place of oviposition and the infested fruits start rotting. These affected fruits drop down prematurely and the maggots come out from these fallen fruits to pupate in the soil. Semi ripe fruits are attacked usually by April-May. Sometimes it becomes serious.

Life history: The adult fly is light brown with transparent wings. Adult flies are very conspicuous. These are about 7 mm long, with hyaline wings (expanse : 13 - 15 mm), thorax ferrugineous without yellow middle stripe, legs yellow, abdomen conical in shape and dark brown in colour. Preoviposition period is 2 - 5 days. A single female can lay 150 - 200 eggs (average 50) in about a month. The eggs are laid in clusters of 2 - 15 eggs and these hatches in 2 - 3 days during March and 1 - 1½ days during April. Maggot duration is 6 days in summer and extends up to 19 days with the fall in temperature. Pupation usually takes place 80 - 160 mm below the soil surface and pupal period ranges from 6 days (summer) - 44 days (winter).

Management strategies:

(i) The best way to avoid infestation of fruit flies is to harvest the fruits before ripening.

(ii) To check the carry over of the pest, collect and destroy all fallen and attacked fruits.

(iii) Plough around the trees during winter to expose and kill the pupae.

(iv) The adult flies may be trapped and killed by poison-baiting or bait-spray (20 gm Malathion, 50% wettable powder in 2 liters of water for baiting and 20 litres of water for spraying.

(v) Spraying with 0.3% oxydemeton methyl or 0.03% phosphamidon or 0.06% dimethoate or 0.2% carbaryl.

5. Mango nut weevil or stone weevil *Sternochetus mangiferae (*Fb.) (Curculionidae: Coleoptera)

Distribution: It is widely distributed in the tropics. The pest is more common in South India where late varieties suffer the most.

Nature of damage: Eggs are laid singly on the epicarp of partially developed fruits or under the rind of ripening fruits. The grubs as soon as they hatch out from the eggs tunnel in a zigzag manner through the pulp, endocarp and the seed coat and finally reach the cotyledons. As the fruit develops the tunnels get closed up. The grubs feed on the cotyledons and destroy them. The adults which emerge from the pupae also feed on the developing seed and this may hasten the maturity of infested fruits. The adults hibernate in between the crevices on the tree trunks. The weevil attacks only mango.

Life history: The dark brownish stout weevil measures about 6 mm long. The female scoop out the surface of the developing fruit (till it is half ripe) and deposits the eggs singly. On a fruit 12 - 36 eggs may be deposited. However, finally only a maximum of about 7 weevils can be noticed in a highly susceptible variety. The fluid that oozes from the fruit covers the egg. The incubation period is 7 days. The grub is apodous, fleshy, light yellow with a dark head and pupates inside the nut itself. It emerges as adult in 7 days. The total life cycle from egg to adult occupies 40 - 50 days. The weevils hibernate from July – August till next fruiting season. There is only one generation in a year.

Management strategies:

(i) The damage due to nut weevil can be minimized appreciably by spraying deltamethrin 0.025 % thrice at 15 days interval commencing 45 days after fruit set.

(ii). Carbaryl 0.2% spray when the fruits are lime sized followed by another spray after 15 days.

(iii). Destruction of affected fruits and digging of soil to expose hibernating weevils.

6. Mango stem borer *Batocera rufomaculata* DeG. (Cerambycidae: Coleoptera)

Distribution: Widely distributed all over India and Bangladesh attacking apart from mango other trees such as fig, rubber, jackfruit, eucalyptus, mulberry etc. The mango varieties Amlet and Mulgoa are highly susceptible to the attack of this insect.

Nature of damage: Eggs are laid singly either in the slits of tree trunks or in the cavities in the main branches and stem which are covered with a viscous fluid. The grubs feed by tunneling through the bark of branches and cause wilting. Though it is an occasional pest of importance, in case of severe attack the trees succumb. Normally, the attack goes unnoticed till the branch start drying up. Sometimes sap and frass may be seen exuding from the bore holes.

Life history: The adult beetle has two pink dots and lateral spines on thorax and measures about 50 mm long. The eggs laid singly on the bark or in crevices on tree trunk or branches hatch in about 1 - 2 weeks. The grub feeds for 3 - 6 months and pupates inside the tunnel itself. The adult emerges in about 4 - 9 months.

Management strategies:

(i) The attacked portions should be removed and destroyed.

(ii) The grubs can be killed by pouring chloroform, petrol or carbondisulphide into the bore hole or placing some crystals of paradichlorobenzene and then closing the hole with mud.

7. Red tree ant *Oecophylla smaragdina* Fb. (Formicidae: Hymenoptera)

Distribution: It has been reported from the entire Oriental region extending from Australia to Africa.

Nature of damage: The ants web and stitch together a few leaves usually at the top of the branches and build their nests on citrus, jack-fruit, jamun, litchi, mango, sapota etc. The ants do not cause any direct injury or loss to the tree. Indirectly, the damage is caused by protecting aphids and scale insects from being preyed upon by their parasitoids and predators and also carries the nymphs of aphids, mealy bugs and scale insects from tree to tree thus spreading the infection of these noxious pests. Besides, being very ferocious, they also prove to be a nuisance to the persons who climb the trees and other workers around, who often get badly bitten by these ants.

Life history: Eggs are oval in shape and whitish in colour. Larvae are also whitish, 1.2 - 1.4 mm long when freshly formed while full grown ones are 9 - 11 mm long. Pupae are also pure white in colour. Adults are light orange red in colour; the workers are 14 - 18 mm long, wingless and infertile. Sexually functional males and females are winged and usually mate outside the nests in the course of their nuptial flights. The fertilized females, also known as Queens, shed their wings at the time of nest formation. Egg, larval and pupal periods occupy 4 - 8, 10 - 17 and 5 - 7 days respectively.

Management strategies:

(i) Spray application of cypermethrin 0.025 % controls it.
(ii) Removal and destruction of nests mechanically.

8. Mango mealy-bug, *Drosicha mangiferae* (Green) (Coccidae: Homoptera)

Distribution: In India, it is widely distributed in the Indo-Gangetic plain and has a very wide range of host plants. This pest has been reported from many places in India, Bangladesh, Pakistan and China. It is reported to attack a number of fruit crops such as apple, apricot, ber, cherry, citrus, falsa, fig, grapevine, guava, gular, jack-fruit, jamun, litchi, mulberry, papaya, peach, plum and pomegranate.

Nature of damage : These are large, fleshy, flat-bodied creatures measuring about 1.5 cm in length and a little less than a centimeter in width, covered with ashy-white mealy powder and crawling up or down the tree-trunks or on the ground round the tree-base or even invading the houses if the mango trees are near about. These mango mealy-bugs are also referred to as the giant mealy-bugs. They suck the plant-sap and although their name seems to suggest that they are specific pests of mango only, their list of food plants includes at least 62 species of trees, shrubs and herbs. When they are in large number they devitalize the plant and they produce honeydew which encourages growth of sooty mould, giving a very unhealthy look to the plant as a whole. At times, they are found clustering in masses on young shoots, like fungus outgrowths.

Life history: There is a well-established sexual dimorphism in the adult stage which is generally found during the midsummer period, i.e. from April to June. Adult females are wingless and large-bodied. The male is a winged creature with only one pair of wings and a very delicate reddish body which flies actively and fertilizes the females. The adult gravid females after fertilization crawl down along the tree-trunk to the ground where they lay eggs at depths of about 5 - 15 cm and in clusters of 300 -

400 eggs each. The oviposition is generally confined to an area near and around the base of the tree. These activities of migration from the tree downwards to the ground and oviposition in the soil are generally confined to the months of April, May and June. The males die soon after mating and the females soon after oviposition. The eggs laid in the soil take quite a few months before they hatch and is influenced by the temperature and moisture conditions of the soil. Hatching can be as early as November of the same year or as late as March of the succeeding year. The young nymphs soon after hatching crawl about in search of some suitable food-plant on which, if found, they spend some time. Thereafter, they begin their ascent along the tree-trunks and this upward migration lasts for several weeks. On reaching the fresh growths, the nymphs congregate there and begin to suck the plant-sap. They moult thrice during their nymphal period which lasts about three months or more, depending on the environmental temperature. Thereafter, the nymphs developing into males undergo some sort of pupation and transform themselves into winged adults and the female-producing nymphs do not undergo any appreciable change except in size. Thus, there is only one generation during the year. Unlike many other coccids, the nymphs of this pest do not remain stationary although they are sluggish.

