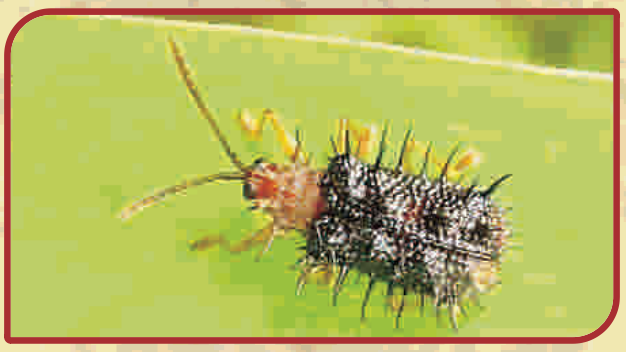
E- COMPENDIUM CUM MANUAL

Ento. 311

(Pests of Kharif Crops, their Management and IPM Concept)



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2020

Department of Entomology

Rajasthan College of Agriculture MPUAT,

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CONTENTS

DECLARATION

The E-compendium-cum-manual is designed according to the course no. Ento. 311 (Pests of Kharif Crops, their Management and IPM Concept) offered in undergraduate degree programme for students of B.Sc. Agri., Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur. The content in this document is prepared with the help of various textbooks, resource materials and various sources available online ICAR, TNAU, *etc*. The authors do not claim for the originality of the work. This E-compendium-cum-manual is meant to be used as a reference material for undergraduate degree programme, RCA, MPUAT for fulfilling the academic purpose of understanding the course.

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Syllabus

ENTO 311 PESTS OF KHARIF CROPS, THEIR MANAGEMENT AND IPM CONCEPT **CREDIT HOURS 2 (1+1)**

Theory:

General account on nature and type of damage by different arthropods pests. Scientific name, order, family, host range, distribution, nature of damage, and management of major pests of various field crop, vegetable crop, fruit crop, plantation crops, ornamental crops, spices and condiments during *kharif.*

Categories of pests. Concept of IPM, Practices, scope and limitations of IPM. Classification of insecticides, toxicity of insecticides and formulations of insecticides. Chemical control-importance, hazards and limitations. Recent methods of pest control, repellents, antifeedants, hormones, attractants, gamma radiation. Insecticides Act 1968-Important provisions. Application techniques of spray fluids. Symptoms of poisoning, first aid and antidotes.

Practical:

Identification of different types of damage. Identification and study of life cycle and seasonal history of various insect pests attacking crops and their produce: (a) Field Crops; (b) Vegetable Crops; (c) Fruit Crops; (d) Spices & condiments during *kharif.* Assessment of losses due to insects. Calculations on the doses of insecticide application technique.

Suggested Readings:

1. David BV and Ramamurthy VV. 2016. *Elements of Economic Entomology.* 8th Edn. Brillion Publ., New Delhi.
2. Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology.* Kalyani Publ., New Delhi.
3. Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects.* Kalyani Publ., New Delhi
4. Evans JW. 2005. *Insect Pests and their Control.* Asiatic Publ., New Delhi.
5. Nair MRGK. 1986. *Insect and Mites of Crops in India.* ICAR, New Delhi.
6. Atwal AS & Dhaliwal GS. 2002. *Agricultural Pests of South Asia and their Management.* Kalyani Publ., New Delhi.
7. Pedigo LP. 2008. *Entomology and Pest Management.* Phi Learning Publisher.

1. INSECT PEST OF CEREALS

Sorghum, Maize and Wheat

Sorghum shoot fly – *Atherigona soccata* Rondani ()

Order – Diptera **Family** – Muscidae

1. **Distribution:** Distributed in Europe, Africa, Asia and India. In India it is more serious in southern part.

2. **Host plants:** Sorghum, Maize, Wheat, broom Cora, small millets and grasses.

3. **Marks of Identification:** Egg elongate, flattened, and somewhat boat-shaped and provided with two wing like projections. Adult is smaller than house fly.

4. **Life cycle:** Female fly lays approximately 40 eggs singly on underside of the leaves during life span of one month. Egg hatch in 1-2 days. Larval period 6-10 days. Pupation takes place inside the stem or in the soil. Pupal period is of one week. Several generations in a year.

5. **Nature and Symptoms of damage:** Maggots bore into stem and cut the main shoot. It causes damage to seedlings as well as the early stage of the crop. High-yielding hybrids are more susceptible to shootfly. Insect attacks the young crop when it is in six leaf stage. Maggots reach in between the sheath & axis and bore into stem. After reaching the soil level, the maggot bores inside the stem and cuts the growing point resulting in “dead heart” symptom and infested plant produces side tillers.

Adult

Egg

Dead heart

Record Work: Write down the IPM practices for the management of Sorghum shoot fly (*Atherigona soccata*) infesting soughum crop.

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Maize stem borer – *Chilo partellus* (Swinhoe)

Order – Lepidoptera **Family –** Crambidae

1. **Distribution:** Pest found in Srilanka, India, Pakistan, Afganistan, Uganda, Central & East Africa. It is found throughout India.

2. **Host Plants:** Maize, Bajra, sugarcane, sudan grass, Baru, Sarkanda, Sarkanda and some grasses.

3. **Identification:** Caterpillars are dirty grayish white, with black head and four brownish longitudinal strips on the back and 20-25 mm long. Adults are yellowish grey moths and 25 mm across wings spread.

4. **Life cycle:** Insect breeds from March to October and for rest of year in hibernation as full grown larva in stubble, stalks or unshelled cobs. Larvae pupate in March and moths emerge in end of March or in early April. Moths lay eggs on the underside of leaves. Eggs flat, oval, yellow laid in overlapping clusters each of upto 20 eggs. Female lays 300 eggs. Adult life is 2-12 days, hatching in 4 to 5 days. Larval period is 14 to 28 days. Pupation takes place in stem. Life cycle completed in 3 weeks and there are 5 generations in a year.

5. **Nature & Symptoms of Damage:** Its caterpillars bore into stems and cobs. Young larvae first feed on leaves making a few shot holes then bore down wards through central whorl & cut main shoot. Plant shows dead-hearts.

Record Work: Write down the IPM practices for the management of (Maize stem borer – *Chilo partellus*) infesting maize crop.

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Fall armyworm- *Spodoptera frugiperda* (J.E. Smith)

Order – Lepidoptera **Family – Noctuidae**

1. **Distribution:** It is widely distributed in Eastern and Central North America and South America, China , Australia Africa since 2016. In 2018, it began to spread widely in India.

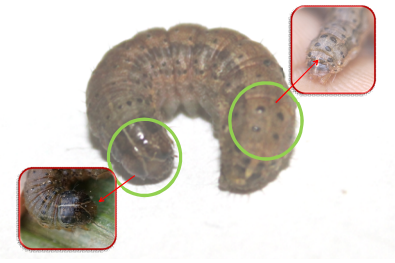
2. **Host Plants:** It has very wide host range, with over 80 plants recorded, but clearly prefers grasses. Field crops are frequently injured, including field corn, sweet corn, sorghum, Bermuda grass, buckwheat, cotton, clover, corn, oat, millet, peanut, rice, ryegrass, sorghum, sugarbeet, Sudangrass, soybean, sugarcane etc. Other crops sometimes injured are apple, grape, orange, papaya, peach, strawberry and a number of flowers.

3. **Identification:** Eggs are covered in protective scales rubbed off from the moths abdomen and change from green to light brown before hatching. Caterpillars change from light green to brown. Fall armyworms caterpillars have a dark head with a pale, upside-down Y-shape on the front. The pupa is shiny brown and usually found 2-8 cm into the soil. The moths have a wingspan of 32 to 40 mm. In the male moth, the

forewing generally is shaded gray and brown, with triangular white spots at the tip and near the center of the wing. The forewings of females are less distinctly marked, ranging from a uniform grayish brown to a fine mottling of gray and brown. The hind wing is iridescent silver-white with a narrow dark border in both sexes. Adults are nocturnal, and are most active during warm, humid evenings.

4. **Life cycle:** The life cycle is completed in about 30 days during the summer, but 60 days in the spring and autumn, and 80 to 90 days during the winter. After a pre-oviposition period of three to four days, the female normally deposits most of her eggs during the first four to five days of life, but sometimes oviposition occurs for up to three weeks. Duration of adult life is estimated to average about 10 days, with a range of about seven to 21 days. Eggs hatch mostly in 2-3 days. There are 6 stages of larvae and larval period is 3-4 days. Pupation normally takes place in the soil, at a depth 2 to 8 cm or cocoon on soil surface. Duration of the pupal stage is about eight to nine days in summer but reaches 20 to 30 days during the winter.

5. **Nature & Symptoms of Damage:** Larvae cause damage by consuming foliage. Young larvae initially consume leaf tissue from one side, leaving the opposite epidermal layer intact. Second or third instar larvae begin to make holes in leaves, and eat from the edge of the leaves inward. Older larvae cause extensive defoliation, often leaving only the ribs and stalks of corn plants, or a ragged, torn appearance. Larvae also will burrow into the growing point (bud, whorl, etc.), destroying the growth potential of plants, or clipping the leaves. In corn, they sometimes burrow into the ear, feeding on kernels in the same manner as corn earworm.



Record Work: Write down the IPM practices for the management of Fall armyworm (*Spodoptera frugiperda*) infesting maize crop.

Armyworm – *Mythimna separata* (Walker)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** The armyworm is a pest of graminaceous crops all over the world. In India it is a sporadic pest of many crops throughout the country.

2. **Host plants:** Wheat, sugarcane, maize, jawar, bajra and other graminaceous crops.

3. **Marks of Identification:** The adult moths of armyworm are pale brown. The eggs are round, light green, when freshly laid and turn pale yellow and finally black. The larvae are very active, dull white and later turn green.

4. **Life cycle:** Adult moths live for 1 to 9 days and lay eggs singly in rows or in clusters on dry or fresh plants or on the soil. In Punjab eggs hatch in 4-11 days from March-May and in 19 days in December-January. In spring season larval period is 13-14 days but in winter it is 88 to 100 days. Pre-pupal period is 1-11 days during January to May. Pupation takes place in soil but also occur under dry leaves among stubble or fresh litters. Pupal period is 9 to 13 days in May and 36 to 48 days in winter moths. The survival of pupae depends on soil moisture. The maximum population of caterpillars found on wheat in March. The population build-up starts in beginning of March and increases with rise of temperature in spring season.

5. **Nature & Symptoms of damage:** In the early stage caterpillars feed on tender leaves in the central whorl of plant. As grow they are able to feed on older leaves and skeletonize them totaly. In sever attack of armyworm whole leaves, including the mid-rib, are consumed and field looks as grazed by cattle. The pest also eat away ears, with awns and immature grains.

Record Work: Write down the IPM practices for the management of insect pests infesting wheat crop.

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PADDY

Brown plant hopper – *Nilaparvata lugens* (Stal)

Order – Hemiptera **Family** – Delphacidae

1. **Distribution:** South-east Asia, China, Japan and Korea. In India, U.P. M.P., W.B., A.P. and Tamil Nadu.

2. **Host plants:** Paddy, Sugarcane & grasses.

3. **Marks of Identification:** Adults brownish with brown eyes and 3.5 to 4.5 mm long. Legs light brown, tarsal claw black. Nymphs brownish-black with greyish-blue eyes.

4. **Life cycle:** Pest breeds on paddy round the year. Maximum population reach during October to February. In North India population becomes high during September-October. Adult active at 10 to 32°C. Female start eggs laying 3 to 10 days after emergence. Eggs are deposited in masses by lacerating the parenchymal tissue. Eggs per mass 2 to 11 Female lays average 124 egg-masses. Eggs dark cylindrical & incubation period is 4 to 8 days. Nymph become adult in 2-3 weeks by 5 moulting. Life cycle in South India 18-24 days June to October, 33-44 days during November to January, and 18-35 days February-April.

5. **Nature & Symptoms of Damage:** Both nymphs & adults cause damage by sucking cell sap, yellow leaves, early attack plant dry up, poor tillering, decrease plant height.

Yellow stem borer of rice – *Scirpophaga incertulas* (Walker)

Order – Lepidoptera **Family** – Pyraustidae

1. **Distribution:** Pest found in all Asian countries

2. **Host plants:** Rice

3. **Marks of Identification:** Female moth has bright yellowish brown fore wings with a black spot on each and an anal tuft of yellow hairs. Male moth is smaller with pale yellow forewing and without spots.

   Larva: The newly hatched larva is pale white with dark brown head and prothoracic shield. Larva move down after wandering on leaf blade for one or two hours. Larva hang down by a silken thread and get blown off to adjoining plant or larva may fall on water and swim freely till it get to rice plant.

4. **Life cycle:** Egg – Female lays 15-80 eggs (2 to 3 egg masses) near tip on the upper surface of tender leaf blade early at night. Eggs cover with tuff coloured hairs and scales derived from anal tuft.

   Incubation period is 5 to 8 days. Larval period is 33 to 41 days and larva is 20 mm long. Pupal period is 6 to 10 days and pupa is 12 mm long. Entire life cycle is completed in 50 to 70 days. Female to male ratio 2:1 and 3 to 5 broods in a year.

5. N**ature and Symptoms of damage:** The larvae feeds inside the stem causing drying of the central shoot or dead heart in young plant and drying of the panicle or white ear in older plant. It attacks only rice plants/crop and serious on it during October to January. Larva enters the leaf sheath and feeds for 2-3 days and bores inside stem near nodal region. Usually one larva inside stem but occasionally 2 to 4 larvae noticed.

Rice hispa – *Dicladispa armigera* (Olivier)

Order – Coleoptera **Family –** Chrysomelidae

1. **Distribution:** The pest is distributed throughout India. In Punjab & H.P. cause damage by larva & adult both.

2. **Host Plants:** Paddy

3. **Nature & Symptoms of damage:** After hatching grubs feed inside leaves in between upper & lower epidermis. Leaves show blisters or blotches and become membranous. Leaves wither and die in heavy attack. Larvae feed inside leaves and adults feed green matter and cause streaks on leaves.

4. **Marks of Identification:** Adult beetle is small bluish black and 5mm long. Adult beetles having spines on the body. Larvae legless creamy-white concealed inside leaf tissue.

5. **Life cycle:** Pest breeds from May to October and hibernate in adult stage during winter. Eggs embedded in leaf tissue towards tip. Pupate inside leaf tissue and emerged black beetles. In Bihar 6 generations in a year. In Punjab 2-3 generation in paddy season.

Nilaparvata lugens

Dicladispa armigera

Scirpophaga incertulas

Record Work: Write down the IPM practices for the management of insect pests infesting paddy.

2. INSECT PEST OF SUGARCANE

Sugarcane Root borer – *Emmalocera depressella* Swinhoe

Order – Lepidoptera **Family** – Pyralidae / Pyraustidae

1. **Distribution:** Pest is serious in Eastern India, Pakistan, Haryana and Punjab.
2. **Host Plants:** Sugarcane, Sarkanda, Baru, Napier grass.
3. **Marks of Identification:** Full grown caterpillar measures about 30 mm long, creamy white with yellowish-brown head and a rather wrinkled body. Moths are pale yellow brown and have white hindwings & 30-35 mm wing span.
4. **Life cycle:** Pest is active from April to October and pass winter as full grow larvae within stubble. Some time pupate in March and moth emerge in 2-3 weeks. Adult life is 5-7 days. Female lays 277 to 355 scale-like creamy white eggs singly on leaves, stems or on ground. Egg hatch in 5-8 days, young larvae bore into stem below the soil surface. Life cycle of larvae is through 5 instar (stages) in four weeks. Pupate inside canes by making emergence wholes just above soil surface. Pupal stage is 9-14 days. Life cycle is 6-7 weeks. Four generations in a year.
5. **Nature & Symptoms of damage:** During feeding they cut right across the stem and reach to adjoining tillers. Central leaves of attacked plant dry and form 'dead hearts' before cane forming stage. Dead hearts are not easily pulled out. This pest is primarily destructive to young plants and attack is severe from April to June. Plants attacked after cane formation are not killed but weight and sugar content are reduced and decrease yield.

Sugarcane shoot borer – *Chilo infuscatellus* Snellen

Order – Lepidoptera **Family** – Pyralidae

1. **Distribution:** India, Pakistan, Afghanistan, Myanmar, Indonesia, Formosa and Philippines. In Punjab serious infestation from April to June.
2. **Host Plants:** Sugarcane, Maize, Bajra, Sarkanda, Kahi, Baru and other grasses.
3. **Marks of Identification:** Caterpillars dirty white with five light longitudinal stripes on body. Moths have straw coloured forewings & whitish hind wings with light buff apical area. Attract to light at night & wing span is 25-40 mm.
4. **Life Cycle:** Pest is active from March to November and passes winter as a full-grown larva in stubble. Some time larvae pupate in February and Moths emerge in March. Moths active at night. Female lays creamy white scale like eggs in clusters of 11-36 eggs on lower surface of leaves. Female lays 300-400 eggs. Hatching period is 4-5 days. Larvae grow in 5 stages & complete development in 3-4 weeks. Each larva constructs chamber in cane for pupation and make exit hole and emerges moth after 6-7 days. Adult life is 2-4 days. Life cycle completed in 5-6 weeks & 4-5 generation in a year.

5. **Nature & Symptoms of damage:** After hatching larvae reach to plant base, bore into shoot and feed there. The plant attacked by this pest at young shoot stage produce dead hearts from April to June & completely dry up. The attack is after cane formation then there is no dead heart and damage is confined to few internodes only and reduced yield.

Pyrilla or Sugarcane leafhopper – *Pyrilla perpusilla* (Walker)

Order – Hemiptera **Family** – Lophopidae

1. **Distribution:** Throughout India and Pakistan. In Punjab, Haryana and Rajasthan appears periodically as destructive pest of sugarcane.

2. **Host Plants:** Sugarcane, Wheat, Barley, oats maize, sorghum, baru, Guinea grass, Swank and Sudan grass.

3. **Marks of Identification:** Nymph is pale yellow has two white feather like filaments at tail end of body. Leafhopper is very agile and jumps around & make faint noise when person walks in field and 10-15 mm long. Adult is 20 mm long and equally active as nymph has straw-coloured body, dark patches or spots on wings. Front end has snout like prolongation and prominent red eyes.

4. **Life Cycle:** Adult females lay 300 to 536 eggs in clusters on underside of leaves in summer and within leaf sheaths in winter. Egg clusters covered with white fluffy material of anal tufts of female. Under fluff oval, pale-white eggs in 3-5 longitudinal rows 35-50 each. Hatching in 8-10 days in summer and 3-4 week in November or December. At the time of hatching nymph pale brown 1.3 mm long and without snout, wings and tuft. After a week two long tufts of waxy secretion at end of abdomen. Become adult in 5 stages in 8 weeks in summer & in 5-6 months in winter. Adult live for 27 to 52 days in summer and 18 to 20 weeks in winter & 3-4 generations in a year.