Management strategies:

(i) Raking of the soil around the base of the tree which has been infested, so that the egg-masses get exposed to the sun and heat and get killed. Also, the application of chlorpyriphos 0.05% in the same area when hatching begins or is expected, so that the just-hatched nymphs may be poisoned.
(ii) Application of a sticky band round the tree-trunk so as to check the nymphs from crawling up the trees.
(iii) If nymphs are observed on trees, spray 0.05% monocrotophos or phosalone.

(B). Sapota (*Manilkara achras*) :

1. Leaf webber *Nephopteryx eugraphella* Rag. (Phycitidae: Lepidoptera)

Distribution: A common pest of sapota throughout India.

Nature of damage: The caterpillar webs and feeds on the leaves. It also feeds on flower buds and fruits and 3 - 4 larvae may occur together occasionally. Leaves of *Mimusops elengi* and cured tobacco are also infested by the larvae.

Life history: The grayish moth lays pale yellow eggs on leaves singly or in groups of two or three. The pinkish larva measuring 25 mm long has close-set of longitudinal lines on the dorsal surface. Pupation takes place in the leaf web itself. The total life-cycle occupies 32 - 45 days, the egg, larval and pupal periods respectively being 3 -5, 17 - 32 and 7 - 11 days.

Management strategies:

(i) The damaged leaf webs with larvae should be collected and destroyed.
(ii) Spray application of cypermethrin 0.025 % affords protection.

2. Hairy caterpillar *Metanastria hyrtaca* C. (Lasiocampidae: Lepidoptera)

Distribution: This pest is found on a number of tree crops including sapota in different parts of India.

Nature of damage: The caterpillars feed on leaves voraciously and defoliate the trees.

Life history: The female moth has grayish brown wings and is stout. The male is smaller and has a white spot in the centre of a black patch on forewing. The antenna is pectinate. The moth oviposits on leaves or twigs in rows or groups and lays about 140 eggs. The incubation period is 9 - 12 days. The long stout grayish hairy caterpillar measuring about 65 mm long has black head and median dorsal brownish band extending to second abdominal segment. The larval stage occupies 45 - 60 days. Pupation takes place on tree trunks in a cocoon of silk and body hairs. Pupal stage occupies 7 - 10 days.

Management strategies:

(i) Spraying of cypermethrin 0.025%.
(ii) Burning the groups of larvae found on tree trunks with torches.

(C). Guava *(Psidium guajava)*

1. Tea Mosquito bug : *Helopeltis antonii* S. (Miridae : Hemiptera)

Distribution: It is found attacking tea, neem, cashewnut and guava in different parts of India. It is serious on tea in Kerala.

Nature of damage: The nymphs and adults of the tea-mosquito bug *Helopeltis antonii* (Miridae) cause corky scabs formation on fruits. The blisters are formed due to the toxic substance injected by the bugs. Due to the attack the fruits become unsuitable for marketing.

Life history: It is a slender insect 6 - 8 mm in length with a yellowish brown head and abdomen, a dark red thorax and long dark appendages. The adult lays elongate and sausage shaped eggs that possess two filamentous long processes which remain jutting out from the tender plant tissue in which the eggs are bedded by the female. Incubation period varies between 5 - 27 days. The newly hatched nymphs resemble spider in general appearance with elongate appendages. They undergo five moults and complete one generation in two weeks in June and eight weeks or more in cold weather.

Management strategies:

(i) Periodical spray application of Malathion 0.1 per cent has been reported to minimize damage.

(D). Banana *(Musa* spp.)

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

Distribution: One of the most serious insect pests of banana all over the world, found distributed in South Asia, Africa, many pacific islands, Australia, Northern South America, Central America, West Indies and some parts of North America. In India reported as serious pest in Kerala, Tamil Nadu, Andhra Pradesh and other banana growing areas.

Nature of damage: The dark weevil oviposits in the root stock or leaf sheath just above the ground level. The grubs and adults bore into the rhizome and cause stunting of rhizome development. If the infestation occurs on a mature rhizome,

damage symptoms appear through the reduction in the leaf number, bunch size and the fruit number. Most damage is done by extensive tunneling of the larvae in the corn, thus weakening the plant and causing blow-down by even slight winds.

Life history: Adults lay eggs in between leaf sheaths and stems as well as around the corn, often in an enlarged cell-like compartment in the tissue. Eggs are laid singly and the newly hatched larvae bore into the corm. The egg, larval and pupal stages are completed in 5 - 7, 15 - 20 and 6 - 8 days, respectively. Adults can live over two years without food.

Management strategies:

(i) Adopt strict field sanitation by removing infected plants and destroying them.
(ii) Deep ploughing before planting to expose the weevils to sun and predators.
(iii) Use of healthy planting material and removal of outer layer of rhizome and sun dry for 3 - 4 days before planting after smearing with slurry of cowdung and ash.
(iv) Setting traps in the field using length-wise split pseudostem of 50cm length. Adults attracted to it during nights may be collected and destroyed.
(v) Drenching with chlorpyriphos 0.1% emulsion in the soil before planting may afford some relief.

2. Banana Stem Weevil *Odoiporus longicollis* Oliver (Curculionidae: Coleoptera)

Distribution : It is distributed in Asia, Bhutan, China, Guizhau, Hong Kong, Indonesia, Java, Sulawesi, Sumatra, Japan, Laos, Malaysia, Sabah, Myanmar (Burma), Nepal, Nicobar Islands, Phillippines, Sri Lanka, Taiwan and Vietnam. In India, it is distributed in Assam, Bihar, Haryana, Kerala, Manipur, Sikkim, Uttar Pradesh, West Bengal and in Andaman Islands.

Nature of damage: Infestation of the weevil starts in 5 month old plants. Early symptoms of the infestation are the presence of small pinhead sized holes on the stem, fibrous extrusions from bases of leaf petiole and exudation of a gummy substance from the holes on the pseudostem. In advanced stages of infestation, the stem when split open will show extensive tunneling both in the leaf sheath and in the true stem. Rotting occurs and foul odour is emitted due to secondary infection of pathogens. When the true stem and peduncle are tunnelled after flowering, the fruits do not develop properly, become dehydrated with premature ripening of the bunch. Weakening of the stem by larval tunneling often result in breakage by wind. The estimated yield loss due to this pest is between 10 – 90% depending on the growth stage in which the infestation occurs and it is the highest in 5 months old crop.

Life history: The adult weevils are black-coloured and measures 23 - 39 mm. Red coloured morphs are also encountered. All life stages of the weevil are present throughout the year. Adults are strong fliers and this way they spread quickly from field to field. The pre-oviposition period is 15 - 30 days. The adults mate throughout the day and night and after a single mating lay an average number of one egg per day for 9 days. Gravid females lay yellowish white, 3.14 x 1.1 mm sized elliptical eggs through ovipositional slits cut by the rostrum on the outer epidermal layer of the leaf sheath of the pseudostem. The incubation period ranges between 3 - 8 days. The larvae are fleshy, yellowish white and apodous and they pass through 5 instars. Pupation takes place in a fibrous cocoon and the pupate are exarate. The total life cycle from egg to adult stage is competed in 44 days.

Management strategies:
(i) Field sanitation by removing and destroying the affected plants alongwith rhizome and also the destruction of pseudostem and rhizome of harvested plants is the most important method.
(ii) Application of carbofuran 3g @ 30g/plant at planting and @ 15g/plant at 60^{th} and 90^{th} day after planting.
(iii)Spray application of quinalphos 0.05% or chlorpyriphos 0.03% or carbaryl 0.2% at planting. In case of severe infestation spraying may be repeated after 3 weeks.

3. Banana aphid – *Pentalonia nigronervosa* (Coquerel) (Aphididae : Homoptera)

Distribution: It is present every where in the world where banana is grown. It occurs on a number of food and ornamental plants including floral red and pink ginger, cardamom, *Heliconia*, Ginger etc.

Nature of damage: Nymphs and adults suck the sap causing deformation of plants. The leaves become curled and shriveled and in case of severe infestation young plants are killed. Feeding also results in honey dew secretion on which the sooty mould grows resulting in decrease of photosynthetic activity and vigour of the plant. It is a vector of the "bunchy top disease" in banana and "Katte disease" in cardamom.

Life history: They reproduce parthenogenetically giving rise to nymphs which complete their life cycle in 9 - 16 days. The first, second, third and fourth nymphal stages are completed in 2 - 4, 3 - 4, 2 - 4 and 2 - 4 days, respectively.

Management strategies:
(i) Application of 25g of phorate 10G or 20g of carbofuran 3G /plant 20 days after planting around the rhizome in the soil.
(ii) Application of 12.5g phorate 10G or 10g of carbofuran 3G /plant in the leaf axils or 25g phorate 10G or 20g carbofuran 3G /plant in the soil 75 days after planting which may be repeated 165 days after planting.

(E). Pomegranate (*Punica granatum*) :

1. Anar butterfly *Deudorix* (=*Virachola*) *isocrates* F.) (Lycaenidae : Lepidoptera)

Distribution: It is a polyphagous pest having a very wide range of host plants, including, aonla, apple, ber, citrus, guava, litchi, loquat, mulberry, peach, pear, plum, pomegranate, sapota and tamarind. It is widely distributed all over India and is found wherever pomegranates are grown. Pomegranate fruits are also damaged by pomegranate borer, *Deudorix epijarbas* (Moore).

Nature of damage: The female lays eggs singly on calyx of flowers or small fruits. On hatching, the caterpillars bore inside the developing fruits and are usually found feeding on pulp and seeds just below the rind. As many as eight caterpillars may be found in a single fruit. Subsequently, the infested fruits are also attacked by bacteria and fungi causing the fruits to rot. The conspicuous symptoms of damage are offensive smell and excreta of the caterpillars coming out of entry holes, the excreta are found stuck around the holes. Sometimes the holes may also be seen plugged with the anal end of a caterpillar. The affected fruits ultimately fall down and are of no use.

Life history: The bluish brown butterfly has an orange spot on each of the fore wings and black spots on the hind wings. The eggs are laid singly on flowers and tender fruits. Eggs are shiny white in colour and oval in shape. The egg hatches out within 7 - 10 days. The caterpillar measures 16 – 20 mm long, dirty brown and has short hairs on its body. Larval period is 14 – 45 days. Just before pupation, the caterpillars come out of the fruits and tie the stalk of fruit with main branch of the tree with fine silken strands to ensure that the fruit does not fall down, then reenter the fruit and pupate therein or on fruit stalk. Pupal period varies from a week to more than a month. The total life-cycle may take 1 - 2 months depending upon the weather. It has four overlapping generations in a year.

Management strategies:

(i) The fruits if screened with polythene or paper bags may escape infestation.

(ii) Five spray application of fenvalerate 0.01 %, or carbaryl 0.2 % or triazophos 0.05% or 0.03% phophamidon at intervals of three weeks commencing at initiation of fruit setting.

(iii) Removal and destruction all the affected fruits.

XII. Pests of Temperate Fruits

1. San Jose Scale *Quadraspidiotus perniciosus* (Comstock) (= *Aspidiotus perniciosus* Comstock) (Diaspididae: Homoptera)

Distribution: It is indigenous to Eastern Asia and has spread to many parts of the world. It is widely distributed in all the apple growing countries of the world. It was introduced in India (Kashmir) from France in 1906 and by now it has been recorded on more than 150 host plants, including almond, apple, apricot, cherry, chestnut, citrus, crab apple, grapevine, gooseberry, mulberry, peach, pear, plum, quince, raspberry and strawberry.

Nature of damage: These tiny insects suck the sap; as a result, the young plants in the nursery become weak and ultimately die away. The leaves, twigs, fruits and sometimes even the entire bark may be seen covered with ashy-grey scales which can be easily scraped off exposing the orange coloured individuals beneath. The affected fruits present pink coloured areas around the scales and the market value of such fruits is reduced.

Life history: The nymphs hibernate from December to March, resume their activity around end of March and mature in about 4 weeks. The second stage lasts 10 - 12 days. The males (winged) fertilize the females (wingless) and die. The females do not lay eggs but produce young ones; 300 - 400 per female, the eggs mature into tiny nymphs in the female ovisac in about a month, during April - May. Nymphal period varies between 40 - 50 days. The number of generations in a year depends mainly on elevation and climatic conditions. There are six to seven overlapping generations in a year. The 1st instar crawlers are the main dispersal phase and are carried for a few kilometers by the wind.

Management strategies:

(i) Spraying the dormant trees in winter with 3% miscible oil (***Dormant oil**).

(ii) In addition to spraying, the parasitoid, *Encarsia pernicoisi* (Tower) may also be released to check the over wintering population of San Jose scale on wild host plants growing around.

*** Dormant oil:** These are heavy and less refined oil suitable for application on fruit trees and shrubs during dormant season when they will be devoid of leaves. These are available in emulsifiable forms having 85 – 95% of actual oil.

2. Wooly aphid *Eriosoma lanigerum* (Hausman) (Aphididae: Homoptera)

Distribution: It is native of America and is cosmopolitan in distribution except for hotter parts of the tropics. In India, it was first recorded in 1889 at Conoor (Tamil Nadu) damaging young apple trees and has since then, spread to all the apple growing areas of India. Its alternate hosts in India include crab apple, pear and quince. The pest is active throughout the year.

Nature of damage: It attacks primarily the underground roots but winged form also attacks trunk, branches, stems, twigs, leaf petioles and fruit stalks. Upward and downward migrations are accentuated during hottest and coldest seasons respectively. Maximum migration from roots to aerial parts takes place in May and in the opposite direction during December - January. Due to the desapping caused by this pest, the affected trees present a sickly appearance, lose vigour and the growth of these trees as also their fruiting capacity are adversely affected. In case of young tees, the roots disintegrate to such an extent that these trees are easily blown over by even moderately strong winds.

Life history: The pest overwinters either as egg or young nymph on the roots of the host tree. The eggs hatch and the nymphs mature during spring. The reproduction during this period is parthenogenetical as well as viviparous. A single female produces 30 - 116 young ones in her life time. New nymphs soon settle down in batches and start sucking the plant sap. Within 24 hours, these nymphs begin to secrete wooly filaments of wax over their bodies – hence the name, wooly aphid. Nymphal period is about 11 days in June which gradually increases with fall in temperature and becomes 93 days by December. During summer and early monsoon months there is rapid multiplication both on stems and roots and considerable dispersal of pest. The winged adults fly away while the wingless forms are blown off by the wind. With the advent of winter, the sexual forms appear, mate and lay eggs; while the immature nymphs on the trees descend and enter the root zone for hibernation.

Management strategies:

(i) Soil application (80 - 100 mm deep) of dimethoate or thiometon granules @ 15g / tree during spring and summer against the root forms.

(ii) Foliar spraying with 0.03% dimethoate or phosphamidon or oxydemeton methyl during March – April (spring) and again in June.

(iii) The aphid population can also be effectively checked by an exotic parasitoid, *Aphelinus mali* Hald.

3. Fruit fly *Dacus ciliatus* (Loew) (Tephritidae: Diptera)

Distribution: *Dacus ciliatus* commonly called Ethiopian melon fly is of African origin, now widely distributed in European countries, Africa, Middle East, Pakistan, Bangladesh, India, and Srilanka. Its main hosts are cucurbits, including various melons and alternate hosts are, citrus, apple, etc.

Nature of damage: Female flies make cavities on fruits with their ovipositor and lay 3 - 8 eggs in each cavity. On hatching, maggots feed on the pulp. The affected fruits gradually rot and fall down.

Life history: Eggs are shiny white, slightly curved and about 2.5 mm long. Egg stage lasts for 2 - 4 days. Maggots are whitish in colour and 8 mm long. Larval stage lasts for 4 – 6 days. Pupae are cylindrical, brownish to ochraceous in colour and about 5.5 mm long. Pupal stage is completed in 8 - 10 days. Adult flies are ferruginous-brown with hyaline wings and have two dark spots on 4th abdominal segment. Pre oviposition period is four days.

Management strategies:

(i) To check the damage by these flies, fruits should be harvested before they start ripening.
(ii) All the fallen and infested fruits should be collected and destroyed to prevent the carry over of the pest.
(iii) Spray application of three to five rounds of profenofos 0.05 % or fenthion 0.1 % or carbaryl 0.1 % at intervals of 15 days commencing from flowering may be useful.
(iv) Frequent raking of the soil under the trees or ploughing the infested fields after the crop is harvested can help in killing the pupae.