5. **Nature & Symptoms of damage:** Nymphs start sucking sap of canes and grow in five stages. Succulent and broad leaves varieties preferred more but at severe infestation no variety spared. Due to loss of cell sap leaves turn pale yellow shriveled, canes dry up and die. Honeydew is excreted on leaves which caused black mould. Leaves become black reduce the photosynthesis.

   The sucrose in canes is used up or suck by pest and cane juice becomes high in glucose, gives rise to soggy mass and not solidify.

Sugarcane Whitefly – *Aleurolobus barodensis* (Maskell)

Order – Hemiptera **Family** – Aleyrodidae

1. **Distribution:** White fly of sugarcane is found throughout Indian sub-continent. It is notorious pest in Gurdaspur, Jalandhar and Yamunanagar districts of Punjab and Haryana.

2. **Host Plants:** Sugarcane, Sarkanda, Wheat, barley and grasses.

3. **Marks of Identification:** The grown up nymphs are oval in outline but flattened and scale like in form. They are black and silvery grey, waxy coating on body & 3mm long. Adults small delicate, pale yellow and 3 mm long, white mealy appearance on wings, mottles with black dots.

4. **Life Cycle:** Pest breeds throughout year, except during winter, remain as nymphs and pupae present. Winged adults appear in spring, copulate in end to end position for 30-40 seconds. Female lays 60-65 eggs. Eggs are creamy white conical and glued on leaves. Eggs in group of 15 to 20 in a single file. Eggs turn black and hatch in 8 to 10 days. Young nymphs are pale yellow, they move to find suitable feeding place by insertion of piercing mouthparts. Nymphal period is 25-30 days in 4 instars. Pupal period is 10-11 days. Adult life is 24 to 48 hours.

5. **Nature and Symptoms of Damage:** Only nymphs cause damage by sucking cell sap. Yellow streaks on attacked leaves & crop become polish green and vitality reduced. Quality and quantity of gur is poor due to subnormal crystalization of sugar. Black mold developed by honeydew and cause poor functioning of leaves. Leaves are unfit for fodder due to black mold.

Sugarcane mealy bug – *Saccharicoccus sacchari* (Cockerell)

Order – Hemiptera **Family** – Pseudococcidae

1. **Distribution:** In India, wherever the sugarcane is grown.

2. **Host Plants:** Sugarcane

3. **Marks of Identification:** Mealy bugs are inert pink insects, having round, sack like, segmented body covered with white mealy powder. Female 5 mm long & 2.5 mm in width. Eggs yellowish, smooth, cylindrical round at both end 0.35 mm long & 0.16 mm width.

4. **Life Cycle:** Mealy bugs breed throughout year. Females are highly fecund and lay large number of eggs in short interval. Eggs become soft and elongated and crawlers emerge they are transparent, pink and active. They remain and feed in leaf sheaths near basal nodes. As canes grow taller older bugs remain at lower end and crawlers reach higher nodes. Nymphs feed voraciously and nymphal period is 2-3 weeks in 6 stages. Female longevity is 3-5 days and entire life cycle is one mouth.

5. **Nature & Symptoms of Damage:** Nymphs and wingless female cause damage by sucking cell sap. Mealy bugs are first appeared when canes are four mouths old and remain on plants till harvest. Drought affected crop is more damaged. The mottling disease of sugarcane is caused by mealy bugs.

Sugarcane top borer – *Scirpophaga nivella* (Fabricius)

Order – Lepidoptera **Family** – Pyralidae

1. **Distribution:** In India, Pakistan, Myanmar, Sri Lanka, China, Formosa, Japan, Philippines and Thialand.

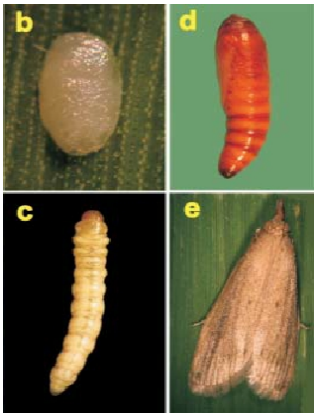
2. **Host plants:** Sugarcane, Sarkunda, kahi, and grasses.

3. **Marks of Identification:** Full-grown caterpillars are creamy white and sluggish and 25 to 30 mm long. Moths are pure white. Males are smaller than females. Females is 25-40 mm wing spread. Brownish or redish tuft of silken hairs on tip of abdomen.

4. **Life Cycle:** Pest active from March to November and passes winter as a full-grown larva in cane tops. Larvae pupate second half of February and Moths emerge in March. Females lay eggs on lower surface of leaves about 150 in clusters of 30-60 eggs &

covered with brown tuft of hairs. Egg hatch in 5-7 days. Larvae bore into midrib and go to the base, enter the spindle and feed on growing point of cane. Larval period is 4-5 weeks in 5 stages. Pupation in cane above node. Pupal period 7-9 days. Moth active at night. Adult life is 4-5 days.

5. **Nature & Symptoms of Damage:** First two broods of pest attack young plants before cane formation. These plants are killed and cause total loss. The subsequent broods attacks terminal portions of cane and cause bunchy tops. Loss in weight and sugar recovery.

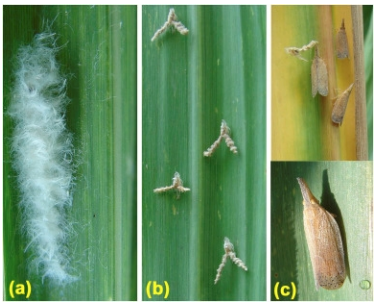


Emmalocera depressella

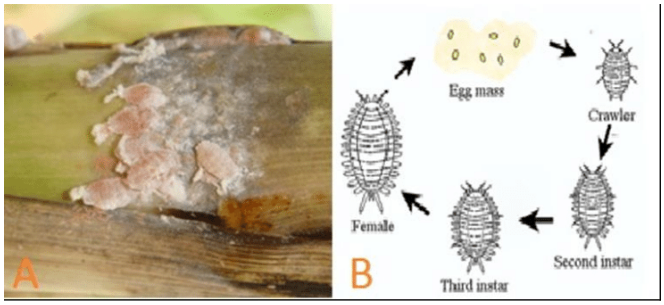
Aleurolobus barodensis

Scirpophaga nivella

Chilo infuscatellus



Pyrilla perpusilla



Saccharicoccus sacchari

Record Work: Write down the IPM practices for the management of insect pests infesting Sugarcane crop.

3. INSECT PEST OF FIBRE CROPS

Cotton

Cotton jassid: *Amarasca biguttula biguttula* (Ishida)

Order – Hemiptera **Family** – Cicadellidae

1. **Distribution:** The cotton jassid widely distributed in India and most destructive pest of American cotton (*Gossypium hirsutum* L.) in North-Western region.

2. **Host Plants:** Cotton, okra, potato, brinjal, hollyhock, kangi buti (*Abutilon indicus*).

3. **Marks of Identification:** Nymphs are wedge-shaped and very active. Adults are about 3mm long greenish yellow during summer and acquiring reddish tinge in winter.

4. **Life Cycle:** The jassids are breed throughout the year, but during the winter months only adults are found on host plants. Females lay about 15 yellowish eggs on under side of leaves, embedding them into leaf veins. Hatching period is 4 to 11 days. Nymphal period is 7 to 21 days through six stages. Adult life is 5-7 weeks and complete 7 generations in a year.

5. **Nature & Symptoms of Damage:** Damage to crop is caused by adults and nymphs both which are very agile and move briskly forward and sideways. Injury to plants is due to loss of cell sap and also due to injection of toxins. Attacked leaves turn pale and the rust-red. Leaves also turn down wards, dry up and fall on ground. Due to loss of plants vitality cotton bolls also drop off.

Cotton white fly – *Bemisia tabaci* (Gennadius)

Order – Hemiptera **Family** – Aleyrodidae

1. **Distribution:** Cotton whitefly is distributed throughout northern and western regions of Indian sub-continent.

2. **Host plants:** Cotton, cabbage, cauliflower, mustard, toria, melon, potato, brinjal, okra and weeds.

3. **Marks of Identification:** Nymphs are pale yellow, louse-like and clustered together on under surface of leaves and make stand out against green background. Winged stage 1.00 to 1.5 mm long and yellowish body slightly dusted with white waxy powder. They have two pairs of pure white wings.

4. **Life Cycle:** White fly of cotton breeds throughout the year and all developmental stages are found but adults are predominate in winter season. Females lay eggs singly on underside of leaves averaging 119 eggs per female. The eggs are stalk, sub-elliptical, light yellow and turning brown later on. Hatching period is 3-5 days in April-September, 5-17 days in October-November and 33 days in December-January. Nymphal period is 9-14 days during April-September and 17 to 81 days in October to March. Pupal period is 2-8 days. Complete life cycle in 14-122 days and 11 generations in a year.

5. **Nature & Symptoms of Damage:** The vitality of plant is lowered by loss of cell sap. The normal photosynthesis interfered due to growth of sooty mold on honeydew and excreted by white fly.

Cotton aphid – *Aphis gossypii* Glover

Order – Hemiptera **Family** – Aphididae

1. **Distribution:** Cotton aphid generally distributed throughout temperate, subtropic and tropic zones, the cotton aphid occurs in all cotton-producing area of the world.

2. **Host Plants:** It is potential pest of cotton, cucurbits, solanaceous vegetables, pulses, groundnuts, guava, citrus, coffee, cocoa, peppers, okra and many ornamental plants including *Hibiscus* spp.

3. **Marks of Identification:** Apterous (wingless) aphid is greenish brown soft bodied and measuring 0.9 to 1.8 mm (apterae) wingless. Adult alatae (winged) 1 to 1.8 mm long and colour of alatae is very variable dark green, black, pale yellow and white.

4. **Life Cycle:** Life cycle of *A. gossypii* is very complicated. It is polymorphic and adults of both apterae (wingless) and alatae (winged) viviparous and produce by parthenogenesis. Female deposits 80 to 100 nymphs (8-22 nymphs/day). Nymphs become adults in 7-9 days on cotton through 4 moults.

5. **Nature & Symptoms of Damage:** The nymphs and adults both suck the plant juice (Cell sap), deprive plants with nutrients and become weak. Severe infestation causes curling of leaves, stunted growth and gradual dry and death of young plants. Black sooty mould develops on honey dew of aphids on leaves and hamper photosynthetic ability of plants and cause blackening of cotton thread & reduce quality.

Red Cotton bug – *Dysdercus koenigii* (Fabricius)

Order – Hemiptera **Family** – Pyrrhocoridae

1. **Distribution:** This insect is widely distributed in India and a minor pest of cotton in Punjab and Uttar Pradesh.

2. **Host plants:** Cotton, okra, maize, pear millet, wheat, hollyhock, clovers.

3. **Mark of Identification:** The eggs are spherical, bright yellow and are laid in clusters or in loose irregular masses. The bugs are elongated slender insects, crimson red with white bands across the abdomen. Membranous portion of fore wings, antennae and scutellum is black.

4. **Life Cycle:** This pest is active throughout the year and passes winter in adult stage. In spring season bug become active and lays 100-130 eggs in moist soil or in crevices in ground. Spherical, bright yellow eggs laid in cluster or loose irregular masses of 70-80 eggs in each. Hatching period is 7-8 days. Young nymphs have flabby abdomen, in old age become slender and develop black markings on body.

5. **Nature & Symptoms of Damage:** Both adults and nymphs such cell-sap from leaves and green bolls of cotton. Heavily attacked bolls open badly and lint is of poorer quality. Seed produced may have low germination & less oil. When bugs crushed they stain lint by excreta or body juices. Staining of lint by growth of certain bacteria inside the bolls.

Dusky cotton bug – *Oxycarenus laetus* Kirby

Order – Hemiptera **Family** – Lygaeidae

1. **Distribution:** Dusky cotton bug is minor pest of cotton in India.
2. **Host plants:** Cotton, okra, hollyhock, and other malvaceous weeds.
3. **Marks of Identification:** Adults are 4-5 mm long, dark brown and have dirty white transparent wings. Young nymphs have rotund (round) abdomen as they grow older resemble the adults but smaller and have wing pads only.
4. **Life Cycle:** Dusky cotton bug is active throughout the year but in winter season only adults are found in unginned cotton. The cigar shaped eggs are laid in spring season on *Hibiscus* then on okra and finally on cotton during monsoon. Whitish eggs turn pale and finally light pink before hatching. The eggs laid in lint of half opened bolls singly or small clusters of 3-18 each. Hatching period is 5-10 days, nymphal period is 31 to 40 days through 7 moulting (stages). The complete life cycle in 36 to 50 day and many generations in a year.
5. **Nature and Symptoms of Damage:** Nymphs and adults suck the cell sap from immature seeds. These seeds may not ripen, lose colours remain light in weight. Adults and nymphs found in cotton are crushed during ginning and stain the lint and reduce market value of cotton.

Cotton thrips – *Thrips tabaci* Lindeman

Order – Thysanoptera **Family** – Thripidae

1. **Distribution:** Pest is distributed throughout cotton growing area of country and all over world.
2. **Host plants:** Cotton, cabbage, cauliflower, potato, tobacco, tomato, cucumber etc.
3. **Marks of Identification:** Adults are slender, yellowish brown and 1mm in length. The males are wingless but female have long narrow strap-like wings, having long hairs along hind margins. The nymphs are resemble as adults in shape & colour but smaller than adults. Move briskly on flower & leaves.
4. **Life Cycle:** Pest is active throughout the year first breeds on onion & garlic from November to May then it migrates to cotton and breeds there till September. Female lays 50-60 kidney-shaped eggs singly in slits of leaf tissue, which made by sharp ovipositors. Adult life is 2 to 4 weeks, hatching period is 4-9 days. Nymphal period is 4-6 days through 4 stages. Nymphs descend to ground and pupate upto 25 mm depth. Pre-puple stage is 1-2 days and puple stage is 2-4 days and several generations in a year.
5. **Nature and Symptoms of Damage:** They feed on lower surface of leaves. The leaves become wrinkled and fall off. The plants bear very few bolls.

American boll worm of cotton – *Helicoverpa armigera* (Hubner)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** American bell worm is cosmopolitan and is widely distributed in India and throughout the world.
2. **Host Plants:** Serious pest of cotton, chickpea, pigeonpea, pea, mungbean, urdbean, lentil, soyabea, cowpea, sorghum, okra, maize, tomato, berseem, sunflower etc.

3. **Marks of Identification:** Moth is stoutly built and yellowish brown. Dark speck (Spot) and dark area near outer margin of fore wings. Fore wings have grayish wavy lines black spots on upper side and black kidney shaped mark and round spot on under-side. Hind wings are whitish and lighter in colour and have broad blackish band on outer margin. The caterpillar greenish with dark grey lines on side of the body and constricted body.

4. **Life Cycle:** Females lay egg singly on tender parts of plants. Single female may lay 741 eggs in 4 days. Eggs are shining greenish yellow and round. Hatching period is 2-4 days in April-October and 6 days in February. Larval period is 13-19 days and larva is 35 mm long in last instar. It pupate in soil. The pupa is dark brown and has sharp spine at posterior end. In active season pupal period is 8-15 days and prolong in winter and 8 generations in a year.

5. **Nature & Symptoms of Damage:** After hatching young larvae feed on the foliage for some time and later bore into bolls of cotton and feed on developing seeds, with their body hanging outside. They move boll to boll on plant and also from one plant to another.

Spotted boll worm of Cotton – *Earias insulana* (Boisduval)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** Spotted boll worm is widely distributed in North Africa, India, Pakistan and other countries and serious pest of cotton.

2. **Host Plants:** Cotton, Okra, Sonchal, gulkhaira, hollyhock and other malvaceous plants.

3. **Marks of Identification:** Full grown caterpillars is dull-green, 20 mm long and have tiny stout bristles and longitudinal black spots on body. The moths are yellow green and measure 25 mm across wings.

4. **Life Cycle:** Pest breeds throughout year but in winter only pupae are found hiding in plant debris. The moths appear in April and lay 200 to 400 eggs at night singly on flower buds, brackets and tender leaves of cotton. Hairy parts of plants are preferred for oviposition. In warm weather hatching period is 3-4 days. Larval period is 10-16 days through 6 moulting. Pupation on plants or on ground among fallen leaves. Pupal period is 4-9 days. Complete life cycle, egg to adult is 17-29 days in summer. In winter hatching is in one week and pupal period is 6-12 weeks. Several overlaping generations in a year.

5. **Nature and Symptoms of Damage:** The larvae bore into growing shoot, flower buds, flowers and fruits (bolls) of cotton, either killing the plants or heavy shedding of fruiting bodies. Drying and dropping of terminal shoots, infested bolls open prematurely and produce poor lint also reduce or lower market value of cotton.

Pink boll worm of Cotton – *Pectinophora gossypiella* (Sounders)

Order – Lepidoptera **Family** – Gelechiidae

1. **Distribution:** Pink boll worm is most destructive pest of cotton in the world. It is found in America, Africa, Australia and Asia.

2. **Host Plants:** Cotton, okara and other allied plants.

3. **Marks of Identification:** Adult moth is deep brown measuring 8-9 mm across spread wings. Blackish spots on fore wings and margins of hind wings are deeply fringed. Larvae white and turn pink as older.

4. **Life Cycle:** Moth emergence takes place in May-June and July-August. Females lay whitish, flat eggs singly on underside of young leaves, new shoots, flower buds and young green bolls. The egg hatch in one week, the caterpillar is white and turn pink as grow older. Larvae enter the flower-buds, flowers or bolls. The holes of entry close down but larvae continue feed inside the boll on seed kernels. Larval period is two weeks & full-grown larva in 8-10 mm long. Larvae come out of holes from bolls for pupation on ground among fallen leaves, debris etc. Pupal period is one week. By October-November 4-6 generations are completed.

5. **Nature & Symptoms of Damage:** The larvae enter into flower-buds, flowers or bolls and results into rosette flowers. The entry holes closed by excreta and larvae feed on seed kernels inside the bolls, sometimes double seed are noticed. Shedding of fruiting bodies. The attacked bolls fall off prematurely and those which do mature do not contain good lint. Damaged seed-cotton gives lower ginning and oil percentage and inferior spinning quality.

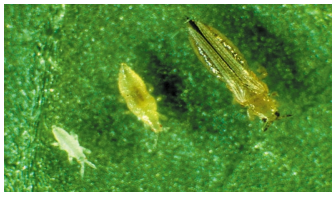
Amarasca biguttula biguttula

Bemisia tabaci

Aphis gossypii

Dysdercus koenigii

Oxycarenus laetus



Thrips tabaci

Earias insulana

Pectinophora gossypiella

Helicoverpa armigera

Record Work: Write down the IPM practices for the management of insect pests infesting cotton crop.