4. Apple codling moth *Cydia pomonella* (Linnaeus) (Tortricidae: Lepidoptera)

Distribution: This pest is widely distributed throughout Europe, North America and Australia. Nearer India, it has been found in abundance in Baluchistan (Pakistan) where it causes havoc on apples and other fruits and is stated to constitute a threat to the rest of subcontinent. In India, its occurrence was reported from Ladak. Codling moth is a notorious pest of temperate fruits, showing marked preference for apples. It is a polyphagous pest and has also been recorded on citrus, peach, pear, quince, walnut etc.

Nature of damage: Eggs are laid singly on leaves, blossoms and fruits. The freshly hatched caterpillars feed on leaves for a while, then burrow inside the fruits and feed on the pulp. The entry holes become quite conspicuous as these are filled with dry brown frass and are surrounded by a dark reddish ring. The infested apples become brighter in colour than those that are not infested and also ripe prematurely. The fruits that are attacked early in the season often drop down before the crop is ready for harvest.

Life history: Eggs are flattened and white in colour. Full grown caterpillars are 16 - 22 mm long and pinkish in colour. Moths are greenish to dark brown with chocolate-brown or copper coloured circular markings near the tip of forewings. The colour pattern resembles bark of the tree trunk which makes the moths quite inconspicuous. Wing expanse is 18 - 24 mm. Egg, larval, and pupal periods are 4 - 12, 28 - 35 and 8 - 14 days respectively. The caterpillars of third brood over-winter by forming thick silken cocoons in which they pass the winter under loose scales of the bark of the host trees. When spring comes, the larvae become pupae inside these cocoons and the moths emerge from the cocoons during March – April.

Management strategies:

(i) Strict domestic quarantine is to be followed by screening of consignments of fruits to prevent the spread of the insect from Ladak to other apple growing regions.
(ii) Collect and destroy the infested fruits to prevent the carry over of the pest.

(iii) Application of 0.2% Pyrethrum extract is also helpful in checking the pest infestation. The protective treatment may be applied about ten days before ripening of the fruits.

5. Peach leaf curl aphid *Brachycaudus helichrysi* (Kaltenbach) (Aphididae: Homoptera)

Distribution: In India, the pest is more serious in Kullu valley, Simla hills and sub-mountaneous area of Uttar Pradesh. Its preferred host is peach but it is also found on almond, apricot, plum etc.

Nature of damage: Nymphs and adults suck the cell sap from leaves, petioles, blossoms and fruits. Affected leaves turn pale and curl up; blossoms wither and fruits do not develop into normal size and drop prematurely.

Life history: The alternate host in cooler region is *Golden rod*, *Erigeron canadensis* Linnaeus while in plains the aphid breeds on a weed, *Ageratum conyzoides* Linnaeus. Eggs are cylindrical, 0.6 mm long, light green in colour when freshly laid, later turning shiny black. Nymphs are dark green in colour and the adults that feed on leaves are green while those that feed on bark are chocolate coloured. Reproduction is sexual as well as parthenogenetic. Sexual forms appear early in November in cooler regions and lay eggs which hatch in March. At lower altitudes there is no egg-laying and over-wintering is in adult stage. With the rise in temperature, there is rapid multiplication (parthenogenetically). A single female gives birth to about 50 young ones in her life time of two weeks and each of these takes about 10 days to mature during March – April and start reproducing. All these young ones are apterous, viviparous females. After producing 3 - 4 asexual generations the aphids migrate to pass summer on its alternate host. The migration takes place during mid May in plains and around July in cooler regions.

Management strategies:
(i) Spray with 0.03% dimethoate or oxydemeton methyl or phosphamidon or quinalphos or 0.04% diazinon or dichlorvos just before flowering (pink bud stage) and again after 7 - 10 days.
(ii) Another one or two sprayings should be given when the fruit is pea-sized. In higher hills only one pre-bloom spraying is sufficient while in mid and lower hills, in addition to pre-bloom spray, a post-bloom spray (8 - 10 days after petal fall) is also necessary.

XIII. Pests of Beverages

a). Pests of Coffee (*Coffea arabica*) :

1. Coffee white borer *Xylotrechus quadripes* Ch. (Cerambycidae: Coleoptera)

Distribution: The insect is considered to be one of the important pests of coffee in different parts of India.

Nature of damage: The grubs burrow into the stem for 8 - 9 months and cause wilting of branches and occasionally death of bushes. It is a serious pest of Arabica coffee. Infested plants show external ridges around the stem. Affected plants also show yellowing and willing of leaves.

Life history: The beetle has white cross hands and dark brown elytra. The adults emerge in large numbers at two distinct periods *viz.*, April-May and October-November. A beetle lays about 50 - 100 eggs in crevices of the bark on stem. The grubs hatch out from the eggs in 8 - 10 days and pass through the larval stage for 8 - 9 months. Pupation takes place in the stem itself and pupal stage lasts for 25 - 30 days.

Management strategies:

(i) Maintain optimum shade.

(ii) The wilting branches and bushes should be removed and destroyed.

(iii) Lindane 20 EC @ 1300 ml in 200 litres of water with 200 ml wetting agent may be swabbed over the stem once in April - May and twice at an interval of a month during October - December for effective control of infestation by the pest or 0.05% monocrotophos or phosalone.

2. Coffee Berry Borer *Hypothenemus hampei* (Ferrari) (Scolytidae: Coleoptera)

Distribution : Central and South America, Mexico, Ecuador, Indonesia, Kenya, India, Srilanka, Korea, Malaysia, Thailand, Viet Name, Congo, Ethiopia, Ghana etc. In India it is distributed in Kerala, Tamil Nadu and Karnataka.

Nature of damage: Pin holes at the tip of berries. In severe cases of infestation two or more holes may be seen. Infested berries may fall due to injury or secondary infection. Severe infestation may result in heavy crop loss up to 40 - 80%.

Life history: Adult females bore a hole in coffee berries and lay their eggs near the two coffee beans found inside the berry. Once the eggs hatch, the larvae feed on the beans rendering them unfit for commerce or lowering their quality. The total life cycle is completed in 25 - 30 days.

Management strategies:

(i) Timely and clean harvest. Use mats to prevent gleanings.

(ii) Remove off-season berries and gleanings.

(iii) Spot spray 0.07% endosulfan 35 EC when most of the beetles are waiting near the naval region of fruit.

(iv) Dry coffee to prescribed moisture level (arabica / robusta parchment 10%, arabic cherry 10.5% and robusta cherry 11%).

(v) Mass trapping of beetles with coffee fruit extract in 1 : 1 combination of ethanol and methanol.

3. Green scale *Coccus viridis* (Gr.) (Coccidae: Homoptera)

Distribution: Found in different coffee growing regions in India.

Nature of damage: The scale is 3 mm long, flat, yellowish green ovate and slightly convex and covers the tender leaves and shoots and sucks the sap. Sometimes it becomes serious affecting the vigour of the bushes considerably and sooty mould development is commonly noticed affecting photosynthesis. It causes debilitation of older plants and death of nursery plants.

Management strategies:

(i) Maintain optimum shade.

(ii) Spray application of Malathion 0.1% or methyl parathion 0.05% or profenofos 0.05 % or phosalone 0.07%.

b). Pests of Tea (*Camellia chinesis*)

1. Tea-mosquito bug *Helopeltis theivora* Waterhouse (Miridae: Hemiptera)

Distribution: It is considered to be a serious pest of tea particularly in Kerala. The pest has been reported from India, Indonesia and Indo-China.

Nature of damage: The nymphs and adults suck the sap from tender buds, leaves and stem and the toxic saliva of the insect injected at the time of feeding cause brownish patches and curling of leaves and ultimate drying of the shoots.

Life history: It is a slender insect, 6 - 8 mm long, with a yellowish-brown head and abdomen, a dark–red thorax, and long dark appendages. The prothorax has a prominent and characteristic clubbed horn. The elongate and sausage shaped eggs are also peculiar in possessing two filamentous long processes which remain jutting out from the tender plant-tissue in which the eggs are embedded by the female. The eggs are laid practically in all tender parts of the plant. The incubation period varies within wide limits (5 - 27 days). The freshly-hatched nymphs are rather spidery in general appearance due to their elongate appendages. They undergo five moults to become adults and the time required for the completion of one generation varies from about two weeks in June to eight weeks or more in the cold weather.

Management strategies:
(i) Monitoring the infestation level in the field.
(ii) Removal of stalks containing eggs while plucking.
(iii) Encouraging the egg parasitoid, *Erythmelus helopeltidis* population to build up.
(iv) Application of endosulfan 35 EC @ 1000 ml/ha or quinalphos 25 EC @ 750 ml/ha or chlorpyrifos 20 EC @ 750 ml/ha or fenthion 80 EC @ 200 ml/ha or quinalphos 25 EC + dichlorvos 76 EC @ 750+250 ml/ha. Spraying may be undertaken during early mornings or evenings when these bugs are active.

XIV. Insect Pests of Spices and Condiments

A). Chillies (*Capsicum annum* Linnaeus)

1. Chilli thrip, *Scirtothrips dorsalis* Hood (Thripidae: Thysanoptera)

Distribution: It is a polyphagous pest having a wide range of host plants such as tea, grapevine, castor, cotton, *Prosopis juliflora*, etc. It is distributed all over India.

Nature of damage: Eggs are laid on or just under leaf tissues. Both nymphs and adults lacerate the leaf tissues and imbibe the oozing sap; sometimes even the buds and flowers are attacked. Tender leaves and growing shoots are preferred. The infested leaves start curling and crumbling and is ultimately shed whereas buds become brittle and drop down. Yield loss due to thrips attack may range from 25 - 50 %.

Life history: Eggs are minute and dirty white in colour. Nymphs and adults are also tiny, slender, fragile, and yellowish-straw in colour; adults have heavily fringed wings that are uniformly grey in colour. Reproduction is both sexual and parthenogenetic. In case of sexual reproduction, oviposition period lasts for about a month during which a female lays on an average 100 eggs @ 2 - 4 eggs per day. A single life-cycle is completed in 2 -2½ weeks. As many as 25 overlapping generations are completed in a year. The thrips *Franklinothrips vespiformis* (Crawford) and *Erythrothrips asiaticus* R. &. M. are predaceous on the insect.

Management strategies:

(i) Spray with 0.03% dimethoate or phosalone or monocrotophos or 0.2% carbaryl.

B). Pepper Vine (*Piper nigrum*)

1. Pepper flea beetle *Longitarsus nigripennis* M. (Chrysomelidae: Coleoptera)

Distribution: The most important and specific pest of the pepper crop which is chiefly grown only along the Western Ghats.

Nature of damage: This is a small shinning yellow and blue flea beetle called the 'Pepper Pollu beetle' which is about 2 mm in length. It has the hind legs stout and is capable of jumping long distances like grasshoppers. The small pale yellowish grub of this insect bores into the ripening pepper berry, feeds on the seed and makes the berry hollow; sometimes appreciable damage is caused to the pepper crop.

Life history: Eggs are deposited by the mother beetle, each into a small hole made by it on the rind of a green tender pepper berry. In about a week or ten days the eggs hatch into pale yellowish grubs which have three pairs of legs and well developed jaws. These feed on the berry contents and gradually grow in size; before becoming full fed, one grub generally damages two or three berries in a spike. The grub becomes mature in about a month. At this stage, it is 3 – 4 mm in length and has a yellow body and dark head region. When full fed the grub drops into the soil and changes into the pupa in a pupal chamber made of soft soil. In another week the adult beetle emerges out of the pupa. The feeding by the grub not only affects the berries in a spike but often the stalk of the whole spike. Attacked berries can be made out by the pale sickly dark color and also by the small hole on its surface.

Management strategies:

(i) Precautions may be taken to hoe the soil well to kill the underground pupae.
(ii) Spray the spikes with a repellent mixture like Bordeaux mixture.

XV. Insect Pests of Stored Products

Among the biotic and abiotic factors which affect grains in storage, insects play a major role in the deterioration of food grains and seeds causing both quantitative and qualitative losses. Various estimates on post harvest losses across the country reveal that there is loss of 2 - 12% during storage exclusively by insects. The group of insects that damage stored grain can broadly be grouped in two groups. The first group is internal feeders that spend most of their life feeding within the kernel of grain and the second group, external feeders that spend their life feeding on the surface of grains or on the finished products of grains. Some of the insects that attack the grains in the field even before harvest and continue damaging the grains in storage under favourable conditions. The insects that attack the healthy grains and cause damage to the stored grains are called primary pests and the insect pests that cause further damage to the grains or stored products that are already damaged by other insects are called secondary pests.

A. Internal Feeder

1. Rice weevil *Sitophilus oryzae* Linn. (Curculionidae: Coleoptera)

Distribution: It infests the grain both in storage and in field in different parts of India.

Nature of damage: It is destructive to wheat, corn, rice, jowar etc. Larvae and adult bore into the grains and cause damage making them unfit for consumption.

Life history: The weevil measuring 4 mm long is dark brown and has four light reddish or yellowish spots on elytra. The female makes a small hole on the grain, deposits an egg and covers it with a gelatinous fluid. In a period of 4 – 5 months a female may lay from 60 - 400 eggs. The apodous grub feeds inside the grain, pupates there itself and emerges through an irregular hole made on the grain. The life cycle ranges from 26 – 28 days.

2. Sweet potato weevil *Cylas formicarius* Fb. (Curculionidae: Coleoptera)

Distribution: Present in all localities where sweet potato is grown.

Nature of damage: The grubs and adults bore into the tender vines, stems and tubers making them unfit for use. Adults attack the leaves, vines and tubers. It is a pest both in the field and storage.

Life history: Eggs are laid singly in cavities in stems or tubers covered over with pulp. These hatch in 3 – 5 days and about 200 eggs are laid by a female. The white grubs eat into the tissue leaving only the hole of entry. The grub pupates in the burrow and the adult emerges in 7 – 10 days. Total life cycle lasts about 40 – 45 days. The adult is ant-like, slender and shiny black with thorax and legs being red. It is sluggish in movement and lives for about 3 months. The weevil enters the soil through cracks. The adult is also capable of causing damage to the tubers.

3. Leser grain borer or paddy borer beetle *Rhyzopertha dominica* Fabr. (Bostrichidae: Coleoptera)

Distribution: Occurs mostly in tropical and subtropical regions of the world. It may also occur in warm situations in temperate zones.

Nature of damage: It is important as a pest of whole cereals. Both larvae and adults bore into the grains and feed on. In undamaged grains adults most frequently attack the germ. Besides whole grains it can develop on milled rice and cereal flours but not on highly polished rice. It is found to feed on dried cassava and many pulses.

Life history: Adults mate soon after emergence and the females lay their eggs in crevices or on the rough surfaces of a seed. Adult female lives up to 4 months. It lays 244 eggs on an average at 25ºC and 418 eggs at 34ºC. On emergence the larvae will make use of even minute husk defects to bore into the grains. On whole wheat at 34ºC and 70% R.H. larvae undergo 3 - 5 moults and reach the pupal stage in about 17 days and the pupal stage is completed in about 3 days.

4. Cigarette or tobacco beetle *Lasioderma serricorne* Fb. (Anobiidae: Coleoptera)

Distribution: Distributed all over India in stored tobacco, turmeric, ginger and chillies.

Nature of damage: The whitish hairy grubs feed on stored tobacco, ginger, turmeric and chillies.

Life history: The light brown round beetle has its thorax and head bent downward and this presents a strongly humped appearance to the insect. The elytra have minute hairs on them. Antenna is of uniform thickness. Each female lays up to 110 creamy white oval eggs loosely on the surface of stored material and the incubation period is 9 – 14 days. The larval and pupal periods range respectively from 17 – 29 days and 2 – 9 days.

Management strategies:
(i) Redrying of tobacco and other stored products.
(ii) Fumigation with aluminum phosphide tablets at 20 - 30 tablets for 28 cu. m. for 96 hrs. and aeration of tobacco for 72 hrs.
(iii) Storing at 16 - 18ºC
(iv) Fogging with pyrethrum 1% oil mist @ 3 fl. Oz/28 cu. m. or DDVP aerosol @ 1 to 2 g a.i./28 cu. m. once or twice a week are recommended.