SUNNHEMP

Sunnhemp Hairy Caterpillar – *Utetheisa pulchella* (Linnaeus)

Order – Lepidoptera **Family** – Arctiidae

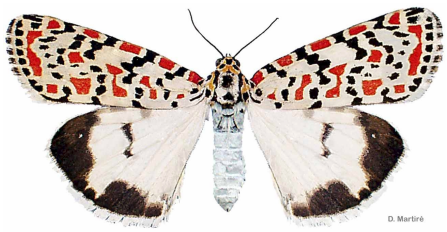
1. **Distribution:** This pest is the most important pest of sunnhemp and found in many parts of the country.

2. **Host Plants:** Sunnhemp, cotton and other fiber crops & weeds.

3. **Marks of Identification:** The adult moth is pale, whitish with red black spots on the upper side of wings and black marginal blotches on the lower side of wings. Full-grown caterpillar is about 3.8 mm long and has red, dark and white markings on body and brownish head.

4. **Life Cycle:** The moths lay small whitish eggs on the tender leaves and shoots. On emergence from the eggs the larvae feed on leaves. When the crop matures and pods appear, the caterpillar feed by thrusting (entering) the head in side pod and leaving the rest of the body exposed out side the pod. Pupation takes place either in the leaf folds or in the soil. The life cycle completed in about 5 weeks and number of generations completed in a year.

5. **Nature & Symptoms of Damage:** The caterpillars feed on leaves and bore into the capsules. The caterpillars defoliate the crop and cause a decrease in seed production.



Record Work: Write down the IPM practices for the management of Sunnhemp Hairy Caterpillar.

JUTE (FIBER CROP)

Jute Mealy bug –*Phenacoccus hirtutus* Cr.

Order – Hemiptera **Family** – Pseudococcidae

1. **Distribution:** Found in many parts of the country.

2. **Host Plants:** Jute and reselle fibre crop (*Hibiscus sabdaritta* Linn.)

3. **Marks of Identification:** Mealy bug's female is a rotund, sac-like, light pink wingless creature and 3mm long. The males are slender and have a pair of delicate wings. Nymphs are light pinkish and secrete both a white mealy powder and honey-dew.

4. **Life Cycle:** The mated females lay pink cylindrical eggs which are rounded at the ends. The eggs are laid on plants inside the ovisacs. Egg is 0.3 mm long and 0.2mm wide (breath). The incubation period varies from 7 to 14 days in different seasons. After hatching the emergence of the nymphs starts from ovisacs in batches as per sequence of egg laying. The tiny nymphs crawl on host select suitable spot and settle down. Nymphs are light pinkish and secrete white mealy powder and honey-dew. They develop distinctive sere characters after undergoing in few early moultings. Full-grown larva secretes fine white mealy fibres and forms cocoon for pupation females remain wingless, on maturity develop ovisacs and laid eggs in side ovisac.

5. **Nature & Symptoms of Damage:** The nymphs and females feed on apical part of plant and plant becomes stunted and shows bunchy top symptoms. The petiole becomes shortened, limina crumples, and internodal length reduced cause fibre deterioration and yield reduction.

Record Work: Write down the IPM practices for the management of Jute Mealy bug.

4. INSECT PEST OF PULSES

Greasy cutworm or gram cutworm - *Agrotis ipsilon* (Hufnagel)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** This is a pest of world wide occurrence and is found in America, Europe, North Africa, Syria, Japan, China, Indonesia, Australia, Newzealand, Hawai, Sri Lanka, Myanmar and India. It found in potato growing regions from Punjab to Bengal and M.P. in South.

2. **Host Plants:** It has been reported feeding on gram, potato, tobacco, peas, wheat, lentil, mustard, linseed, maize, sugarcane, cucurbits, bhang (*Cannabis sativa* L.) vegetable seedling and several weeds.

3. **Marks of Identification:** The caterpillar slightly yellowish with shiny, black head and black shield on prothorax. The newly emerged larva is 1.5 mm long and full-grown larva is 42-45 mm long and is dark or dark-brown with plump and greasy body. The adult moth is 25 mm long from head to the tip of the abdomen and look dark or blackish with some greyish patches on back and dark streaks on fore wings.

4. **Life Cycle:** The pest is active from October to April and migrates to the mountains during summer for further breeding. The moths appear in plains in October and come out at dusk and fly about until darkness sets in. The moths oviposit at night and lay creamy white, dome-shaped eggs in clusters of about 30 each on under surface of leaves or in the soil. The female lays 199 to 344 eggs. Oviposition continues from 5 to 11 days. Hatching period 2 days in summer and 8-13 days in winter. Newly hatched larva feed on their egg-shells and move like semilooper. The larval period is 30 to 34 days in February-April. The advanced stage larvae may become cannibalistic. They make earthen chambers and pupate in the soil. Pupal period 10 days in summer and 30 days in winter. The moths emerge at night. Life cycle completed in 48-77 days and three generations in a year. Pest is active from October-March in plains.

5. **Nature and Symptoms of Damage:** During the day-time larvae live in cracks, crevices and holes in the ground and come out at night and fell the crop plants by cutting their stems, either below the surface or above the ground.

Pod borer – *Helicoverpa armigera* (Hubner)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** The gram pod-borer or gram caterpillar is cosmopolitan and is widely distributed in India.

2. **Host Plants:** Chickpea, pigeonpea, pea, mungbean, urdbean, lentil, soybean, cowpea, also feed on cotton, sorghum, okra, maize, tomato, berseem and sunflower.

3. **Marks of Identification:** Same as described in American boll worm of cotton.

4. **Life Cycle:** Same as described in American boll worm of cotton.

5. **Nature & Symptoms of damage:** The young larvae after hatching feed on the foliage for some time and later on bore into the pods and feed on the developing grains, with their bodies hanging outside.

Record Work: Write down the IPM practices for the management of insect pests infesting chickpea.

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Arhar pod bug – *Clavigralla gibbosa* Spinola

Order – Hemiptera **Family** – Coreidae

1. **Distribution:** This insect is widely distributed in the Indian sub-continent and adjoining countries including Myanmar. In India it has been recorded from Delhi, Orrisa, Tamil Nadu, Uttar Pradesh, Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and Bihar.

2. **Host Plants:** It feeds on pigeon pea, lab-lab, cowpea, chickpea, kidney bean, cluster bean etc.

3. **Marks of Identification:** Adult bugs are greenish brown in colour and having a spined pronotum and the femur, swollen at apical end. The bugs are about 20 mm long. The young nymphs are reddish and show prominent lateral spines on the prothoracic and abdominal segments.

4. **Life Cycle:** The bugs appear on crops in October. They mate several times in end to end position and the copulation period varies from an hour to nearly 24 hours. After a lapse of about 11 days, which is pre-oviposition period, the females lay eggs. The eggs usually laid on pods and less frequently, on leaves or floral buds, in cluster of 5-25 each. A female lays 60 eggs during oviposition period of 15 days. The eggs hatch in 8 days and the newly-hatched nymphs move away from the egg shells within 10 to 15 minutes and gather together at a suitable feeding spot. They are gregarious in nature and are seen feeding in groups. Nymphal period is 17 days, through five nymphal stages. The pest is active from the middle of October to end of May and six overlapping generations during this period.

5. **Nature & Symptoms of Damage:** Both the adults and nymphs suck cell sap from the stem, leaves, flower-buds, and pods. Due to loss of cell sap, the pods show pale yellow patches and later on shrivel up. The grain inside pods remain small in size and yield reduced significantly.

Plume moth – *Exelastis atomosa* (Walsingham)

Order – Lepidoptera **Family** – Pterophoridae

1. **Distribution:** This insect is a specific pest of pigeon pea in many parts of India, particularly in Andhra Pradesh, Assam, Madhya Pradesh, Punjab, Tamil Nadu, Maharastra and Karnataka. Outside India, it has also been recorded in Nepal and New Guinea.

2. **Host Plants:** Specific pest of pigeon pea.

3. **Marks of Identification:** The full-grown caterpillar is greenish brown and 1.25 cm long and has hairs on the body.

4. **Life Cycle:** The female moths lay 17-19 eggs singly on tender parts of the plants. The eggs hatch in 2 to 5 days and the young larvae feed on the pods and become full-grown in 10 to 15 days. Pupation takes place outside the pod on its surface or in the entrance hole itself. The pupal period extends from 3 to 12 days. The life cycle is completed in 17-42 days. The pest remains active throughout the year, provided suitable host plants are available, although its incidence remain greater in the monsoon season.

5. **Nature & Symptoms of Damage:** The larvae first scrape the surface of the pods and finally make holes into pods and feed on the seeds, reducing crop yield.

Red gram pod-fly – *Melanagromyza obtusa* (Malloch)

Order – Diptera **Family** – Agromyzidae

1. **Distribution:** This pest occurs wherever red gram (arhar) is grown in India but most common in northern India.

2. **Host Plants:** Arhar

3. **Marks of Identification:** The fly is small and metallic-black. Whose tiny maggots bore into the pods and feed on seeds.

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

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

Agrotis ipsilon

Clavigralla gibbosa

Exelastis atomosa

Record Work: Write down the IPM practices for the management of insect pests infesting Pigeon pea.

5. INSECT PEST OF OILSEEDS
GROUNDNUT

Groundnut aphid – *Aphis craccivora* Koch.

Order – Hemiptera **Family** – Aphididae

1. **Distribution:** Its distribution is throughout India. It has also been recorded in Africa, Argentina and Chile. This species is also present in non-groundnut areas of the USA, Europe and Australia.

2. **Host Plants:** This is one of the most serious pests of groundnut. It also attack peas, beans, pulses, safflower and some weeds.

3. **Marks of Identification:** The aphid is also a vector of a virus disease known as the rosette of groundnut. The winged adults have black wings and off spring are wingless. The nymphs are brownish.

4. **Life Cycle:** The off spring of the winged form may be wingless. Even without fertilization the females may produce 8-20 young ones in a life span of 10 to 12 days. The young nymphs are brownish and they pass through four moults to become adults in 5 to 8 days. The apterous females start producing brood within 24 hours of attaining that stage. Breeding occurs almost throughout the year and both alate and apterae are present.

5. **Nature & Symptoms of Damage:** The nymphs and adults suck the cell sap usually from the under side of the leaves. Early stage infestation causes stunting of the plant as well as reducing the vigour. Infestation on groundnut crop usually occurs 4-6 week after sowing. Infestation at flowering & pod formation reduced yield considerably.

Groundnut leaf minor – *Stomopteryx nertaria* Meyrick

Order – Lepidoptera **Family** – Gelichiidae

1. **Distribution:** This pest is distributed all over India, Pakistan, Srilanka, Myanmar and South Africa. In India it is most serious in Tamil Nadu.

2. **Host Plants:** Groundnut and other plants but it is considered a serious pest of groundnut only.

3. **Marks of Identification:** The larva is small and green, and has a conspicuous dark head. The adult is a small bronze moth with a wing expanse of about 1 cm.

4. **Life Cycle:** During the day the moths remain concealed under clods of soil or in crevices. They become active at night when they are also strongly attracted to light. The female moth lays up to several hundred eggs singly on leaves and on shoots. The eggs hatch after about 3 days. The newly hatch larva is 1.5 mm long. After wondering for some time, it mines into the leaves and later on bites its way out. It then webs together a number of leaflets and feeds inside the chamber thus formed. The larvae are full-grown in 9-17 weeks and 6-8 mm long and turn dirty green. They prepare silken cocoons to pupate in it. The pupal period is 4 days. There are several generations during a year.

5. **Nature & Symptoms of Damage:** Mining caused by larve results into skeletonizing and webbing of the leaves. The crop suffers serious and heavy losses in yield. In badly infested field the crop plants look like as it has been & corohed.

White grub – *Holotrichia consanguinea* (Blanchard)

Order – Coleoptera **Family** – Scarabaeidae

1. **Distribution:** Found in some parts of India as localized but is spreading to larger area. The insect appeared as a pest of groundnut in 1957 in the Gujarat state and later on also in Haryana, Himachal Pradesh, Rajasthan and Punjab.

2. **Host Plants:** Pest infests on groundnut, sugarcane, sorghum, maize, chili, okra, brinjal, etc.

3. **Marks of Identification:** The grubs are mostly found in the upper 5 to 10 cm layer of soil. When grubs full grown, they are about 35 mm long and white colour, having a brown head and prominent thoracic legs. The adult beetles are dull brown and 18 mm long and 7 mm wide.

4. **Life Cycle:** The insect becomes active with the onset of monsoon. The adult beetles lay eggs singly upto 10 cm depth in the soil. The eggs hatch in 7-10 days. At hatching grubs are 12mm long and larval period is 8 to 10 weeks. After the monsoon, the full grown grubs (larvae) migrate to considerable depth of in the soil for pupation. Pupa is semicircular and creamy white and pupal period is about fortnight. The beetles remain in the soil at a depth of 10-20 cm and come out for feeding at night. The adults which formed in November remain in soil till next June. Population is maximum in rainy season and only one generation in a year.

5. **Nature & Symptoms of Damage:** The grubs eat away the nodules, the fine, rootlets and may also girdle the main root, ultimately killing the plants. At night the beetles feed on foliage may completely defoliate even trees like neem and banyan, ber and khejri.

Red hairy caterpillar – *Amsacta moorei* (Butler)

Order – Lepidoptera **Family** – Arctiidae

1. **Distribution:** The red hairy caterpillar or Katra is widely distributed in the orient (East) including India.

2. **Host Plants:** Red hairy caterpillar is a polyphagous insect and feeds practically on all kinds of vegetation growing during kharif season. Its attack is particularly serious on sunhemp, maize, Jowar (*Sorghum vulgare*), guar (*Cyamopsis tetragonoloba*), mung, moth and sesamum.

3. **Marks of Identification:** The colour of caterpillars varies from reddish-amber to olive green and body is covered with numerous long hairs arising from the fleshy tubercles. The moths are stoutly built and have white wings with black spot. The outer margins of fore wings, the anterior margin of thorax and entire abdomen are scarlet red. Black bands and dots on abdomen.

4. **Life Cycle:** Pest is active from mid-June to end of August and passes rest of the year in pupal stage in soil. Moths from these pupae appear usually with first shower of monsoon. They are nocturnal in habit and lay light-yellow spherical eggs in cluster of 700-800 each on under surface of leaves. A single female may lay up to 1,500 eggs which hatch in 2-3 days. The caterpillars feed gregariously and as grow older, they

march in bands destroying field after field of various kharif crops. The larval period is 15-23 day through six stage. They enter soil, shed their hairs and make earthen cocoons at depth of about 23 cm. Here they pupate and remain in this stage for many moths till they emerge next year from the cocoons one generation in a year.

5. **Nature & Symptoms of Damage:** The young red hairy caterpillars prefer to eat the growing point of plant. The older caterpillars feed voraciously on all vegetation resulting in disaster. Field after field is devasted by moving army of caterpillars. The severe infestation causes complete failure of kharif crops.

Record Work:

1. Write down the IPM practices for the management of insect pests infesting groundnut.

2. Write down the IPM practices for the management of white grub infesting groundnut.

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CASTOR

Castor semilooper – *Achaea janata* (Linnaeus)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** This is serious pest of castor in all parts of India and Pakistan also in Sri Lanka and Thailand.

2. **Host plants:** Feeds on castor, citrus fruits etc.

3. **Marks of Identification:** The adult is pale reddish brown moth with a wing expanse of 6 to 7 cm. The wings are decorated with broad zig-zag markings, a large pale area and dark brown patches. The full-grown larva is dark and marked with prominent blue black, yellow and reddish stripes and has a pair of reddish processes and dorsal hump near hind end of body. There is a characteristic white mark on the head. The colour patterns of larvae are variable and larvae are conspicuous on green plants.

4. **Life Cycle:** The moths are active at dark and lay scattered eggs on tender leaves. A female can lays upto 450 eggs during life span. The egg is 1 mm long is fairly large and has on its surface a few ridges and furrows, which radiate from the circular depression at apex. The egg is bluish green. The larva hatch by cutting hole in egg shell in 2-5 days and devours egg shell immediately and then start feeding on foliage. The larvae period is 15 to 20 days through 4-5 moults and first instar larva is 3.5 mm long. Full-grown up larva prepares loose cocoon of coarse silk and soil particles and pupates under the fallen leaves on soil usually at edge of field. In some cases pupation also takes place within folded leaves on plant itself. The pupal period is 10-15 days. The moths feed on soft fruits of citrus and mango and 5-6 generation in a year.

5. **Nature & Symptoms of Damage:** The caterpillars feed on castor leaves, starting from the edges to inwards and leaving behind only midribs and stalks. Damage is maximum in August-September with excessive loss of foliage the seed yield is reduced

considerably. It feed on variety of plants but prefer castor. The adults of this species are fruit sucking moths and cause serious damage to citrus fruits.

Castor Capsule borer – *Dichocrocis punctiferalis* (Guenee)

Order – Lepidoptera **Family** – Pyralidae

1. **Distribution:** This borer is distributed throughout India wherever castor is grown.

2. **Host Plant:** Feeds on castor.

3. **Marks of Identification:** The full-grown caterpillar is 25 to 30 mm long is reddish brown, with black blotches all over the body and pale stripe on lateral side. The moths are orange yellow with black markings on both wings.

4. **Life Cycle:** The moths lay eggs on leaves and other soft parts of plant. The eggs hatch in about a week. The larval period is 2 to 3 weeks through 4-5 in stars. Pupation takes place inside the seed or sometimes in frass that collected after feeding. Pupal period is one week. The life cycle is completed in 4 to 5 weeks and 3 generations in a year. The pest is active on castor from September to March.

5. **Nature & Symptoms of Damage:** The damage of castor capsule borer is recognized due to webbing of capsule heads. The yield is reduced because of damage of capsules and seeds in capsules.

Record Work: Write down the IPM practices for the management of insect pests infesting castor.

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GINGLLI/SESAMUM

Sesamum leaf webber or Til leaf and pod caterpillar –
Antigastra catalaunalis (Duponchel)

Order – Lepidoptera **Family** – Pyralidae

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

2. **Host Plants:** Til and wild species of sesamum.

3. **Marks of Identification:** The caterpillars are pale yellow, when young but gradually become green and develop black dots all over the body and 14 to 17 mm long. The

moth is a small insect with a wing span about 2 cm and having dark brown markings on the wing-tips.

4. **Life Cycle:** In northern India, the moths appear in August. Females lay up to 140 eggs singly on the tender portions of the plants at night. The eggs are shiny, pale-green and they hatch in 2-7 days depending upon season. Emerging young larva is 2 mm long and feeds for little while one leaf epidermis or within leaf tissue. Soon after it binds together the tender leaves of the growing shoots with the help of silken threads and continues to feed in the webbed mass. The size of this rolled mass increases gradually as the caterpillar grows older. Larval period in summer is 10 days and in winter 33 days.

   The grown-up larvae creep to the ground and pupate in silken cocoons in soil. Some times pupation takes place in the plant itself. Pupal period is 4 to 20 days depending upon season. In summer a generation is completed in about 23 days but in winter it takes about 67 days. The moths start eggs laying 4-5 days after emergence. Moths are active in the cool hours of the day and adult life is 3 weeks. All stages are available in autumn and sometime upto December. During January & February insect hibernates as larva inside the pods, stubble or harvested stalks and 14 generations in a year.

5. **Nature & Symptoms of Damage:** Young caterpillars feed on leaves. They bore into the shoots, flowers, buds and pods. At early attack kills the whole plant but infestation of shoots at a later stage hampers the growth and flowering of plant. One larva can destroy 2 to 3 young plants. The maximum infestation occurs in May and again in September-October.

Til Hawk-moth – *Acherontia styx* (Westwood)

Order – Lepidoptera **Family** – Sphingidae

1. **Distribution:** This pest of sesamum is common in India and also distributed in Indonesia, Sri Lanka, Philippines and Myanmar.

2. **Host Plants:** Til (Ginglli), potato, brinjal, lablab, and ornamental plants such as balsam.

3. **Marks of Identification:** This insect is variously known as hawk moth, sphinx-moth or death's head moth based on its structural & behavioural characteristics. The adult is a large redish brown, robust thick-set moth with a wing span of about 10 cm. The forewings are decorated with a mixture of dark-brown and grey patterns with dark or black wavy markings and a prominent yellow spot on each wing. The prominent Death's head mark on the thorax. The moths are swift fliers and make hawk like darts to light at dusk.

   The full-grown caterpillar is 5cm long and 1cm wide, often retracts some of its anterior body segments and looks like sphinx. The horn-like projections on the hind

end of the abdomen are conspicuous. The body of larva is plump and decorated with pleasant mixture of soft colours.

4. **Life Cycle:** The moths lay globular eggs singly on the underside of leaves of host plants. The eggs are conspicuous since they are fairly large. The eggs are greenish white when freshly laid but turn yellow later on hatching period is 2-5 days, the young larvae are pale-yellow and start feeding on leaves. Larval period is two months or more. Pupal period in summer is 2-3 weeks and in winter 7 months. The changes in colouration of larvae and adults aid them in protective mimicry. The impression of ferociousness created by larva and adult moth is probably a protection against predators. There are 3 generations in a year. The winter is passed in pupal stage in soil.

5. **Nature & Symptoms of Damage:** The larvae feed voraciously on leaves and defoliate the plants. The insect is capable of inflicting heavy damage at times, but generally it is not very serious pest in India.

Record Work: Write down the IPM practices for the management of insect pests infesting sesamum.

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SOYBEAN

Soybean girdle beetle – *Oberia brevis* Swed.

Order – Coleoptera **Family** – Cerambycidae

1. **Distribution:** Soybean girdle beetle is found in U.P., M.P., Rajasthan and in the area where soybean is cultivated.

2. **Host Plants:** Soybean girdle beetle feeds on soybean, lablab and cowpea.

3. **Marks of Identification:** Body length of adult is 3-5 mm, antennae serrate and longer than body length. Body colour partially black & partially orange.

4. **Life Cycle (In M.P.):** *Oberia brevis* is an important pest of soybean causing 13.4 per cent damage on an average. Egg period or hatching period lasts for 3-4 days, larval period is 34 to 47 days and pupal period is 8-11 days under laboratory conditions. In the field the developmental periods are protracted (prolonged).

5. **Nature & Symptoms of Damage:** The ovipositing female beetle girdles the stem twice and makes 3 punctures just above the lower ring before inserting a single egg through the largest hole into the pith. This results in the dropping of the upper part of the stem. Larva tunnels upwards and downwards within the stem and a single larva can destroy the whole plant.

Aphis craccivora

Stomopteryx nertaria

Holotrichia consanguinea

Amsacta moorei

Achaea janata

Antigastra catalaunalis

Uroleucon (Dactynotus) carthami

Acherontias

Oberia brevis

Record Work: Write down the IPM practices for the management of Soybean girdle beetle infesting soybean.

6. INSECT PEST OF VEGETABLES

BRINJAL

Brinjal shoot and fruit borer – *Leucinodes orbonalis* Guenee

Order – Lepidoptera **Family** – Pyralidae

1. **Distribution:** It is widely distributed in Malaysia, Myanmar, Sri Lanka, India, Pakistan, Germany and East-Africa.

2. **Host Plants:** Brinjal, Solanaceous plants and occasionally on green pods of peas.

3. **Marks of Identification:** The young caterpillars are creamy white but light pink when full grown and 18 to 23 mm long. The moth is white with pale brown or black spots on dorsum of thorax and abdomen. The wings are white with a pinkish or bluish tinge and ringed with small hair along apical and anal margins. The fore wings are ornamented with a number of black, pale and light brown spots and moth is 20-22 mm across the wing span.

4. **Life Cycle:** The caterpillars hibernate in winter and pupate early in spring. The moths appear in March-April and lay 80-120 creamy white eggs singly or in batches of 2-4 on underside of leaves, green stems, flower buds or calyx of fruits in their life span of 2-5 days. The hatching period is 3 to 6 days. The larval period is 9-28 days through 5 stages. The mature larvae come out of feeding tunnels and pupate in tough silken cocoons among fallen leaves. The pupal period is 6-17 days and entire life cycle is completed in 20-43 days. There are five overlapping generations in a year.

5. **Nature & Symptoms of Damage:** When terminal shoots are attacked, growing points are killed. Damage to fruits particularly in the autumn is very severe and it is common to see the whole of crop destroyed by the borers.



Leucinodes orbonalis

Record Work: Write down the IPM practices for the management of Brinjal shoot and fruit borer.

OKRA

Shoot and Fruit borer of Okra – *Earias insulana* (Boisduval)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** The pest is widely distributed in North Africa, India, Pakistan and Other countries and found on okra.

2. **Host Plants:** Feed on okra, cotton, gulkhaira, hollyhock and some other malvaceous plants.

3. **Marks of Identification:** The full-grown dull-green caterpillars are 20 mm long having tiny stout bristles and a series of longitudinal black spots on body. The moths are yellow green and about 25 mm across wings.

4. **Life Cycle:** The pest breeds practically throughout the year but during winter only pupae are found hiding in plant debris. The moths appear in April and adult life is 8 to 22 days. The moths lay 200 to 400 eggs at night, singly on flower buds, brackets, and tender leaves of okra plants. The hairy parts of plants are preferred for oviposition. The hatching period in warm weather is 3 to 4 days and larval period is 10 to 16 days through 6 stages. The pupation take place on plants or on ground among fallen leaves and pupal period is 4 to 9 days. The life cycle is completed in 17 to 29 days in summer. In winter eggs hatch in about one week and pupal period is 6-12 weeks. Several overlapping generations in a year.

5. **Nature & Symptoms of Damage:** When bhendi (okra) plants are young, larvae bore into the terminal portions of the shoots which wither away and dry up. Later on they bore into fruits cause heavy damage. The infested fruits are unfit for human consumption.



Earias insulana

Record Work: Write down the IPM practices for the management of

TOMATO

Tomato fruit borer – *Helicoverpa armigera* (Hubner)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** The pest is cosmopolitan and widely distributed in India. In the United States of America it is well known pest of corn (corn earworm) and cotton (cotton bollworm).

2. **Host Plants:** The pest is cosmopolitan and serious pest of gram, pigeonpea, pea, mung, urd, lentil, soyabean, cowpea, cotton, sorghum, okra, maize, tomato, berseem and sunflower.

3. **Marks of Identification:** Same as described in gram pod borer.

4. **Life Cycle:** Same as described in gram pod borer.

5. **Nature & Symptoms of damage:** The pest feed on the foliage, when young and on fruits and seeds in later stages and thus reduced yield. A single larva may destroy many fruits.



Helicoverpa armigera

Record Work: Write down the IPM practices for the management of tomato fruit borer.

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Tomato pinworm/Tomato Leaf miner/South American tomato moth-
Tuta absoluta (Meyrick)

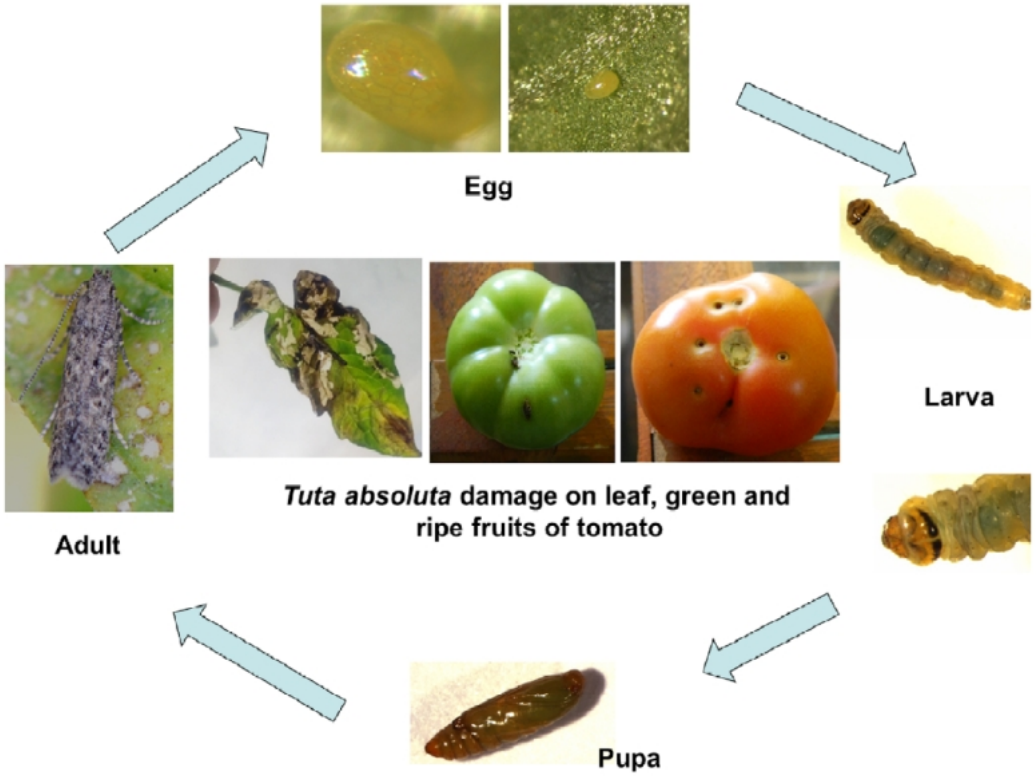
Order – Lepidoptera **Family** – Gelechiidae

- **Host range:** Tomato is the main host plant; also attacks other crop plants like potato, egg plant, pepper, tobacco, common bean and other wild solanaceous plants etc.
- **Distribution:** Argentina; many South American countries; Japan; Spain; Morocco; Algeria; France; Egypt; Sub-Saharan Africa; Sudan; Ethiopia; Senegal; Kenya; Nepal; India.

Damage:

- All larval instars feeds on the whole plant.

- Larvae feeds on the mesophyll tissue; irregular papery mines (blotches) and galleries developed and become necrotic; visible from both the sides of the leaves; Generally covered with the frass.
- Larvae also mines the apical buds and stems.
- Stem portion also gets extensive galleries; affects the growth of the plants.
- Green and matured fruits attacked by larval stage and rottening of fruits.
- Infested fruits shows small holes on the surface and larval tunnel below the surface of the fruit.
- Total Life cycle: 24 to 76 days .
- Female: lay eggs (260).
- Eggs: Oval-cylindrical cream coloured; singly laid on the underside of leaves; on buds or calyxes of green fruit period: 4-6 days.
- Larva: Early instars cream with black head; turned into greenish to pink with brown head; 11 days.
- Pupa: light to dark brown Period: 5-7 days.
- Adult: small moths having brown or silver with black spots on the narrow wings; hindwings with outer margin concave posterior of apex.



Source: Sridhar et al., 2014

Record Work: Write down the IPM practices for the management of Tomato pinworm.

Serpentine leaf miner of tomato – *Liriomyza trifolii* (Burgess)

Order – Diptera **Family** – Agromyzidae

1. **Distribution:** Serpentine leaf miner is a native of Florida in Southern United States and Caribbean islands and believed to be accidentally introduced into India and widely distributed in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu etc.

2. **Host Plants:** Vegetables, ornamentals, fibre crops, pulses, oilseeds, green manures, fodder, narcotics, and weeds. It becoming serious pest on tomato, cotton, ridge gourd, brinjal, cucumber, potato etc.

3. **Marks of Identification:** The freshly laid eggs are creamy white and shaped like an elongated oval. The maggots are bright yellow to yellow green in color and 4mm long and 0.5 mm in breadth. Pupa is yellow brown and segmented and rectangular oval in shape. Adult is a small fly of mat gray with black & yellow spots and 2.1 mm long.

4. **Life Cycle:** The average period of life cycle of leaf miner, *Liriomyza trifolii* is 21 days but can be as short as 15 days. The length of life cycle varies with host and temperature. Eggs are laid singly in punctures in leaf epidermis and there is no preference for upper or lower surface. The hatching period is 2-4 days. There are three larval stages and each larval instar is completed in 2 to 3 days. Pupal period is 5 to 12 days and pupa is yellow-brown in colour and rectangular oval shaped narrowing at ends. Adult life is 10-20 days depending on environmental conditions and 2.1 mm long.

5. **Nature & Symptoms of Damage:** The first and second stage larvae burrows into mesophyl tissue and feed there and third stage larvae feed towards upper and lower leaf surface. The larval leaf mine vary in form depending on host but when adequate space is available mine is long, narrow not greatly widening towards the end. Larval mines in small leaves with limited feeding space characterized by a secondary blotch. Damage caused only by large populations and destroying leaves and affecting growth of plants.



Liriomyza trifolii

Record Work: Write down the IPM practices for the management of Serpentine leaf miner.

CUCURBITS VEGETABLES

Melon fruit fly – *Bactrocera cucurbitae* (Coquillett)

Order – Diptera **Family** – Tephritidae

1. **Distribution:** This is commonest and most destructive fruit fly of musk melon and other cucurbits throughout India. It is also found in Pakistan, Myanmar, Malasia, China, Formosa, Japan, East Africa, Australia and Hawaiian Islands.

2. **Host Plants:** It feeds on melon, tomato, chillies, guava, citrus pear, fig, cauliflower, etc.

3. **Marks of Identification:** The maggots are legless and appear as head less, dirty-white winggling creatures, thicker at one end and tapering to point at other end. The full-grown maggot is 9-10 mm long and 2 mm broad (wide) in middle. The adult flies are reddish brown with lemon-yellow markings on thorax and have fuscous (dark colour) area on the outer margins of their wings.

4. **Life Cycle:** This pest is active throughout year but life cycle is prolonged during winter. The adult flies emerge from pupae in the morning hours and mate at dusk. The pre-oviposition period is 14 days and it prolonged in winter. They oviposit in comparatively soft fruits and avoid hard rind fruits. After selection of suitable site a cavity is made by sharp ovipositor and about dozen white cylindrical eggs are laid mostly in the evening hours. After eggs laying the female releases a gummy secretion which cements the tissues surrounding the puncture and makes the entrance water proof. The secretion solidifies to form a shiny brown resinous material. The female on an average lays 58 to 95 eggs in 14 to 54 days. The hatching period is 1 to 9 days. The larval period is 3 days in summer and 3 weeks in winter. The mature larvae come out of rotten fruits and move away in jumps of 12-20 cm. After reaching suitable place they bury in soil up to 5 mm deep and pupate. The pupae are barrel shaped, light brown and pupal period is 6 to 9 days in rainy season and 3 to 4 weeks in winter and several generations in a year.

5. **Nature & Symptoms of Damage:** The maggots pollute and destroy fruits by feeding on pulp. The damage of this fruit fly is most serious in melons after first shower of monsoon, infestation often reaches 100 per cent.

Bactrocera cucurbitae

Record Work: Write down the IPM practices for the management of melon fruit fly infesting cucurbits.

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Red pumpkin-beetle – *Raphidopalpa foveicollis* (Lucas)

Order – Coleoptera **Family** – Chrysomelidae

1. **Distribution:** This pest is common in north-western India. It is widely distributed in Asia, Australia, Southern Europe and Africa.

2. **Host Plants:** It is serious pest of cucurbitaceous vegetables such as ash gourd, pumpkin, tinda, ghia tori, Cucumber and melon.

3. **Marks of Identification:** The full-grown grubs are 12 mm long and 3.5 mm across the mesothorax. They are creamy white and slightly darker oval shield at back. The beetles are oblong and 5 to 8 mm long. Their dorsal body surface is brilliant orange red and ventral surface is black, being clothed in short white hair.

4. **Life Cycle:** The beetles are found concealed in groups under dry weeds, bushes and plants or in crevices of soil. They resume activity as soon as the season warms up and in their life span of 60 to 85 days, they lay about 300 oval yellow eggs singly or in batches of 8 to 9 in moist soil, near the base of plants. The hatching period is 6 to 15 days and grubs remain below soil surface feeding on roots, underground stems of creepers and on fruit lying in contact with soil. The larval period or grub stage is 13 to 25 days and pupate in thick-walled earthen chambers in soil at a depth of about 20-25 cm. The pupal period is 7 to 17 days. The life cycle is completed in 26 to 37 days and five generations from March to October.

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



Raphidopalpa foveicollis

Record Work: Write down the IPM practices for the management of red pumpkin beetle infesting cucurbits.

Spotted beetles or Leaf feeding beetles – *Epilachna* spp.

1. *Homosepilachna vigintioctopunctata* (Fabricius)
2. *Epilachna dodecastigma* (Wiedemann)
3. *Epilachna demurili* **–** Attacks cucurbitaceous vegetables exclusively.

Order – Coleoptera **Family** – Coccinellidae

1. **Distribution:** Commonly occurs throughout South-East Asia and in India.

2. **Host Plants:** Feeds on Melons, Water melon, pumpkin, bitter gourd, bottle gourd, potato, tomato, *Coccinia* spp., brinjal etc.

3. **Marks of Identification:** Adults are spherical, pale yellowish brown elytra mottled with black spots. 28 spots are found on *Honosepilachna vigintioctopunctata* and *Epilachna dodecastigma* has 12 spots. Grubs are yellowish with spines all over body.

4. **Life Cycle:** Female lays as many as 120 to 180 eggs. The yellowish, elongated, cigar-shaped eggs are laid in batches, generally on lower surface of leaves, with their tips pointing, which are in batches of 30 to 35 in number. The eggs hatch in 2 to 4 days and spiny, yellowish grubs start feeding on the epidermis of leaves. Pupation takes place on leaves and pupae are hemispherical. Life cycle is completed in 25-50 days.

5. **Nature & Symptoms of Damage:**

   Both grubs and adults feed by scrapping chlorophyll from epidermal layers of leaves, leaving the veins and veinlets, and cause characteristic skeletonized patches on the leaves and forming ladder-like windows. In sever cases even calyx of the fruit may also be infested. Later, the affected areas on leaves dry and fall off and damage appears in the form of holes in the leaves.

Homosepilaehna vigintioctopunctata

Epilachna dodecastigma

Epilachna demurili

Record Work: Write down the IPM practices for the management of spotted beetle infesting cucurbits.