5. *Trogoderma granarium* Everts (Dermestidae : Coleoptera)

Distribution: Believed to have originated in India. It occurs in hot, dry conditions, predictably in areas which, for at least 4 months of the year, have a mean temperature greater than 20ºC and R.H. below 50%. It is prevalent in Middle East, Africa and also in certain warm habitats in temperate countries like Britain.

Nature of damage: It is a serious pest of oilseeds, cereals especially wheat and to a lesser extent pulses. Adults are dark brown in colour mottled with black, oval in shape and vary in size from 2 - 3 mm. The larvae are typically very hairy which feed on the grains making them unsuitable for consumption.

Life history: Adults upon emergence remain inside the pupal skin for a day or more and move out. The adults mate after emergence and there is a pre-oviposition period of 2 - 3 days. Normally, the oviposition lasts 3-4 days at 40ºC and it may extend up to 12 days at 25ºC. Approximately, on an average 35 eggs are laid by a female. Larvae are hairy having spici setae scattered over the dorsal surface and there are also two large tufts of setae projecting posteriorly like a tail. The larvae have 4 moults for males and 5 moults for female. Without food the larvae undergo diapause and survive about nine months. Pupa usually remains in the cast skin of the last instar larva. Pupal periods vary between 5 days at 25ºC and 3 days at 40ºC.

6. Red Flour Beetle *Tribolium castaneum* (Tenebrionidae: Coleoptera)

Distribution: *T. castaneum* is thought to have originated in India, from where it has spread throughout the tropical and subtropical world. It is capable of living on a variety of commodities and on detritus of vegetable or animal origin.

Nature of damage: The larvae and adults feed on a wide range of durable commodities and are important secondary pests of cereals, having a preference for the embryo. It also attacks stored groundnuts, nuts, spices, coffee, cocoa, dried fruits and occasionally peas and beans. Infestation leads to persistent disagreeable odour in the commodity due to the secretion of benzo-quinones from a pair of abdominal defense glands.

Life history: The females may copulate many times and subsequently throughout their lives lay sticky eggs in the food. Adult can live up to 6 months and a female lays on an average 2.5 eggs per day at 25ºC and 11 eggs per day at 32.5ºC. At 35ºC and 75 R.H., the average incubation period is 2.7 days. The larvae undergo 7 - 8 moults in about 13 days and the pupal stage is completed in 4.5 days. Under optimum conditions development from egg to adult may take only 20 days. Cannibalism and predation play an important role in the nutrition of *T. castaneum*. The eggs and pupae are often cannibalized by the adults, the males showing a preference for pupae and females for eggs. The adults and larvae are known to prey upon all stages of *Plodia interpunctella*, *Ephestia cautella* and *Corcyra cephalonica* and upon eggs, young larvae and pupae of *Oryzaephilus surinamensis*.

7. Drug store beetle *Stegobium paniceum* (Linn.) (Anobiidae: Coleoptera)

Distribution: Found distributed in all godowns and households where stored products like turmeric, ginger, coriander, dry vegetables etc. are stored.

Nature of damage: It tunnels into stored products like turmeric, ginger, coriander and dry vegetable and animal matter and make them unfit for consumption.

Life history: The reddish brown small beetle has striated elytra and measures 3 mm long. Antenna is clubbed. It lays the eggs in batches of 10 - 40. Grub is not hairy but is pale white, fleshy with the abdomen terminating in two dark horny points. The larval and pupal periods occupy respectively 10 - 20 months and 8 - 12 days.

8. Pulse beetle *Callosobruchus chinensis* Linn. (Bruchidae: Coleoptera)

Distribution: It is a pest of pulses both in the field at the time of harvest and in storage

Nature of damage: Affected grains show emergence holes of beetles as well as minute white eggs adhering to the seed coat. The beetle is small, dark brown and rounded abruptly posteriorly. White, elongate eggs are laid on the pulse. The grubs feed on the inner contents of pulses, pupate inside them and emerge out by cutting circular holes in the grains.

Life history: The egg, larval and pupal periods are respectively 3, 12 and 4 days. It causes appreciable damage to stored cowpea, bengalgram, greengram, blackgram, *Lab-lab niger*, etc. It also infests redgram and cowpea pods in the field.

9. Rice meal moth *Corcyra cephalonica* Stainton (Galleridae: Lepidoptera)

Distribution: This is a pest of milled rice, sorghum, maize and other millets in storage. Infestation results in loss of quality of stored grains. It is distributed all over India.

Nature of damage: The larvae web the grains together and feed from inside the web.

Life history: The adult moth is grayish brown in colour. The females are relatively big in size and can be recognized by the frontal projection observed at the anterior side of the head. Males outlive the females. Each female lays on an average 100 - 200 oval, creamy white, coloured eggs. Incubation period is about 4 - 5 days and the larval period varies between 20 - 30 days. The pre-pupal and pupal period range between 10

- 12 days. The larvae are dirty white in colour and they web the grains together and feed from inside. They pupate in silken cocoons.

10. Angoumois grain moth *Sitotroga cerealella* Oliv. (Gelechiidae: Lepidoptera)

Distribution: It has worldwide distribution. It inflicts severe damage to unhusked paddy. It also attacks wheat, barley, maize and sorghum.

Nature of damage: It attacks ripening grains in the standing crop and the grains in storage. The caterpillars feed on the internal contents of grains and pupate inside the grains.

Life history: The moths mate immediately after emergence. The female lays eggs singly or in clumps on the grain. A female can lay up to 200 eggs during a life span of 5 – 10 days. The larva upon hatching bore into a grain and completes its development entirely within a single grain. At 30ºC and 80% R.H. the larval development is completed in about 19 days and the pupal stage lasts about 5 days and the total life cycle is completed in about 28 days.

Management strategies for insect pests of stored products:

I Preventive methods

(i) Before stacking the grains, the godowns, store rooms or receptacle should be cleaned and made free from insects. Disinfestation is done by fumigation.
(ii) The material to be stored should be cleaned and dried well in the sun to remove excess moisture in the grain and to bring it down below the optimum level (less than 10%).
(iii) The bags or bins can be made damp proof by providing dunnage of bamboo poles or bamboo matting or wooden crates.
(iv) The bags should be sacked in such a way as to allow proper ventilation and sufficient moving space for periodical inspection.
(v) Malathion @ 15ml of 50% EC/4.5 litres of water may be sprayed as a thin film on bags and about 3 litres of the spray solution may be necessary for 100 sq. m.
(vi) The incoming new arrivals should not be stored along with old or infested stocks in the godowns.

II Curative Methods

(i) The stocks of grains should be periodically examined and if insects are noticed to appear the stock should be removed, sundried and cleaned.
(ii) Heavily infested material should be fumigated with phosphine or hydrogen phosphide, phosphine. Phosphine is generated from 3 g tablets containing aluminum phosphide and ammonium carbamate and the commercial product is used at 1 tablet / tonne for the control of major pests and ½ tablet/tone for minor pests, the exposure period being 6 days. The tablets are placed in between the bags and entire stock covered with rubberized cloth cover and mud applied along the edges to make it air tight.
(iii) Seed material may be mixed with insecticides like carbaryl or Malathion at 1: 200 by weight and the treatment may keep the stock insect free for one year.

XVI. Polyphagous Pests

A. Locust (Acrididae: Orthoptera)

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

Distribution: Certain species of short-horned grasshoppers have acquired the name 'locust' mainly because at certain times they breed in large numbers and form huge congregations and then fly about in swarms of immense magnitude invading and devastating vast areas in distant regions up to hundreds and thousands of miles away from the place of their origin. The summer-breeding regions of locusts receive monsoon rains and extend from the south of Sahara, Libya and Egypt in Africa through southern Arabia and Pakistan to north-west India; the spring-breeding regions, on the other hand, receive winter rainfall and extend from the northern belt of Africa and Arabia through Iran up to Baluchistan. In all, eleven species or sub-species of grasshoppers have acquired the name 'locust' in different countries of the world. Three of these species occur in India. These are the Desert Locust (*Schistocerca gregaria* Forskal), the Migratory Locust (*Locusta migratoria* L.) and the Bombay Locust (***Patanga*** *succincta* (Linnaeus). The desert locust *Schistocerca gregaria* is the most destructive of them. The swarms that form due to breeding in West Iran and Eastern Arabia during winter-spring migrate during May – July to Indo-Pakistan region. The Bombay locust *Patanga succincta* (L.) is known from India, Sri Lanka and Malaysia. The migratory locust, Locusta *migratoria* Linn. breeds during the spring in Baluchistan and the adults migrate to desert areas of India and breed there during the summer.