Red vegetable mite or Red spider mite or Two spotted spider mite

***Tetranychus telarius* Linnaeus**

Order – Acari **Family** – Tetranychidae

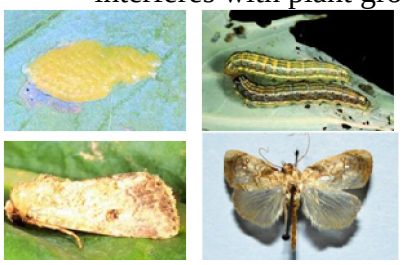
1. **Distribution:** The red vegetables mite, also called the two spotted spider mite is world-wide. In India it is found in all states and is very common in Bihar, Karnataka, A.P., Rajasthan, Uttar Pradesh and Punjab.

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

3. **Marks of Identification:** The full developed nymph is microscopic and 0.33 mm long. It is light brown and has two eye-spots, four paris of legs and is quite active. The adult male is about 0.52 mm long and 0.30 mm wide. The body of female is oval pyriform and variable in colour. The colour may be ferruginous red, greenish ambar, or rusty green. Two large pigmented spots are present on body.

4. **Life Cycle:** The mite is active from March to October and passes winter as a gravid female. As the season warm up in March, it spins webs on the undersurface of leaves of various host plants and lays 60 to 80 eggs. The eggs are spherical and hatching period is 2 to 6 days. The emerging larvae are light brown and have three pairs of legs. They feed underneath webs and within 3 to 4 days change into nymphs which have four pairs of legs. The nymphal period is 4 to 9 days in two stages and adult life is 9 to 11 days. The life cycle in active period is completed in 9 to 19 days. In Punjab 32 generations in a year.

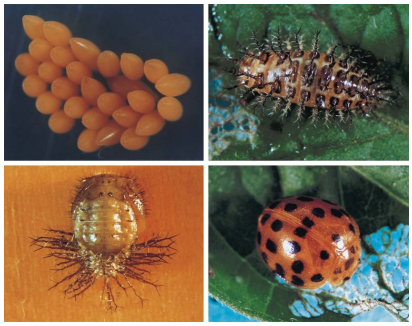
5. **Nature & Symptoms of Damage:** All the active stages usually feed on the underside of the leaves by sucking cell-sap. Gradually, the infested leaves dry up and webbing interferes with plant growth. There is poor setting of fruits and yield reduced.



Hellula undalis

Bactrocera cucurbitae

Raphidopalpa foveicollis



Epilachna dodecastigma

Tetranychus telarius

Record Work: Write down the IPM practices for the management of red spider mite infesting cucurbits.

SWEET POTATO

Sweet potato weevil – *Cylas formicarius* (Fabricius)

Order – Coleoptera **Family** – Apionidae

1. **Distribution:** This weevil is a serious pest of sweet potato in India.
2. **Host Plants:** Sweet potato.
3. **Marks of Identification:** The adult weevils are small 5 to 6.5 mm long, bluish black in colour, with reddish brown prothorax and long snout. The apodous grub is whitish with brown head and 8.22 mm long.
4. **Life Cycle:** The pest is particularly active during the rainy season coinciding with the growth of sweet potatoes. The female lays 97 to 216 eggs in cavities made on vines or tubers. The oviposition period may range from 51 to 102 days. The hatching period is 3 to 7 days. The grubs feed on both vines and tubers and larval period is 21 to 26 days. The pupation takes place either in vine or in tuber and pupal period is 7 to 11 days. The life cycle is completed in 36-43 days and more than one generations in a year.
5. **Nature & Symptoms of Damage:** This is a pest cause damage at both in field and in storage. The weevils feed on leaves, vines and tubers, whereas grubs bore into tender vines and tubers and making tubers unfit for marketing and consumption.

Cylas formicarius

Cylas formicarius

Record Work: Write down the IPM practices for the management of sweet potato weevil.

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COLOCACIA

Colocacia thrips – *Coliothrips indicus*

Order – Thysanoptera **Family** – Thripidae

1. **Distribution:** Pest is widely distributed in India.
2. **Host Plants:** The pest is polyphagous and feeds on many crops like colocacia, tomato, castor, cotton etc.

3. **Marks of Identification:** The adults are slender, brown yellow in colour and 1 mm long. The nymphs resemble as adults in shape and colour but are wingless and smaller in size.

4. **Life Cycle:** Pest is active throughout the year.

5. **Nature & Symptoms of Damage:** Leaves and flowers are damaged by this pest. Occasionally serious and cause characteristic crinkling of leaves, flowers drop.

Record Work: Write down the IPM practices for the management of colocacia thrips.

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Colocacia aphid – *Pentalonia nigronevosa* (Coquerel)

Order – Hemiptera **Family** – Aphididae

1. **Distribution:** Probably native to South east Asia.

2. **Host Plants:** Pest feeds on colocacia, banana, Xanthosoma, cardamom, Heliconia, tomatoes, taro, calla, kahili ginger, torch ginger and zingiber.

3. **Marks of Identification:** The newborn nymphs are oval at first and become slightly elongated. They are reddish brown, antennae four segmented and 1/250 inch long and second stage nymphs are similar and 7/250 inch long. Third nymphal stage light brown and has compound eye, five segmented antennae and 9/250 inch long. Fourth stage nymphs have six segment antennae and are light brown and 1/25 inch long. The nymphal period of first, second, third and fourth stage nymph is 2-4 days, 3 to 4 days, 2 to 4 days and 2 to 4 days, respectively. Adults are small to medium sized (1/25 to 1/12 inch), shiny, reddish to dark brown or black and have six segmented antennae. Alates have prominent dark wing veins.

4. **Life Cycle or Biology:** Reproduction in calocacia aphid is entirely parthenogenetic (without mating). Females give birth to live female young. Males are not known for this species. The life cycle (nymphs to adult) is completed in 9 to 16 days. The adult life span ranges from 8 to 26 days and there could be as many as 30 generations produced per year in Hawaii.

5. **Nature & Symptoms of Damage:** The aphids suck cell sap and cause plants to become deformed, leaves become curled and shriveled and in some cases galls on leaves. Aphids excrete honey dew on which sooty mold develop and decreases photosynthetic activity and vigour of plants. Aphids transmit viruses and cause diseases in plants and cause greater damage to crop.

Record Work: Write down the IPM practices for the management of colocacia aphid.

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7. INSECT PEST OF SPICES

CHILLIES

Chillies Thrips – *Scirtothrips dorsalis* Hood

Order – Thysanoptera **Family** – Thripidae

1. **Distribution:** The chillies thrips is a polypagous pest and is widely distributed in India.

2. **Host Plants:** It feeds on number of plants including chillies, tomato, castor, sunflower, cotton, mango and citrus.

3. **Marks of Identification:** The adults are slender, yellow brown in colour, having apically pointed wing and about 1 mm long. Females possess long, narrow wings with fore wings fringed with long hairs. The nymphs resemble the adult in shape and colour but are wingless and smaller in size.

4. **Life Cycle:** This pest is active throughout the year except during rainy season. The female thrips lays 45 to 50 eggs inside the tissues of leaves and shoots. The hatching period is 5 days. The larval or nymphal period is 7 to 8 days and pupal period is 2 to 4 days. The adult life is 31 days. There are several overlapping generations in a year.

5. **Nature & Symptoms of Damage:** Damage is caused by both adults and nymphs. They suck cell sap from tender parts of plant and leaves gets shrivelled. In severe infestation there is malformation of leaves, buds and fruits. The infested plants are stunted and finally dry up. The insect is responsible for transmitting the virus which cause leaf curl disease of chillies.

Record Work: Write down the IPM practices for the management of chilli thrips.

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TURMERIC

Castor Capsule borer or Castor pod borer or stem borer

Dichocrocis punctiferalis (Guene)

Order – Lepidoptera **Family** – Pyralidae / Pyraustidae

1. **Distribution:** This borer is distributed throughout India wherever castor is grown and found in Gujarat, Andhra Pradesh, Madhya Pradesh, Karnataka, Maharashtra, Uttar Pradesh, Rajasthan and West Bengal.

2. **Host Plant:** Pest feeds on turmeric, castor, ginger and other crops.

3. **Marks of Identification:** The full-grown caterpillar is 25-30 mm long and is reddish brown, with black blotches all over the body and a pale stripe on the lateral side. The moths are orange yellow with black markings on both the wings.

4. **Life Cycle:** The moths lay eggs on leaves and other soft parts of the plant. The hatching period is about one week. The larval period is 2 to 3 weeks through 4-5 instars. Pupation takes place inside the seed or sometimes in the frass that collected after feeding. Pupal period is about one week. The life cycle is completed in 4 to 5 weeks and 3 generations in a year.

5. **Nature & Symptoms of Damage:** The caterpillar enters into the aerial stem killing the central shoot which results in the appearance of "dead heart".



Record Work: Write down the IPM practices for the management of castor capusule borer.

BLACK PEPPER

Pollu beetle – *Longitarsus nigripennis* (Motschulsky)

Order – Coleoptera **Family** – Chrysomelidae

1. **Distribution:** Pest is distributed in India where the black pepper is cultivated.

2. **Host Plants:** The pest is a specific pest of black pepper in India and occurring regularly.

3. **Marks of Identification:** The adult is a small shining, yellow and blue flea beetle with stout hind legs. The full grown grub is yellowish with a black head and it is 5 mm long.

4. **Life Cycle:** The adult beetles appear in July when the new tender berries appear on the plants. The females make shallow holes on the berries and lay 1-2 eggs in each hole. A female on an average lay about 100 eggs. The hatching period is 5-8 days and the young grubs bore into the berry. The larval period is 20-32 days. Then grubs drop to the ground and pupate in the earthen cell in the soil at 5.0 to 7.6 cm depth. The pupal

period is 6-7 days. The total life cycle is completed in 39 to 50 days. There are four overlapping generations in a year.

5. **Nature & Symptoms of Damage:** The grubs cause damage by boring into the berries and eating the contents completely in about 10 days. Each grub destroys at least 3-4 berries during the larval period. The attacked berries appear dark in colour and hollow inside and crumble when pressed. The grubs may also eat into the spike and cause the entire distal region to dry up. The adults feed voraciously on tender leaves and make holes in them.

Record Work: Write down the IPM practices for the management of pollu beetle infesting black pepper.

Pepper Shoot borer – *Laspeyresia hemidoxa* Meyer.

Order – Lepidoptera **Family** – Eucosmidae

1. **Distribution:** The pest is commonly occurring in Kerla and also found in other states in India.

2. **Host Plants:** This is serious pest of pepper and feeds on it.

3. **Marks of Identification:** The adult is a small beautiful moth with the basal half of the fore wings black and distal half orange red. The caterpillar is a shoot borer which greyish-green in colour and 12 to 14 mm long when full-grown.

4. **Life Cycle:** Pupation takes place in larval tunnel and pupal period is 8 to 10 days.

5. **Nature & Symptoms of Damage:** The growing shoot is killed as a result of the attack by the caterpillar thereby arresting the growth of the young vines.

Record Work: Write down the IPM practices for the management of pepper shoot borer infesting black pepper.

8. INSECT PEST OF FRUIT CROPS

MANGO

Mango hoppers – *Idioscopus clypealis* (Lethiery)

Amritodus atkinsoni (Lethiery)

Idioscopus niveosparsus (Lethiery)

Order – Hemiptera **Family** – Cicadellidae

1. **Distribution:** Mango hoppers are widely distributed in India, Malaysia, Indonesia and Formosa. No alternative host plants of these insects are known.
2. **Host Plants:** Mango.
3. **Marks of Identification:** The nymphs of *I. cylpealis* are dull yellow or dust yellow. Adult of large mango-hopper *I. clypealis* is 6.3 mm long and is grayish. There is three dark brown spots on the pronotum. The black triangular marking on scutellum and a central longitudinal dark streak dilated anteriorly and posteriorly are the characteristics of this species.
4. **Life Cycle:** This pest is active practically throughout the year but during hot months of May-June and cold months of October-January only adults are found sitting in thousands on bark of trunks, branches etc. The adults surviving winter emerge in February from underneath bark of trees and other places of shelter. They cluster on floral buds suck cell sap. When inflorescence appears they start egg laying in then in second or third week of February and continue for some weeks. The eggs are deposited singly and are embedded in plant tissues it is difficult to observe them under natural condition. A female lays average 200 eggs and moderate temperature being more condusive to egg laying. The hatching period is 4 to 7 days. The nymphal period is 8 to 13 days through three stages. The full-fed or full-grown nymphs then moult and give rise to winged hoppers. The life cycle from eggs laying to adults appear is 15 to 19 days.
5. **Nature & Symptoms of Damage:** Mango hopper is most destructive pest of fruit trees. Injury to inflorescence and young shoots is caused by egg-laying and feeding. Inflorescence wither and turn brown and fruit setting may cease. The growth of young trees is much retarded and older trees do not bear much fruits.

Idioscopus clypealis

Amritodus atkinsoni

Idioscopus niveosparsus

Record Work: Write down the IPM practices for the management of mango hopper.

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Mango Fruit fly – *Bactrocera dorsalis* (Hendel)

Order – Diptera **Family** – Tephritidae

1. **Distribution:** Mango fruit fly or oriental fruit fly is most serious of all fruit-flies and is widely distributed in India and South-east Asia.

2. **Host Plants:** Pest feeds on mango, guava, peach, apricot, cherry, pear, chiku spota, ber, citrus and other plants totaling more than 250 hosts.

3. **Marks of Identification:** The full-grown legless maggots are 8 to 9 mm long and 1.5 mm across the posterior end and are yellow and opaque. The adult is stout, little larger than ordinary house fly and 14 mm across wings span and 7 mm in body length. It is brown and has almost transparent wings with yellow legs and dark rust-red and black patterns on thorax.

4. **Life Cycle:** This pest is active during summer months and pass winter (November to March) as a hibernating pupa in soil. The flies are most active in gardens at 25°C to 30°C and they become inactive below 20°C. Adult life is about 4 months. Fly mate at dust for one hour or more. 10-15 days old fly lays 2-15 eggs at a time in clusters, 1-4 mm deep in soft skin of fruit with the help of sharp ovipositors. Female lays on an average 50 eggs but under favourable conditions 150-200 eggs are laid in one mouth. The hatching period 2-3 days in March-April, 1 to 1.5 days in summer and 10 days during winter. The larval period is 6 to 29 days through 3 stages. Full-fed larvae leaves fruit and bury into soil and pupate in soil upto 8-13 cm deep and pupal period is 6 to 44 days. The life cycle is completed in 2 to 13 weeks and many generations in a year.

5. **Nature & Symptoms of Damage:** Maggots are very destructive and cause heavy losses to all kinds of fruits. The infested fruits become unmarketable and at a times almost all of them contain maggots.



Record Work: Write down the IPM practices for the management of mango fruit fly.

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Mango – Stone weevil – *Sternochetus mangiferae* (Fabricius)

Order – Coleoptera **Family** – Curculionidae

1. **Distribution:** The pest is widely distributed throughout the tropics. The exports of mango fruits from India to USA has been banned to prevent the entry of this weevil.

2. **Host Plants:** Mango.

3. **Marks of Identification:** This is a short stoutly built, ovoid, dark brown weevil which is found inside the stone of mango fruit or in its pulp.

4. **Life Cycle:** The weevils are inactive from July-August onwards when they remain concealed in soil or underneath the bark of mango trees. They become active as soon as formation of mango fruits takes place. The weevils lay eggs in skin or ripening fruit. The wound caused by ovipositor heals soon after and fruit does not exhibit any outward sign of infestation. On emergence from egg the grub moves further inwards, eating its way through unripe tissue until it bores into embryo of mango stone. The weevil cuts its way through stone and pulps comes out. The life cycle is completed in 40-50 days but emerging adults become inactive and resume breeding only in next season and single generation in a year.

5. **Nature & Symptoms of Damage:** The insect attacks mango varieties of relatively soft flesh. The injury caused by larvae feeding in pulp sometimes heals over but certain number of fruits always get spoiled when weevils make an exit through ripe or near-ripe mangoes.



Record Work: Write down the IPM practices for the management of mango stone weevil.

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Mango stem borer – *Batocera rufomaculata* DeGeer

Order – Coleoptera **Family** – Cerambycidae

1. **Distribution:** This beetle has wide range of distribution in India and found in north-western parts of Indian sub- continent.

2. **Host Plants:** The pest feed on mango, fig and other trees.

3. **Marks of Identification:** The full-grown larva is a stout, yellowish-white, fleshy grub and is 6 mm long. Its head is dark with strongly developed mandibles. The adults are longicorn beetles, well built, large and pale grayish and about 5 cm long and 2 cm wide. Beetle has long legs and antennae and dirty white band extending from the head to tip of body on each side. Number of dirty yellowish spots on elytra. Head is distinct by large eyes and pronotum is ornamented with two crescent orange-yellow spots.

4. **Life Cycle:** The life cycle is prolonged and adults generally appear during monsoon. The eggs are deposited under loose bark in a wounded or diseased portion of trunk or branch. The grubs are equipped with strong biting mouth parts and they penetrate into stem or even roots, feeding on woody tissues. Winter is passed in grub stage in that same burrow. They again start feeding as soon as weather warms up in spring season and during feeding process bore through wood by cutting large galleries. The full-grown larvae then hollow out a cell for pupation. The larval period is one month. The life cycle may be completed in 1 to 2 years.

5. **Nature & Symptoms of Damage:** Although borer is not very common, yet whenever it appears in the main trunk or a branch, it invariably kills the host plant. Though external symptoms of attack are not always visible, the site can be located from sap or frass that comes out of holes. The mango stem borer is also found in newly fallen trees.



Record Work: Write down the IPM practices for the management of mango stem borer.

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Bark eating caterpillar – *Indarbela quadrinotata* (Walker)

Order – Lepidoptera **Family** – Metarbelidae

1. **Distribution:** The pest is widely distributed in Myanmar, Bangladesh, Sri Lanka and India.

2. **Host Plants:** The bark eating caterpillars of the moth *Indarbela quadrinotata* feed on mango, citrus, guava, Jamun, Loquat, mulberry, pomegranate, ber, drumstick, litchi, amla, rose and a number of forest and ornamental trees.

3. **Marks of Identification:** The freshly hatched larvae are dirty brown while full-grown caterpillars have pale brown bodies with dark brown head and 50-60 mm long. The adults are pale brown moths with rufous head and thorax. The fore wings are pale rufours with numerous dark rufons bands. The hind wings are fuscous (dark colourd).

4. **Life Cycle:** With the start of summer season moths emerge and become active. The females lay eggs in cluster of 15-25 eggs each under loose bark of trees. The egg laying continues throughout summer and as many as 200 eggs may be laid by a single female. The hatching period is 8-10 days and freshly hatched larvae nibble at bark and after 2-3 days bore inside. The larvae make webs along feeding galleries and above holes where they bore deeper into wood. The galleries and webs above them have zig-zag shape and contain wooden frass and excreta. Larval period is 9-11 months and pupate inside the wooden hole. Pupal period is 3-4 weeks only one generation in a year.