Nature of damage: Under favourable conditions locust form swarms and migrates in millions from country to country or from place to place. Such swarms on their way settle on green vegetation and destroy them in short time. The Desert Locust has been causing greatest havoc, particularly in the Indian subcontinent.

Life history: The Desert Locust exists in two distinct phases, namely, *solitary* phase during the periods of recession and *gregarious phase* during the periods of outbreak and that it gets transformed from one into the other through the *transiens* phase. The same species of locust in these three phases behaves and looks so different that in the past the different phases were considered to be different species; even the body-structure differs significantly in different phases. During recession periods, the Desert Locust lives in its solitary phase and breeds like ordinary grasshoppers in certain desert and semi-desert areas and the breeding is scattered in patches. Later on, when the conditions are favourable, there is a definite phase transformation from solitary to gregarious. Breeding becomes concentrated and the progeny develop a tendency for gregarious existence with an urge for long-distance migration. This change in behaviour is also accompanied by certain morphological and physiological changes. Also the colour of the body is different in the two phases, both in the younger stages and in the case of adults.

According to the Biotic theory of the periodicity of locust cycles, the periodic locust outbreaks have been following periods of climatic extremes which annihilate the enemies particularly, the vertebrate predators, of the locust in desert and semi-desert regions where this species lives in its solitary phase during periods of recession.

Locust-breeding takes place in more or less transitional areas between the desert and semi desert regions.

The full life history of an individual locust consists of the egg-stage, the hopper stage and the adult stage. The eggs are laid in batches of up to 150 or more, deposited in soil at depths of 8 to 15 cms. The female locust is able to deposit its eggs so deep in the soil by thrusting and extending the hind end of its abdomen which allows much elongation for this purpose. Hence loose sandy soil is suitable for egg-laying. An individual egg looks like a grain of rice which is yellowish in colour, 7 - 8 mm in length and about one millimeter in girth. This egg stage lasts, subject to the prevailing temperature, for periods of about 1½ weeks to 4 weeks. At this stage a suitable amount of soil moisture is most essential for the proper development of eggs. If this prerequisite is provided by timely rainfall, the eggs hatch into what are called vermi-form larvae which wriggle their way out of the soil and, after casting off a kind of membranous covering in which they are enveloped, they enter the hopper stage of their life. From this stage onwards the colour, the structure and the behaviour depend on whether the locust is in its *solitary* phase, breeding in a scattered manner and in low population density or in its gregarious phase, and breeding in a concentrated manner and in high population density. However, the hopper stage lasts for about 3 - 10 weeks depending on the prevailing temperature and during this stage the individuals moult, i.e. cast off their skin several times. After the final moult as a hopper, the individual enters the adult stage and about 10 - 15 days thereafter reproduction starts. In the *solitary* phase, the hoppers are either green or acquire the colour of the vegetation they are in; they behave like ordinary grasshoppers and remain scattered and as adults they stay grey and fly mainly during the night and as individuals. In the gregarious phase, on the other hand, the hoppers exhibit a black colour pattern and march for long distances in definitive bands. When adults, they are pink while immature and yellow in the sexually mature stage; they fly in swarms during day.

Management strategies:

(i) *****Eggs had to be destroyed by mechanical means like digging out, ploughing or flooding the egg-infested land, etc.

(ii) Chemicals, such as chlorpyriphos, if sprayed or dusted as strip application on the egg-infested fields.

(iii). Mechanical destruction of locust hoppers by burning the whole congregation of hoppers with flame-throwers, driving the marching bands of hoppers into trenches made specially for burying them alive.

(iv). Poison-baiting using wheat bran moistened with enough water to make it crumby and treated with some stomach poison.

(v). Treating the crop with NSK extract @ 0.1 % to 0.5% was found to prevent damage by locust.

*** Organisations which are involved in the management of Locust at National and International level.**

1. Locust Warning Organisation (LWO)
2. Desert Locust Control Organization for Eastern Africa (DLCO-EA)
3. United Nations Special Desert Locust Project of FAO

2. Termite *Odontotermes obesus* Rhamb. (Termitidae: Isoptera)

Distribution: Termites or white ants are warmth loving insects and inhabit the entire tropical and subtropical regions of the world except higher altitudes where temperature are too low and the deserts where there is no food. They are polyphagous and have the widest range of host plants. They devour not only the live plant material but also the dead wood. This species of termite is common in India found attacking wheat and barley under rainfed conditions in North India and attacks sugarcane, maize, millets and also a number of tree crops.

Nature of damage: Termites attack wheat and barley from the time of sowing onwards and the damage is severe in sandy and sandy-loam soils. It can not thrive under conditions of bad aeration and poor drainage. The infestation of termites in sugarcane commences with planting of setts. In sugarcane, the termites damage the cut ends and buds of setts affecting their germination to the extent of 28 - 67% resulting in gaps in the field. Setts are completely eaten away leaving only the outer hard rind. In the attacked plants the outer leaves first show signs of drying and attacked canes may come off easily if pulled. The damage may vary from 40 - 50%. The internal part of millable canes are eaten away up to sixth internode and filled with earth. Termites attack results in heavy loss in yield of cane (2.5% in tonnage) and also in sugar production by 4.47 %. The crop raised in light soils suffers to a greater extent, particularly under drought conditions. Two other species *O. bengalensis* Holm. and *Trinervitermes biformis* Wass are also known to infest sugarcane in India.

Termites also appear and cause havoc in orchards that have been raised on virgin lands. The insects are heliphobic and either remains underground and feed on roots and then move upwards making the trunks completely hollow or they construct mud galleries on tree trunks. The damage is more severe in nurseries and young newly planted orchards where the entire seedlings or saplings may dry and die away. Formation of earthen galleries on tree trunks decreases with rise in temperature from March onwards and it again increases from September onwards.

Life history: The organization of the termite colonies in general is based on such a rigid system of division of labour. These different functionaries constitute well-defined castes like the soldier caste, the worker caste, the reproductive caste and the royalty. The royalty exclusively retains to itself the sole function of reproduction and the queen is the mother of the whole colony. The queen is the largest individual, the size of which at times exceeds five centimeters in length and one centimeter in thickness due to the enlargement of the abdomen which is full of eggs. The rest of the colony consists of the king, the functional consort of the queen, three sub-castes of fertile reproductives and two sterile castes of workers and soldiers. There are generally three types of reproductives (a) the *macropterous* ones which have fully developed membranous wings, comparatively larger brains and eyes and the full compliment of normal reproductive organs, (b) *brachypterous* ones with rudimentary wing pads, and (c) *apterous* ones with no trace of wings at all. The sterile castes the workers, which constitute the main labour force of the colony, have undergone reduction in brain and eye development. Their mouth-parts, which are used as the working tools for all types of odd jobs, are fairly strong although much less developed than in the soldier caste. The mouthparts of the soldier caste are used for very active defense and offence, for giving a tough fight to the enemy. The mandibles are very

large, projecting and shaped for a variety of uses. In some species of termites, there is a special rostrum projecting out from the head region and an offensive secretion from a special gland is ejected out from the top of the rostrum; this represent the evolution of chemical warfare even in such structurally primitive insects; soldiers possessing this organ are called Nasute soldiers. Winged sexual forms appear with the first shower of monsoon. The mating takes place either up in the air or on the ground and soon after mating the insects lose their wings, re-enter the soil and start a new colony. To start with the couple takes all the care of tending and feeding the young ones but once a sufficient number of workers are thus reared up they relieve the founder couple of all kinds of labour and begin in turn to tend their parents as royal dignitaries. They grow and maintain almost pure crops of certain varieties of fungus which are called fungus gardens. The Queen lays one egg every 2 - 3 seconds continuously during her entire life span of 7 - 10 years.

Management strategies:

(i). Destroy termitaria (termite mounds) in the vicinity of fields and treat the spot with sprays. This should be practiced on community basis in villages/farms.

(ii). Use only well rotten manure, otherwise termite incidence is aggravated.

(iii). Treat the seeds of wheat or barley with chlorpyriphos or endosulfan or imidacloprid using, respectively, 90 and 240 ml and 10 ga. i. with 5 litres of water and spraying over one quintal seed spread on floor and periodically turned over to ensure proper treatment. This should be done 1 - 2 days before sowing. For sowings in fields having previous history of termite incidence, this operation should invariably be undertaken.

(iv). In case preventive seed treatment for termites has not been undertaken before sowing and termite incidence is noticed in standing crop of wheat or barley, mix 0.8 liter chlorpyriphos with 50 kg sand and broadcast in one hectare field. This treatment is not as effective as seed treatment but appreciable reduction in termite damage could be achieved.

(v) Subterranian termites can be controlled by destroying queen either by digging it out or dropping aluminium phosphide tablets inside the termetorium @ 2 tabs/termetorium of 1m dia or pouring chlorpyriphos 20 EC diluted @60 ml/18 litre of water.

XVII. Rodents as Pests

Of the near about 136 species of rodents in India only about 16 can be considered economically important; this may be because very little is known of many species. Of the rodents that live with man, commonly called commensals, the mole rat (*Bandicota bengalensis*), the house rat (*Rattus rattus*), the brown rat (*Rattus norvegicus*), the house mouse (*Mus musculus*), the grass rat (*Millardia meltada* (Gray) and the bandicoot rat (*Bandicota indica*) are very important economically because of the damage to stored food supplies, besides serving as reservoirs for some important human diseases as plague, murine typhus, leptospirosis, food-poisoning etc. These animals also live in the field and take their toll of field crops along with the other rodents commonly considered field rats and mice such as the gerbils (*Tatera indica*, *Meriones hurrianae* and *Gerbillus gleadowi*), short-tailed bandicoot (*Nesokia indica*) and field mice (*Mus platythrix* and *M. booduga*).

1. Mole rat, Bandicota *bengalensis*:

It is the most destructive pest of field crops and is distributed throughout India except the extreme arid zones. This species is largely responsible for colossal losses in wheat, rice, sugarcane, groundnut and mustard. It hoards in its burrows about 5 times the amount of food it eats. It is nocturnal and keeps its burrow plugged with a characteristic soil molehill at burrow openings. It is dark grayish brown in colour with a grayish white belly and a bare tail; head and body 15 - 23cm and tail 15 - 18 cm long. It makes large ramifying burrows in soil extending to a depth of 1 - 1.5 m and laterally 9 - 12 m; the burrow along its course is provided with many walls or earthen blocks for protection. There are 4 - 5 openings for the burrow; the entrances are protected by heaps of excavated soil. Separate chambers for bed, breeding and food storage are provided in the burrow. The rat reproduces thrice a year synchronizing with rice harvests. The number of young produced per litter varies from 2 - 18 depending upon the food supply. In rice it appears late in the cropping season and damages the crop most severely. In shot blade stage, it cuts tillers and the affected area is seen as circular patches in a field. The rat revisits the same area next night and spread the damage. It cuts earheads and carries to its burrow and in a burrow up to 2 kg of hoarded grains can be noticed.

2. Soft furred (Field rat or Grass rat), *Rattus (Millardia) meltada* (Gray)

It is a medium sized rodent and ranks second in damage to different field crops. It is mainly a pest of irrigated cropping system. It is also nocturnal but makes simple burrows. It is smaller in size, dark brownish gray above and pale gray below with soft fur. Head and body is about 13 cm long and tail 10 cm long. The burrows of the grass rat are similar to that of the mole rate excepting that they are smaller in length and diameter and that usually more than one adult rat occupies a single burrow. One to 12 young are produced per litter. It breeds throughout the year with peak from March-May and July-October in North India. It attacks rice in all stages and feeds upon young germinating grains, cuts and feeds on tender seedlings and also grown up plants in the shot-blade stage. It damages green cotton bolls in black cotton soils.

3. Indian gerbil rat *Tatera indica* H.

It is reddish gray in colour with white underside and it equals the common house rat in size with about 18 cm long head and body and a hairy tail little longer than the head and body. It generally feeds on grains, grass, roots and fruits. This species is also widely distributed. It is nocturnal and inhabits burrows of simple patterns. Although it breeds round the year but peak breeding takes place during monsoon in north and October - November in South India. Litter size varies from 1 - 10.

4. Desert gerbils, *Meriones hurrianae*

It is distributed in arid tracts of Rajasthan, parts of Punjab, Haryana, and northern Gujarat. It is a predominant rodent pest of pulses and oilseeds in western Rajasthan. It is a diurnal rodent and makes extensive burrow systems. It shares its habitat with *T. indica* and causes extensive damage to young plants. Peak breeding activity is observed during February – March and July – September. The litter size varies from 1 to 9.

5. Short tailed mole rats, *Nesokia indica*

The distribution of the short tailed mole rat is restricted to Punjab, Haryana, Rajasthan, Delhi and Uttar Pradesh. It inhabits cultivated crop fields and canal bunds. It is nocturnal and keeps its burrow openings closed. It breeds from January to March and August to November with a litter size of 2 – 6.

6. Indian field mouse, *Mus booduga* (Gray)

It is about 5 to 8 cm long with 5 cm long tail. It is brown in colour with a white belly. It burrows in field bunds causing extensive damage to bunds and wastage of water. *M. booduga* is number two rodent pests in rice and pulses. It breeds round the year with a litter size of 2 – 15. It cuts and removes grains from rice crop.

7. Common house rat, *Rattus rattus wroughtoni* H.

It is reddish or yellowish brown with a pure white belly. It is destructive to tender coconuts. It lives and breeds inside nests specially constructed in the crowns of the palms. In closely planted gardens it can jump from palm to palm. It bites holes through the husk and drinks the sweet liquid; spoilt nuts fall down in large numbers. The common house rat *R. rattus rufescens* Gray is brownish gray with a dark undersurface and feed on all kinds of vegetable and animal food. It lives in roofs of houses and underground burrows. Its damage is great in warehouses and storage godowns.

Management strategies:

Since rodents are highly evolved mammals, trap avoidance, bait shyness/aversion towards rodenticides, resistance/cross resistance to anticoagulants etc., are few issues that need to be addressed while developing their management strategies.

(i) **Habitat manipulation:**
It is primarily based on ecological concepts wherein the rodents' habitat is manipulated in such a way that creates stress among native rodent pests. The methods are low cost treatments that involve little modification in crop husbandry practices, like deep ploughing, removal of wild vegetation and refuge of previous crops and reduction in bund size.

(ii) **Mechanical control:**
Mechanical removal of rodent's population from any habitat is mainly done by use of different types of traps. Trapping is in vogue all over the world, but its success in large scale field rodent control may not be economical. It can no doubt provide, the information on species composition and density of pest population, hence serves as an excellent diagnostic tool for survey and monitoring. Besides it is recommended as a follow up measure after poison baiting. Introduction of natural glues or sticky traps have opened new avenues in the field.

(iii) **Chemical control**

(a) Using Anti-fertility agents:

A host of chemicals with antifertility effect had been identified world over. Some of these are aniestrogen V-II, diphenylndane derivatives, metepa, tepa, furadentin, colchicines etc. Such chemicals seem to possess a bright future because of their compatibility with toxic rodenticides and are also less controversial from human/animal rights viewpoint.

(b) Rodenticides:

Among the seven registered rodenticides, zinc phosphide, aluminium phosphide, bromadiolone and coumatetralyl are most common. Zinc phosphide, an acute rodenticide is most widely used and recommended at 2% concentration in cereal baits. One part of zinc phosphide is mixed with 19 parts of bait material such as popped corn or rice, or dry fish and kept in convenient places after one or two nights of pre-baiting without the poison. Warfarin is a first generation anticoagulant used in baits as 0.025% or 0.5% concentrate bait. Animal has to feed on the poison at least for 4 to 5 times to cause affective mortality.

Among second generation anticoagulants several molecules *viz*., bromadiolone, brodifacoum, flocoumafen and difethialone, 2000, have shown their potency. Bromadiolone is a coumarin anticoagulant used as 0.25% concentrate bait. This is single dose anticoagulant rodenticides. Coumachlor is also a single dose anticoagulant used as 0.5% concentrate bait. Coumatetralyl, a multi dose anticoagulant is used in cereal mixed baits at 0.0375% for indoor habitats. It has also been recommended for field use against *B. bengalensis* in Punjab. These anticoagulants are highly effective at very small concentrations in baits (0.0025 - 0.005%).

Suggested Readings

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