5. **Nature & Symptoms of Damage:** Thick, ribbon like silken webs are seen running on bark of main stem especially near forks. The larvae also make holes and as many as 16 holes may be seen on a tree and one caterpillar or pupa occupying each hole. The severe infestation may result in death of attacked stem but not of the main trunk. The infestation of *Indarbela* may be interference with translocation of cell sap and thus *aerostation* of growth of tree is noticed which reduce the fruiting capacity of tree.

Record Work: Write down the IPM practices for the management of bark eating caterpillar infesting mango.

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Mango mealy-bug – *Drosicha mangiferae* (Green)

Order – Hemiptera **Family** – Margarodidae

1. **Distribution:** The mango mealy-bug is widely distributed in the Indo-Gangetic plans from Punjab to Assam.

2. **Host Plants:** Besides mango, it also attacks 62 other plants including such trees as jack-fruit, banyan, guava, Papaya, citrus fruits and jamun.

3. **Marks of Identification:** The nymphs and wingless females which are oval, flattened and have body covered with a white mealy powder. The males have one pair of black wings and are crimson red.

4. **Life Cycle:** This pest is active from December to March and spends rest of year in the egg stage. The eggs are generally deposited in April-May in soil upto 15 cm within silken purses. In the crevices or in loose soil egg purses may be found as deep as 60 cm. The egg is 1mm long and 0.7 mm broad, is oval shining pink when newly laid and become paler later on. The eggs hatch at end of December or in January and in given locality continue to hatch for one month.

   Mating takes place soon after emergence of males at a time when females are not fully developed. The males fly about in large numbers apparently in search of their mates. They have a very strong sex instinct and during life-span of about one week they mate frequently. Females mature after 15-35 days and lay eggs for 22 to 47 days during April-May.

5. **Nature & Symptoms of Damage:** Mealy bug is an important pest of mango next to the mango hoppers. Only nymphs are destructive and they suck plant juice, causing tender shoots and flowers dry up. The young fruits also become juiceless and drop off. The pest is responsible for considerable loss to mango and when there is serious attack, the trees, retain no fruits at all.



Record Work: Write down the IPM practices for the management of mango mealy bug.

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CITRUS

Fruit sucking moth – *Othreis fullonica* (Linnaeus)

Othreis materna Linnaeus, *Ophideres materna* Cramer and *Ophideres conjuncta* Cramer, *O. ancilla*

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** The fruit sucking moth is distributed throughout India. *Ophideres conjuncta* Cramer, *O. materna* Cramer, and *O. ancilla* Cramer are the common species found in Tamil Nadu, Madhya Pradesh, West Uttar Pradesh and Punjab.

2. **Host Plants:** The fruit-sucking moth is miner pest of citrus, mango, grapes and apple.

3. **Marks of Identification:** The moth is large and stoutly built and prominent palpi are turned up wards. The body of *O. conjuncta* is faint orange brown. Fore wings are dark grey and hind wings are ornage red and two black curved patches. Larvae are typical semiloopers. Their velvety dark brown back ground and other patterns make them cryptic. They have distinct eye spots on the head, yellow or red lateral spots and dorsal hump on last segment of body. Full grown larvae is 50-60 mm long and when disturbed it assumes a characteristic posture by curving round the head and raising the hind part of body.

4. **Life Cycle:** The moths are nocturnal and are not seen during the day. They lay eggs on wild plants and weeds. The eggs are round translucent and 1 mm in diameter. The hatching period is two weeks and within 24 hours young larvae start feeding on foliage of host plants. The larval period is four weeks through five instars pupation in pupal case of leaves and soil particles. Pupa is thick-set and is dark reddish brown. Pupal period is two weeks. The adult life is one month in spring. The third brood pupae hibernate in winter.

5. **Nature & Symptoms of Damage:** The fruit-piercing moths cause damage in the adult stage. With the help of strong, piercing mouthparts, moth punctures the fruit for sucking juice. Bacterial and fungal infections take place at the site of attack, with the result that the brownish mouth of a puncture becomes pale and the whole fruit turns

yellow. The fruit drops off the tree and looks like a premature fruit. If the damaged fruit is squeezed the juice spurts from the hole. In severe infestation all fruits are damaged.



Record Work: Write down the IPM practices for the management of fruit sucking moth infesting citrus.

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Lemon butterfly or citrus caterpillar – *Papilio demoleus* (Linnaeus)

Order – Lepidoptera **Family** – Papilionidae

1. **Distribution:** The citrus caterpillar or lemon butterfly, is found in Africa, greater part of Asia as far as Formosa and Japan. It has been reported all over India and causes very severe damage.

2. **Host Plants:** The pest feeds and breeds on all varieties of cultivated and wild citrus and various other species of the family rutaceae.

3. **Marks of Identification:** Earlier instars are looks like bird droppings but the full-grown caterpillar is yellowish green has a horn-like structure on the dorsal side of the last body segment and is 40 mm long and 6.5 mm wide. The adult is a large beautiful butterfly, 28 mm in length and 94 mm in wing expanse. The head and thorax are black and creamy-yellow coloration on the underside of abdomen. The wings are dull-black with yellow markings. The general colouration on underside of wings is slightly paler and marking are also larger. The antennae are black and have club like structure at their ends.

4. **Life Cycle:** In plains this pest is found throughout year but in mountain during winter hibernate in pupal stage. The butterfly appear in March and lays eggs on tender shoots and fresh leaves on under surface. Eggs laid singly or in groups of 2-5. The eggs are also seen on thorns of citrus and on other plants. The fresh eggs greenish yellow or pale and turn brown, dark grey later on. The hatching period is 3 to 4 days in summer and 5 to 8 days in winter. Larvae first feeds on egg shell and eat their own exuvae after each moulting. Larval period is 8 to 16 days in summer and 4 weeks in November-December. The mature larvae spins a supporting girdle around its body and pupate on twing, a dry stick or any raised structure. Pupal period is 8 days in summer and 9 to 11 days in spring and autumn. Female usually mates once and lays average 75 to 120 eggs within 2-5 days. The less number eggs are laid in summer. Adult life of male is 3-4 days and female adult life is of week and there are 3 to 4 generations in a year.

5. **Nature & Symptoms of Damage:** The young larvae feed only on fresh leaves and terminal shoots. Habitually they feed from the margin inwards to midrib. In later stage they feed on mature leaves and sometimes the entire plant may be defoliated. The pest is devastating in nurseries and damage to foliage seems to synchronize with fresh growth of citrus plants in April and August-September. Heavily attacked plant do not bear fruits.

Larva **Adult**

Record Work: Write down the IPM practices for the management of lemon butterfly infesting citrus.

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Citrus leaf miner – *Phyllocnistis citrella* Stantion

Order – Lepidoptera **Family** – Phyllocnistidae

1. **Distribution:** This insect is widely distributed in India and also serious pest in nurseries.

2. **Host Plants:** It feeds on citrus and also feeds on ponelo, willow, cinnamon and *Loranthus* spp.

3. **Marks of Identification:** The full-grown larvae 5.1 mm long and is pale yellow or pale green with high brown and well developed mandibles. The adult is a tiny moth and 4.2 mm across wings. Brown stripes on fore wings and prominent black spots along tips. The hind wings are pure white and both pairs of wings are fringed with hairs.

4. **Life Cycle:** The moths lay minute, flattened, transparent egg on young leaves or tender shoots on lower surface near midrib, singly two or three per leaf. The hatching period is 2 to 10 days. The legless larvae mine into leaf tissue and form galleries. Larval period is 5 to 30 days and mature larvae settle down in enlargements of the galleries near leaf margin. Pupation takes place in cocoon in folded leaves. The pupa is as same as larva but turns brownish. The pupal period is 5 to 25 days. The moths are resting on trunks of trees near grown. Life cycle is completed in 12-55 days and several overlapping generations in a year.

5. **Nature & Symptoms of Damage:** Damage is serious on young leaves. The injured epidermis takes the shape of twist silvery galleries. On older leaves brownish patches are formed which serve as foci of infestation for citrus canker. The attacked leaves remain on plants for long time and gradually damage spread to fresh leaves. The

young nurseries are most severely affected and young plants of orange and grape fruits may not survive. In large trees photosynthesis affected and also ruled vitality and cause yield loss.

Mines in leaf

Larva

Adult

Record Work: Write down the IPM practices for the management of citrus leaf miner.

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Citrus psylla – *Diaphorina citri* Kuwayana

Order – Hemiptera **Family** – Aphalaridae

1. **Distribution:** The citrus psylla is distributed throughout orient (East) and has been reported from India, China, Formosa, Japan, Myanmar, Sri Lanka, the East Indies, and New Guinea.

2. **Host Plants:** In India it has been recorded on all species of citrus and number of other plants of family Rutaceae.

3. **Marks of Identification:** The adult is small, 3 mm long, active in habits and rests on leaf surface with closed wings, and tail end of body being turned upwards. The insect is brown with head lighter brown and pointed. The wings are membranous, semi-transparent and a brown band in the apical half of fore wings. The hind wings are shorter and thinner than fore wings. The nymphs are flat louse-like and orange yellow creatures and congregated in large numbers on young leaves and buds.

4. **Life Cycle:** The pest is active throughout the year but life cycle prolonged in winter. Only adults are to be found in very cold winter. Breeding start in February-March and lays on an average 500 almond-shaped, orange and stalked eggs on tender leaves and shoots of citrus trees. The eggs are laid singly or in groups of 2 of 3 and are arranged in straight line and there may be as many as 50 eggs in one place. The hatching period is 10-20 days in winter and 4 to 6 days in summer. Newly emerged nymphs are found congregated on young half open leaves but later migrate to older leaves. The nymphal period is 10-11 days from April to September, 15-20 days in spring and autumn and 34 to 36 days in December-January through five stages. Natural mortality among nymphs varies in different seasons of year. The adults copulate 4-8 days after emergence and females start eggs laying immediately afterwards. There is a great variation in longevity of adults in various seasons. The females live longer than males and duration may be as long as 190 days in winter and only 12-26 days in summer. The life cycle is

completed in 14 to 17 days in summer and there are 8 to 9 overlapping generations in a year.

5. **Nature & Symptoms of Damage:** Only nymphs are harmful to plants. They suck the cell sap in millions. The vitality of plants deteriorates and young leaves and twings stop further growth. The leaf-buds, flower buds and leaves may wilt and die. The fruits fall off prematurely. Nymphs secrete drops of sweet thick fluid on which black fungus develops which adversely affect photosynthesis. The insect produces a toxic substance in plants as a result of which fruits remain undersized and poor in juice and insipid in taste. This insect is responsible for spreading the greening virus. Its infestation is continued for one or two year the plants may be killed.

NYMPHS

ADULT

Record Work: Write down the IPM practices for the management of citrus psylla.

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GRAPEVINE

Grape flea beetle – *Scelodonta strigicollis* Motschulsky

Order – Lepidoptera **Family** – Chrysomelidae (Eumolpidae)

1. **Distribution:** The pest is widely distributed in India and found in Maharashtra, Punjab, Andhra Pradesh, Tamilnadu, Rajasthan etc.

2. **Host Plants:** A common and specific pest on grapevine.

3. **Marks of Identification:** The eggs are cigar shaped cream coloured and 1 mm long. The grubs are creamy white. The adult beetles are small, copper-coloured and emerge from the soil and have three black or copper shining spots on each elytra.

4. **Life Cycle:** The pest is active from March to October. The female beetles lay eggs under the loose bark and cracks and crevices on the vine stem or truck in cluster and rarely laid on leaves. A female may lay 200-600 eggs. The hatching period is 4-8 days. The grubs after hatching drop down on ground and enter into the soil and feed on cortical portion/region of the roots. The larval period is 34-45 days. They pupate in earthen cells in the soil up to a depth of 60-80 mm and pupal period is 7-11 days. The

average life cycle of the pest is seven to nine weeks. There are three to four generations in a year.

5. **Nature & Symptoms of Damage:** The grubs feed on cortical portion/region of the roots. The adults are more destructive than grubs. Soon after pruning adult beetles feed voraciously on the new buds and turning it into a "dried sprout". Later it causes longitudinal slits on the lamina of the leaves.



Record Work: Write down the IPM practices for the management of grape flea beetle.

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BANANA

Banana aphid – *Pentalonia nigronervosa* (Coquerel)

Order – Hemiptera **Family** – Aphididae

1. **Distribution:** The pest is probably native to Southeast Asia, the banana aphid is present just about everywhere, because banana is grown throughout the world. It occurs in tropical Africa, Atlantic Islands, Australia, Califarnia, Central America, Cook Islands Egypt, Fiji, Florida, Hawaii, Kiribati, India, Indonesia, Malaysia, Madagascar, Marshall Islands, Mauritius, Mexica, Micronesia, the middle East, Mozambique, New South wales, Papau New Guinea, the Philippines, Reunion, Samoa, North South America, Taiwan, Tokelau, Tonga, Tuvalu, Vanautu, Wallis Islands and West Indies.

   The banana aphid was first recorded in the state in 1924 from Honolulu.

2. **Host Plants:** The preferred host of this aphid is banana. It also infest many tropical and subtropical food and ornamental plants, including *Alpinia purpurata, Xanthosoma*, Cardamom, Heliconia, tomatoes, taro, calla, costus, kahili ginger, tourch ginger and Zingiber, Colocasia.

3. **Marks of Identification:** Newborn nymphs are oval at first and become elongated later on. They are reddish brown and have four segmented antennae and 1/250 inch long. Second stage nymph same as first and 7/250 inch long. Third stage nymph light

brown and 9/250 inch long and have five segmented antennae. Fourth stage nymph have six segmented antennae & 1/25 inch long. Adults are small to medium size 1/25 to 1/12 inch, reddish to dark brown or almost black. Adult has six segmented antennae and prominent wing veins.

4. **Life Cycle:** Reproduction in the banana aphid is entirely parthenogenetic (without mating). Females give birth to live female young. Males are not known for this species. The adult life span ranges from 8 to 26 days, their could be as many as 30 generations in a year in Hawaii. The nymph has four stage of moulting. First stage in 2 to 4 days, second in 3 to 4 days, third in 2 to 4 days and fourth in 2 to 4 days.

5. **Nature & Symptoms of Damage:** The nymphs and adults both suck the sap from leaves and cause plants to become deformed, the leaves become curled and shriveled and also galls are formed on leaves in some cases. The honeydew is excreted by aphids which develop sooty mold and hamper the phosynthetic activity of plants. Aphid act as vector for transmission of viral diseases.



Record Work: Write down the IPM practices for the management of banana aphid.

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POMEGRANATE

Anar butterfly – *Virachola isocrates* (Fabricius)

Order – Lepidoptera **Family** – Lycaenidae

1. **Distribution:** Anar butterfly is widely distributed all over India and the adjoining countries.

2. **Host Plants:** Anar butterfly is polyphagous pest and feeds on anar, aonla, apple, ber, citrus, guava, litchi, loquat, mulberry, peach, pear, plum, sapota and tamarind.

3. **Marks of Identification:** The full-grown caterpillars are 17-20 mm long, dark brown, and have short hairs and whitish patches all over the body. The adult butterflies are glossy-bluish-violet (males) to brownish violet (females) in colour with an orange patch on fore wings. The wing expand is 40-50 mm.

4. **Life Cycle:** The pest breeds throughout the year on one fruit or other. The female butterfly lays shiny white oval shaped eggs singly on the calyx of flowers and on small fruits. The eggs hatch in 7-10 days and young larvae bore into developing fruits. The larval period is 18-47 days. Pupate inside the fruit but occasionally may pupate outside

even attaching to the stalk of fruit. Pupal period is 7-34 days and four overlapping generations in a year.

5. **Nature & Symptoms of Damage:** The caterpillars damage the fruits by feeding inside and riddling through the ripening seeds of pomegranate. As many as eight caterpillars may be found in a single fruit. The infested fruits are also attacked by bacteria and fungi which cause fruit to rot. The affected fruits ultimately fall off and give an offensive smell.



Record Work: Write down the IPM practices for the management of anar butterfly.

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GUAVA

Guava Fruitfly – *Bactrocera dorsalis* (Hendel)

Order – Diptera **Family** – Tephritidae

Guava fruits are attacked by five species of fruit flies, *viz*., *B.dorsalis*, (Hendel), *B. diversus* (Coquillett), *B. cucurbitae* (Coquillett), *B. nigrotibialis* (Perkins) and *B. zonata* (Saunders).

1. **Distribution:** Fruit fly is widely distributed in India and South-East Asia and also recorded in Malaysia, Indonesia, Formosa, Philippines, Australia and Hawaii Islands.

2. **Host Plants:** Pest feeds on guava, peach, apricot, cherry, pear, spota, ber, citrus, mango and other plants total more than 250 hosts.

3. **Marks of Identification:** The legless maggots, when full-grown is 8-9 mm long and 1-1.5 mm across the posterior end and are yellow opaque. The adult is stout and larger than ordinary housefly and 14 mm across wings and 7 mm in body length. Fly is brown and has transparent wings, yellow legs and dark rust-red & black patterns on thorax.

4. **Life Cycle:** This pest is active during the summer months and pass winter (November to March) as a hibernating pupa in soil. The adult fly emerge in April and reach ripening fruits of season. The flies are most active in garden when temp. ranges from

25°C to 30°C and become inactive below 20°C. The adult life is 4 months and feed on exudations of ripe fruits and honey dew of various insects. Fly mate at dusk for one hour or more and 10-15 days old female lays 2-15 eggs at a time in clusters 1-4 mm deep in soft skin of fruit with sharp ovipositors. Female lays 50 eggs but in favourable condition it may lays 150-200 eggs in one month. The hatching period is 2-3 days in March-April and 1-1.5 days in summer and 10 days in winter. Larval period (maggot development) is 6-29 days in 3 stages in ripening pulp. Pupate in soil 8-13 cm below surface. Pupal period is 4-44 days. The life cycle is completed in 2-13 weeks and many generations in a year.

5. **Nature & Symptoms of Damage:** Maggots are very destructive and cause heavy losses to all kinds of fruits. The infested fruits become unmarketable and at times almost all of them contain maggots.

Record Work: Write down the IPM practices for the management of guava fruit fly.

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SAPOTA

Sapota leaf webber – *Nephopteryx eugraphella* Ragonot

Order – Lepidoptera **Family** – Pyralidae

1. **Distribution:** The leaf webber is a common and major pest of sapota and occurs widely or distributed widely throughout India.

2. **Host Plants:** Pest feeds on sapota, *Mimusops elengi* and cured tobacco etc.

3. **Marks of Identification:** The adult moth is grey in colour. The larva is 25 mm long, slender in body shape and pinkish and has few longitudinal lines on the dorsal surface.

4. **Life Cycle:** The pest is found throughout the year but the activity increases with the appearance of new shoots and buds. The maximum activity of pest is seen during June-July and minimum during winter. With the onset of spring season the female moths start laying pale-yellow, oval shaped eggs singly or in batches of 2 to 3 on leaves and buds of young shoots. A female may lay as many as 374 eggs in 7 days. The hatching period is 2-11 days. The larval period is 13-60 days. Pupation in the leaf-webs and pupal period is 8-29 days. The life cycle is completed in 26-92 days depending upon varying environmental conditions. There are 7 to 9 generations in a year.

5. **Nature & Symptoms of Damage:** The larvae clump the leaves together and feed on green matter of leaves, often on buds and flowers and sometimes on tender fruits as well. The larvae bore into the buds, which wither, and then they move on to next buds, damaging many of them. The infestation of this pest can be easily spotted by presence

of webbed shoots, the appearance of dark brown patches on leaves and clusters of dead leaves.

Record Work: Write down the IPM practices for the management of sapota leaf webber.

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BER

Ber fruitfly – *Carpomyia vesuviana* Costa

Order – Diptera **Family** – Tephritidae

1. **Distribution:** This pest is widely distributed in India, Pakistan and Southern Italy.

2. **Host Plants:** It is most destructive to ber fruits of the species *Zizyphus mauritiana* Lamk and *Z. jujuba* Mill in India and *Zizyphus sativa* in Italy.

3. **Marks of Identification:** The larva are creamy white and slightly smaller than those of other fruit-flies. Adult smaller than housefly and brownish yellow and brown longitudinal strips on the thorax. The black spots on the sides and the back. The greyish brown spots on wings and bristly hair on the tip of the abdomen.

4. **Life Cycle:** The flies are very fast fliers but females can easily caught when ovipositing on very young fruits. At the age of one month, the flies make cavities in the skin of fruit and lay one or two spindle-shaped creamy-white eggs, 1 mm below the skin, leaving behind a resinous material. There is no further growth of the fruit in the vicinity of this puncture and hence fruits become deformed. The hatching period is 2-3 days and maggots feed on flesh by making galleries towards center and fruit rot near stone and as many as 18 maggots have been recorded from one fruit. The larval period is 7-10 days and pupation takes place in soil at 6 to 15 cm below soil surface. The pupal period is 14-30 days. The shortest life cycle from egg to the adult is completed in 24 days and 2-3 broods in a year.

   The pest becomes active in the autumn and builds up population in the winter, reaching a peak in February-March. At that time all the late-maturing ber fruits are found riddled with maggots.

5. **Nature & Symptoms of Damage:** The maggots feed on the flesh of the fruit by making galleries towards center. The attacked fruits are rotten near stones and emit a strong smell.

Record Work: Write down the IPM practices for the management of ber fruitfly.

★ ★ ★ ★ ★

APPLE

Woolly apple aphid – *Eriosoma lanigerum* (Hausmann)

Order – Hemiptera **Family** – Aphididae

1. **Distribution:** This pest is widely distributed in India and Pakistan. The wooly apple aphid known to have world wide distribution.

2. **Host Plants:** Pest feeds on apple, pear and crab-apple (*Pyrus baccata*), hawthorn, mountai ash etc.

3. **Marks of Identification:** The purplish aphid is covered by white cotton mass.

4. **Life Cycle:** The pest is most active during March-September and multiplies at a reduced pace during October-December. The development from December to February is extremely slow. The aphid reproduce parthenogenetically and the progeny thus produced consists of females only. Each female may produce up to 116 youngones in her lifetime at the rate of 1-4 nymphs per day in March-April, 1-5 in May-July, 1-6 in August and only 1-2 per week in winter. The total duration of the nymphal period is 35-42 days in February, 29.5 days in August-November and 10.5-19.5 days in April-July. The winged forms appear in July-September when fresh colonies on new plants or branches are initiated. There may be 13 generations in a year.

5. **Nature & Symptoms of Damage:** The aphids suck cell-sap from the bark of the twigs and from the roots underground. Swellings or knots appear on the roots which hinder the normal plant functions. Owing to the loss of cell-sap the twigs also shrivel and the young nursery plants, which are affected the worst may die quickly.



Record Work: Write down the IPM practices for the management of woolly apple aphid.

★ ★ ★ ★ ★

San Jose Scale – *Quadraspidiotus perniciosus* (Comstock)

Order – Hemiptera **Family** – Diaspididae

1. **Distribution:** This insect is distributed world-wide and is the most serious pest in temperate regions.

2. **Host Plants:** Pest feeds on nearly 700 different species of fruits, shrubs and ornamental plants. It usually prefers plants belonging to the family Rosaceae such as apple, plum, pear and peach.

3. **Marks of Identification:** The covering on the body of the insect is black or brown. Underneath a lemon-yellow insect is visible when the covering is lifted.

4. **Life Cycle:** The pest is active from March to December and passes the winter in nymphal stage. Each female may give birth to 200-400 nymphs. The newly-born nymphs crawl out of the parental scale and lead a free life for 12-24 hours. After finding suitable place they insert their mouth parts into the plant tissue and begin to feed by sucking the cell sap. The nymphal period is 3-40 days and females give again birth to young ones within next 10-14 days. The life of gravid female is 50-53 days. The male nymph becomes adult in 25-31 days. The adult life of male is 24 to 32 hours. Four overlapping generation in a year.

5. **Nature & Symptoms of Damage:** All parts of the plant above the ground are attacked and the injury is due to loss of the cell sap. At first the growth of the infested plant is checked, but as the scales increase in number the infested plants may die.

Record Work: Write down the IPM practices for the management of san jose scale infesting apple.

★ ★ ★ ★ ★

COCONUT

Rhinoceros beetle or Black palm beetle – *Oryctes rhinoceros* (Linnaeus)

Order – Coleoptera **Family** – Scarabaeidae

1. **Distribution:** It is found in Maharashtra, Tamilnadu, Kerla, Andhra Pradesh, Orissa, Assam and West Bengal.

2. **Host Plants:** Coconut, Date palm.

3. **Marks of Identification:** The stoutly build bettle has a pointed horn on its head and is elongate and cylindrical and about 4.5 cm long. It have well developed wings. It is harmful only in the adult stage. The larvae, however, feed on decaying organic matter in the ground.

4. **Life Cycle:** The oval white, seed like eggs are laid 5-15 cm below the soil surface in decaying organic matter. A female lay 100-150 eggs and hatching period is 8 to 18 days. The grubs start feeding on the decaying matter found in vicinity. The larval period is 99-182 days (mean 130 days) in three stages. Pupation takes place in earthen cells at bout 30 cm depth and pupal period is 10-25 days. They remain in the pupal cell for about 11-20 days before coming out of the soil. Soon they fly to the nearer coconut tree and start attack. They lay eggs after 20-60 days. The beetles are active at night and may be attract to a source of light. The adults can live for 200 days and one generations in a year.

5. **Nature & Symptoms of Damage:** The adult beetle attacks the crown and bores into the tender parts, especially in the axils of the leaves. The beetle throw out the fibrous mass while feeding in the burrows made in the young fronds. The series of holes are seen on the fronds when they open out. As a result, the growing point is soon cut off and the tree dies. The damage is more serious on young trees.

Record Work: Write down the IPM practices for the management of rhinoceros beetle infesting coconut.

★ ★ ★ ★

Red palm weevil – *Rhynchophorus ferrugineus* (Oliver)

Order – Coleoptera **Family** – Curculionidae

1. **Distribution:** The pest is found in Andhra Pradesh, Kerala, Tamilnadu, Orissa, Karnataka and Maharashtra.

2. **Host Plants:** Coconut, date palm.

3. **Marks of Identification:** This weevil is reddish brown, cylindrical, with a long curved snout. The male has tuft of hairs along the dorsal surface of the snout, whereas the female is without it. The weevil is incapable of causing direct damage but in the early stage it is harmful. The grubs are yellowish and 65 mm in length.

4. **Life Cycle:** The mother weevil scoops out a small hole with its snout in the soft tissues of the trees or in the existing wounds in the crown or trunk and lays an oval, whitish eggs. A weevil may lay up to 200-500 eggs in its life span of 3-4 months. The hatching period is 2-5 days. The larval period is 2 to 4 months. The pupation takes place in cocoon spined by mature grubs. The pupal period is about 14 days. The adults remain in the case for 11-13 days. The male survive for a longer period than the female.

5. **Nature & Symptoms of Damage:** The larvae feed on the soft tissue of trees and bore into the soft growing parts. The weevil is attracted to the trees by the smell of coconut palm juice, which flows as a result of the wounds caused by man or other agents. The dead palms also attract these insects.

GRUB

ADULT

Record Work: Write down the IPM practices for the management of red palm weevil infesting coconut.

★ ★ ★ ★ ★

Black-headed caterpillar – *Opisina arenosella* (Walker)

Order – Lepidoptera **Family** – Cryptophasidae

1. **Distribution:** The pest is found in all over peninsular India but more injurious along the east and west coasts. Andhra Pradesh, Kerala, Tamilnadu, Karnataka, Maharashtra, Orissa, and West Bengal. In west coast it is prevalent during January-May and in east coast during April-June.

2. **Host Plants:** Feeds on coconut, date palm.

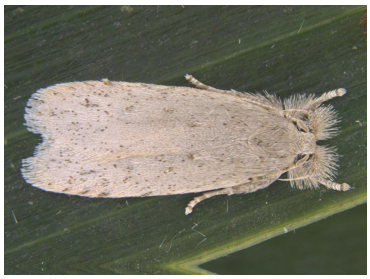
3. **Marks of Identification:** The caterpillar is greenish brown with dark brown head and prothorax, and a reddish mesothorax. The moth is small and grayish white.

4. **Life Cycle:** The greyish white small moth lays about 130 eggs in groups on leaves. The hatching period of egg is about 5 days. The larval period is about 40 days. 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. The pupal period is about 12 days.

5. **Nature & Symptoms 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.

LARVA

PUPA



ADULT

Record Work: Write down the IPM practices for the management of black headed caterpillar infesting coconut.

★ ★ ★ ★ ★

TOBACCO

Tobacco cutworm or Tobacco caterpillar – *Spodoptera litura* (Fabricius)

Order – Lepidoptera **Family** – Noctuidae

1. **Distribution:** The tobacco caterpillar is found throughout the tropical and sub-tropical parts of the world. It is widespread in India.

2. **Host Plants:** It feeds on tobacco, castor, groundnut, tomato, sunflower, cabbage and various other cruciferous crops.

3. **Marks of Identification:** The caterpillars are 35-40 mm long and they are velvety black with yellowish-green dorsal strips and lateral white bands. The moths are about 22 mm long and 40 mm across wings spread. The fore wings have beautiful golden and grayish brown patterns.

4. **Life Cycle:** This pest breeds throughout the year although its development is considerably retarded during winter. The moths are active at night when they mate and

the female lays about 300 eggs in clusters. These egg clusters are covered over by brown hair and hatching period is about 3-5 days. The larvae feed gregariously for the first few days and then disperse to feed individually. The larval period is 15-30 days through 6 stages. The full grown larva enter the soil and pupate in the soil. The pupal period is 7 to 15 days. The adult moth's life is 7 to 10 days. The life cycle is completed in 32-60 days and eight generations in a year.

5. **Nature & Symptoms of Damage:** The larvae feed on leaves and fresh growth. They are mostly active at night and cause extensive damage, particularly in tobacco nurseries.



Record Work: Write down the IPM practices for the management of tobacco caterpillar.

★ ★ ★ ★

COFFEE

Coffee white borer – *Xylotrechus quadripes* Ch.

Order – Coleoptera **Family** – Cerambycidae

1. **Distribution:** The pest is found where coffee is cultivated in kerala, Tamilnadu and Karnataka.

2. **Host Plants:** The pest feeds on coffee.

3. **Marks of Identification:** The grub is dirty white in colour. The beetle has white cross bands and dark brown elytra.

4. **Life Cycle:** The eggs are laid under the bark or inside the cracks and crevices of the stem. The hatching period is about 8-10 days. The grub is dirty white in colour and at

first tunnels under the bark and then bores inside the stem. As the grub bores, frass like wooden material chewed by the grub is ejected out of the tunnel. The larval period is 8-9 months. The pupation takes place inside the tunnel in the stem and pupal period is 25-30 days. The total life cycle takes about a year. The adults emerge in large numbers at two distinct periods *viz.* April-May and October-November. A beetle lays about 50-100 eggs.

5. **Nature & Symptoms of Damage:** The borer- affected plants show yellowing and withering of the leaves in the beginning. This is followed by the drying up of the branches. Young coffee plants are more susceptible than grown up ones.

Record Work: Write down the IPM practices for the management of coffee white borer.

★ ★ ★ ★ ★

Green scale – *Coccus viridis* (Gr.)

Order – Hemiptera **Family** – Coccidae

1. **Distribution:** This pest is found in Tamilnadu, Karnataka and Kerla.
2. **Host Plants:** Pest feeds on coffee.
3. **Marks of Identification:** The newly hatched nymphs is pale green in colour, minute, flat but oval in shape. The adult scale insects are flat yellowish green ovate and slightly convex and 3 mm long.
4. **Life Cycle:** The adult scale insects are flat, oval and pale green or yellowish green in colour. They live throughout the year on the plant and breed. The female scale reproduces asexually. The eggs develop inside the body of the adult scales and hatch out while passing outside the body or immediately after it.

   The newly hatched nymph is yellowish green or pale green in colour, minute, flat but oval in shape. The nymph passes through three stage before developing into an adult.

The adult lives for 3 to 7 months and produces about 50 to 100 young ones during its life time.

5. **Nature & Symptoms of Damage:** These tiny insects suck the cell sap and impair (check or damage) the growth of coffee plants. The scales exude honey-dew which develop black sooty mould and hamper the photosynthesis of plant and cause damage to the plants.



Record Work: Write down the IPM practices for the management of coffee green scale.

★ ★ ★ ★

TEA

Tea-mosquito bug – *Helopeltis theivora* (Water house)

Helopeltis antonii Sign.

Order – Hemiptera **Family** – Miridae

1. **Distribution:** The pest is found in Assam, West Bengal, Kerala, Tamilnadu and Karnataka.

2. **Host Plants:** Pest feeds on tea.

3. **Marks of Identification:** The adult is dark in colour and loves warm and moist climatic conditions for breeding. It flies short distances from one bush to another and rests under shady places.

4. **Life Cycle:** The bugs lay eggs on the stalks of the young leaves. The hatching period is 5-10 days from June to October. The nymphs soon after emergence start feeding on young leaves. The nymphal period is 9 to 13 days through five moultings.

5. **Nature & Symptoms of Damage:** The adult bugs and nymphs suck the cell sap from the tender leaves, buds and stem. The punctured places on the leaves develop a small brown spot about 3 mm in diameter. After some time such spots soon turn black and ooze out brown fluid from centre. The leaves with several dried-up black spots shrivel.



Record Work: Write down the IPM practices for the management of tea mosquito bug.

★ ★ ★ ★ ★

POLYPHAGOUS PEST

Locusts

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

(i) Desert locust – *Schistocerca gregaria* (Forskal)

(ii) Bombay locust – *Patanga succincta* Linnaeus

(iii) Migratory locust – *Locusta migratoria* (Linnaeus)

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

(i) Desert locust – *Schistocerca gregaria* (Forskal)

Order – Orthoptera **Family** – Acrididae

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

1. **Distribution:** The desert locust is an inhabitant of the dry grasslands of desert areas and it found in many countries of the world. Its distribution extends from Rajasthan, to Afghanistan, Iran, Iraq, Arabia, and northern Africa. In India the breeding grounds are located in Rajasthan, part of Gujarat, Hisar and mehindergarh district of Haryana. These part of India as well as Sind and Bahawalpur of Pakistan are summer breeding

areas. The winter breeding areas are located in Baluchistan and in the middle East. The swarming locusts are always in the gregarious phase and form the winter breeding grounds they spread in all directions and invade Southern Europe, Spain, major parts of African continent, Israel, Southern & Western parts of Russia, Afghanistan, Iran and other adjoining areas.

2. **Host Plants:** The pest is polyphagous and feeds all types of vegetations and there is no difference between family and species.

3. **Marks of Identification:** The nymphs of the gregarious phase are yellow or pink with distinct markings and the adults are pink on emergence, gradually turning grey and ultimately yellow. The colour of the solitary hoppers (nymphs) varies according to the colour of surrounding vegetations and the adults of the solitary phase remain greenish grey throughout their life.

4. **Life Cycle:** The locust has three stages in its life cycle viz. the egg stage, the hopper stage (nymph stage) and the adult stage. When sexually mature the adults are yellowish sluggish, reluctant to fly and cluster on ground. While mating the male clings to the back of the female who takes him around. Copulation takes time upto 8 to 24 hours and egg-laying starts soon after mating, sometimes even when the male is clinging to the back of the female. Egg-laying continues for many weeks. A single female may lay up to 11 egg pods, each pod containing 60-120 eggs. Before egg-laying the female with the help of her ovipositor, bores a hole into the loose sandy soil 5-10 cm deep and the time required for hole digging is 1-4 hours. After laying of pods, female secretes a frothy material over the eggs, which hardens on drying and makes the pod water proof. While laying eggs the females may be sitting very close to one another and as many as 5000 eggs may be laid in one square metre. The ground use for egg laying is easily recorgnized by numerous holes, which are of the diameter of an ordinary lead pencil.

   The egg resembling to grain of rice is lightly curved and 7-9 mm long. The duration of egg stage or hatching period is depends upon the soil conditions, temperature, and moisture. The eggs laid in February and March hatch in 3-4 weeks where is those laid in May-September hatch in 12-15 days. In very dry soils the eggs may remain unhatched for a long time until shower of rain comes. The nymphs at the time of emerging, break the egg-shell and creep out of the holes. The freshly hatched hoppers are light yellow but soon turn black (in the gregarious brood). The hoppers march in swarms and feed on all kinds of vegetation as they move. The nymphal period is 6-8 weeks in spring and 3-4 weeks in summer. The young adults are bright pink and at sexual maturity turn bright yellow. The pink locust adults are very destructive to crops directly where as yellow swarms lay eggs and produce the destructive nymphs.

Record Work: Write down the IPM practices for the management of desert locust.

IPM CONCEPT

Pest: Definition:

What is a pest?

Pests are organisms that damage or interfere with desirable plants in our fields and orchards, landscapes, or wildlands, or damage homes or other structures. Pests also include organisms that impact human or animal health. Pests may transmit disease or maybe just a nuisance. A pest can be a plant (weed), vertebrate (bird, rodent, or other mammals), invertebrate (insect, tick, mite, or snail), nematode, pathogen (bacteria, virus, or fungus) that causes disease, or other unwanted organisms that may harm water quality, animal life, or other parts of the ecosystem.

Pest is any organism that is detrimental or harmful to humans, crops, animals, weeds and pathogens.

Pest is defined as "Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products" (FAO).

Pest: An insect (or organism) that causes harm to humans, their livestock, crops or possessions.

Economic pest: When the damage level reaches a certain level at which economic damage and loss are significant, then the pest population is considered as economic pest. So, we have to take initiate control measures based on significant economic loss.

Insect pest is considered as economic pest when it causes an economic loss of 5-10% in terms of yield.

Types of pests or Pests are divided into different groups like

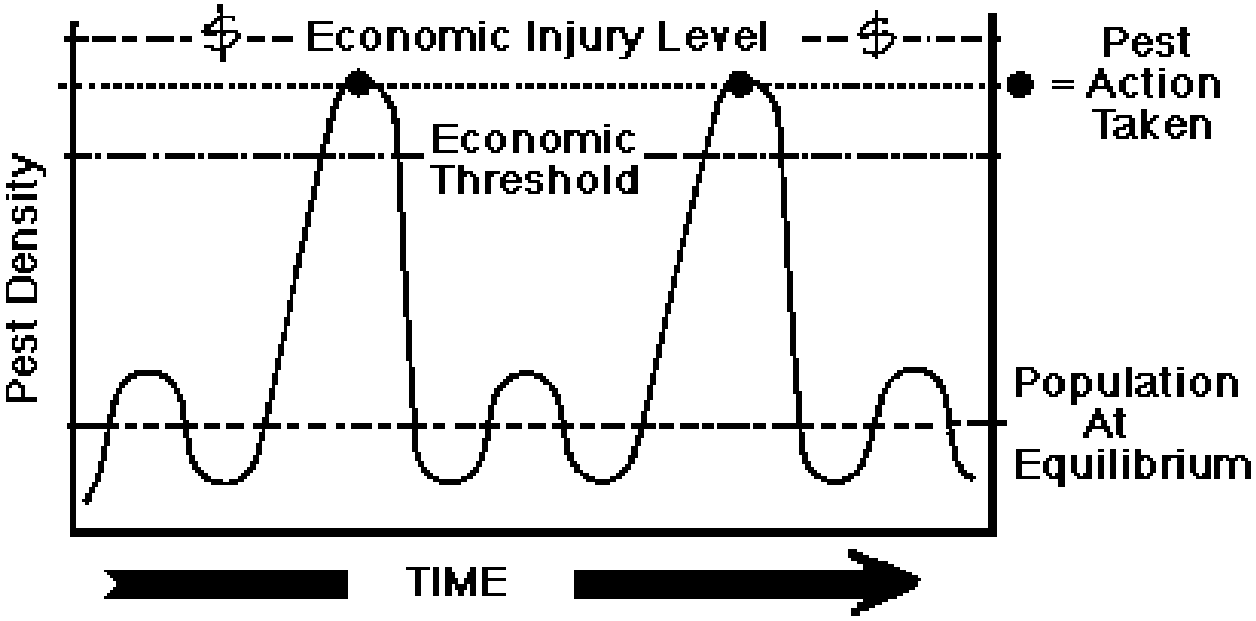
1. Arthropods- - Insects (Cockroaches, mosquitoes, caterpillars etc.,)

   Other Arthropod groups: Mites, Ticks and Spiders

2. Vertebrates – Animals (Snakes, rats, peacock, fish etc.)
3. Weeds -Unwanted plants growing in the main crop field. eg. Parthenium, Prosopis etc.,
4. Pathogens: Fungi, bacteria, virus, Protozoans etc.
5. Nematodes

Categories of Pests:

Based on the population density and damaging capacity to the crop, the insect pests are categorized or classified into key, major, minor, sporadic and potential pests. Categorized of pests are mainly defined based on the concepts of the **general equilibrium position (GEP),** the **economic injury level (EIL), economic threshold level (ETL)** and the **damage boundary (DB).**



Mamun et al., 2014

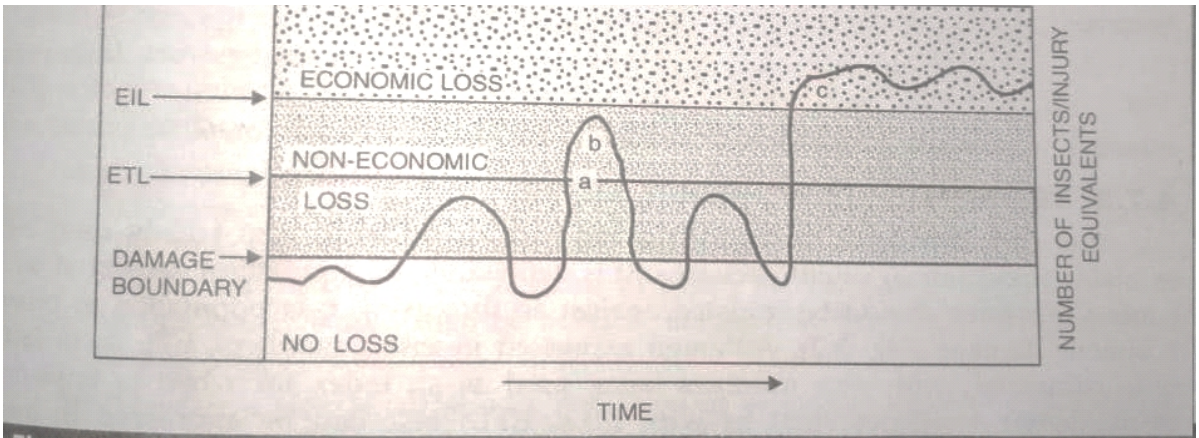


Fig. 4.2 Graph showing relationship between damage boundary (DB), economic threshold level (ETL) and economic injury level (EIL) for a hypothetical insect pest population. (Modified after Dhaliwal and Arora, 1994b). As the increasing insect population approaches ETL (at a), control measures are initiated, so that the population is unable to reach EIL (b) and economic loss is avoided. In case no control measures are undertaken, the increasing insect population crosses DB, ETL and EIL (c) resulting in economic loss.

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Economic damage:a level of damage done to a crop or host caused by insect-pest activity that can be measured as an economic loss.

Damage Boundary: The lowest level of injury where the damage can be measured.

Three economic insect levels:

General equilibrium position (GEP): The average population density of insects over a long period is unaffected by interventions of insect management. This level fluctuates about a

mean level as a result of biotic and abiotic regulating factors. **General equilibrium position**: the average density of a population overtime which is helpful to know the peak of the pest. **GEP** is the mean value of pest density around which the pest population tends to fluctuate as changes occur in the biotic and abiotic components of the environment without accompanied by a permanent modification in the composition of the environment. A permanent modification of any component of the environment may alter the GEP.

Economic injury level (ElL): the smallest or lowest pest population that will cause economic damage: most protection activity is aimed at preventing the pest population from reaching this level. The critical population density where the loss caused by the insect equals in monetary value the cost of management.

Economic threshold Level: defined as the population density of an increasing insect population at which control measures should be started in order to prevent the population from reaching the ElL (Stern *et al*., 1959).The point at which management actions should be taken to prevent an increasing insect population from exceeding the economic injury level. The ET always represents insect density or level of insect damage lower than the EIL.

Calculation of Economic Injury Level (EIL) and dynamics of Economic Injury Level

EIL is defined as the lowest number of insects that will cause economic damage. EIL concept was given by Stern et al (1959). EIL is a level of injury and measuring the injury at field level is very difficult so number of insects are used as an index instead of injury ie we consider critical population density. EIL can be expressed as standard units of injury by means of insect equivalents. An insect equivalent is defined as amount of injury that could be produced by one pest through its complete life cycle.

According to Pedigo, 1991 EIL is given as follows:

EIL=C/VID

EIL=No of injury equivalents per production unit (insects/ha)

C=cost of management activity per unit of production (Rs/ha)

V=market value per unit of product (Rs/tonne)

I=Crop injury per pest density (per cent defoliation/insect)

D=damage or yield loss per unit injury (tonne reduction or %defoliation/ha)

When the losses caused by insect are unavoidable, then the relationship can changed into:

$$EIL = \frac{C}{V \times I \times D \times K}$$

Where, K is proportionate reduction in injury form pesticide use (Eg. 80%=0.8)

Calculate the EIL (pest population/ha):

C=management cost per unit area= Rs. 2500/ha

V=Market value in Rs./unit product=Rs. 1000/tonne

I=Crop injury/pest density=5%defoliation/100 insects

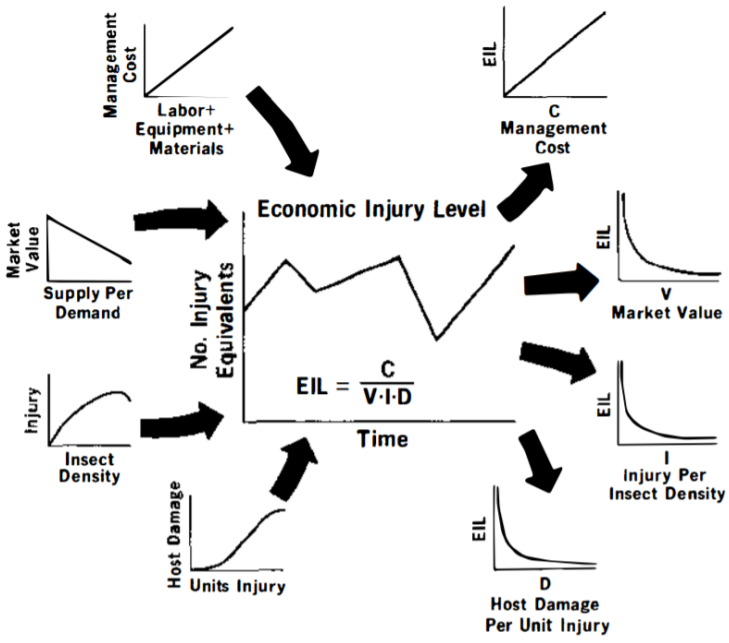
D=loss caused by unit injury=0.1 tonne loss/5% defoliation

K=proportionate reduction in injury by pesticide application=0.8 (80% control)

$$EIL = \frac{2500}{1000 \times 0.05 \times 0.1 \times 0.8} = 625 \text{ insects per ha}$$

Dynamics of Economic-Injury Levels (Pedigo, 2002)

Economic are always dynamic in nature and depending on the changes of costs, values and production environments. Insects feeding on a crop at a given time can be expected to have a different economic injury levels when feeding on the crop at another time the same season or in another season. The major factors ie primary variables responsible for the changes in the economic decision levels are crop value, management costs, degree of injury per insect and crop susceptibility to injury. The primary variables are affected by secondary variables like the host-damage/insect-injury relationship. Then weather, soil factors, biotic factors and human social environment are the tertiary variables which are change the function of the secondary variables.



(Pedigo*et al.*, 1986)

Market value (V): One of the most important variable accounts for the major changes in EILs. The relationship between EIL and market value is inverse; ie. when the market value increases, EIL decreases and vice versa. Market value is showing inverse relationship with EIL: as market value increases, less injury is tolerated.

Management cost (C): As the management cost increases, net benefit of control decreases, so there is a need of raising the EILs to accommodate the higher gain thresholds. Management cost are almost more stable and predictable.

Degree of injury per insect (I): (Pedigo*et al*., 1986)

This also shows inverse relationship with EIL.

The process of injury is governed both by insect and host populations. The insect causes impairment of a host's ability to survive, grow, and reproduce. The host, as the recipient of the behavior, plays a major role in determining the kind and degree of the injury. Insects feeding on host tissues or fluids causing injury to the host, other major causes include injecting toxins and vectoring pathogens. Insect chewing and sucking are the most common feeding behaviors, producing injuries such as leaf skeletonizing, leaf mining, stem boring, and fruit scarring. Insect injury also categorized into stand reducers, leaf-mass consumers, assimilates sappers, turgor reducers and fruit feeders.

The kind of injury by insect-pests is known and it can be measured the determination of injury per insect for a given crop variety at a given injury site is straightforward and can be used in calculating the ElL. The injury per insect usually has been assumed to have a linear relationship with insect density.

a) Insect damaging leaves or reproductive pest have different EIL(Lower EIL for pest damages).

b) If insects are vectors of diseases EIL is very low(1 or 2).

c) If insects are found on fruits – EIL low.

Crop susceptibility to injury (D)

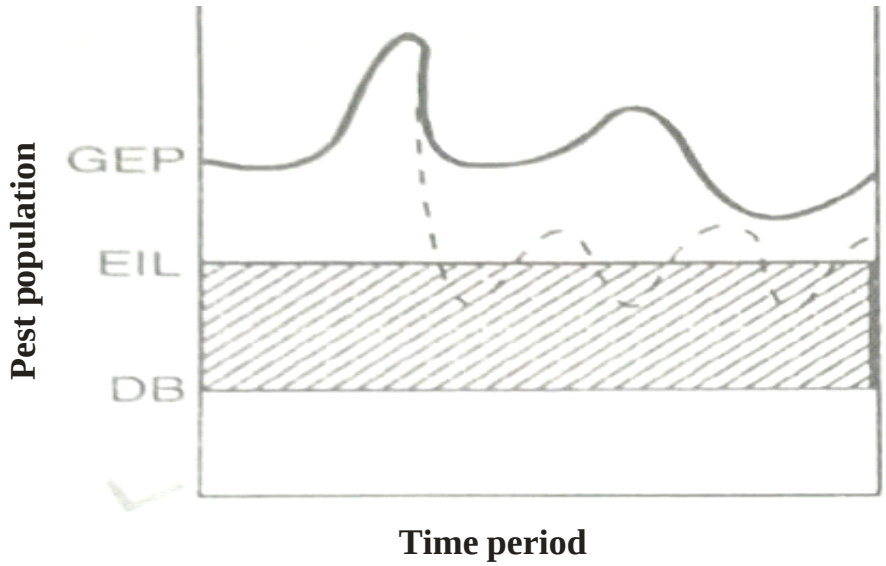
The relationship between injury and crop yield is the most fundamental component of the ElL.

If the crop can tolerate the injury and gives good yield. EIL can be fixed at higher volume. When the crop is older, it can with stand high population- EIL can be high.

Economic threshold level is one of the most widely accepted indexes for making pest management decision. It is a complex value based on the EIL, pest population dynamics, forecasting of weather and the pests potential for injury. The action is not initiated at ETL, then the insect populations can exceeds EIL. Whereas, the management measures can be initiated at ETL the population may come down before it reaches to EIL.

(1) Key pest

- These are one of the most severe, persistent pests and damaging pests. The GEP lies well above DB and EIL. The control measures should be initiated to bring the population temporarily below the EIL and repeated interventions may be required to minimize the damage. There is a need to lower their GEP below EIL by permanent modification of one or more components of the Environment. Eg: Cotton bollworms, diamondback moth, chickpea pod borer, sugarcane borers and sucking pests.



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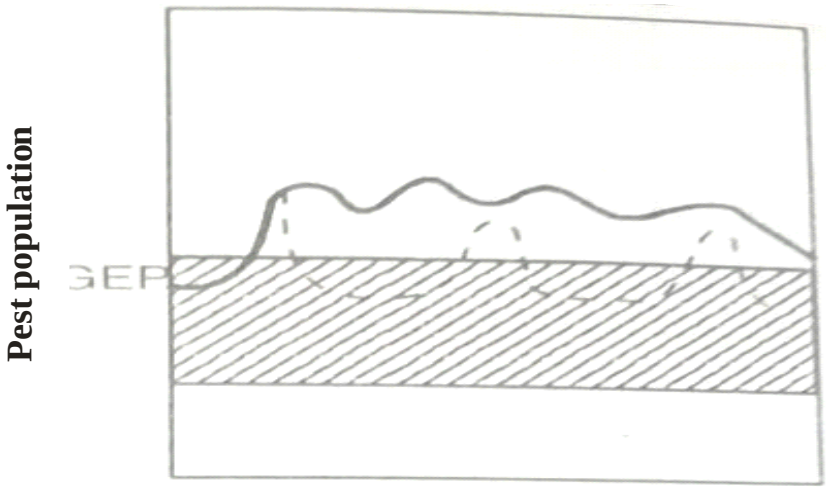
(2) Major pest

- GEP is close to the EIL and in some instances both are be at the same level. So, the population crosses EIL quite frequently and repeated control measures are necessary, but economic damage is avoided by timely interventions.
- Eg: Cotton jassid and whitefly, brown planthopper and leafhopper on rice, sugarcane whitefly and scale insect fall in this category. Rice stem borer, gall midge and leaf folder.



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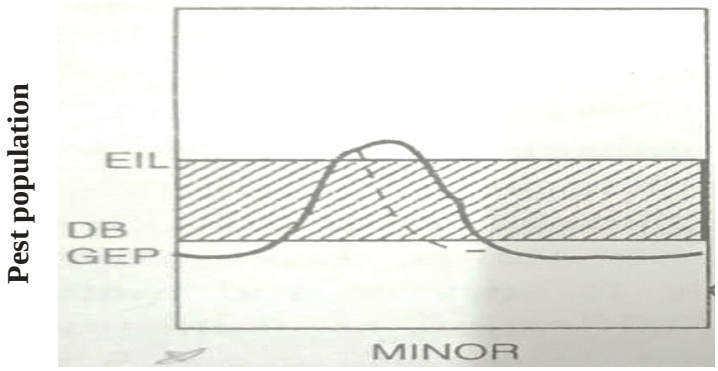
(3) Minor Pest

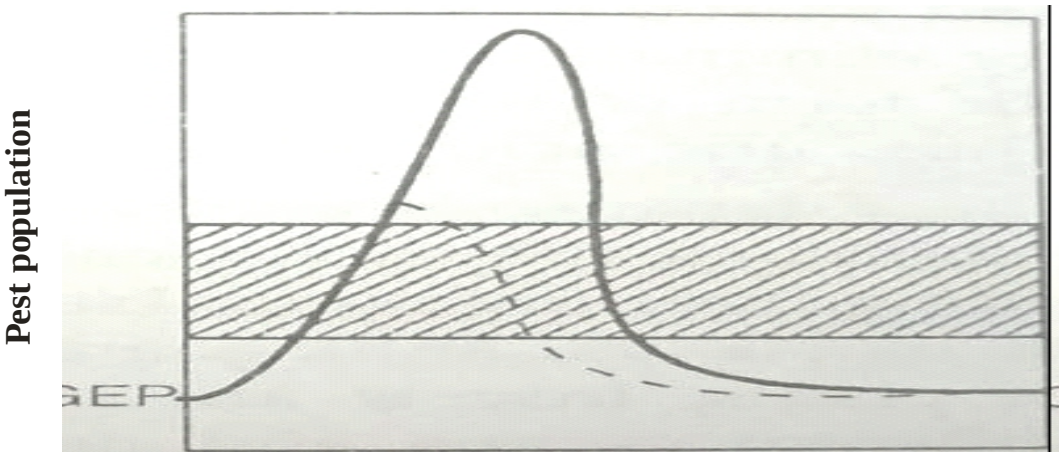
- The GEP lies below both EIL and DB. Under favorable environmental conditions, the population may cross EIL and DB for usually a short interval. These pests are easily manageable to available control measures and a single application of insecticides is usually enough to prevent economic damage.

- Eg: Red cotton bug, grey weevil, thrips and mites; rice hispa and root weevil; sugarcane mealy bugs, thrips and mites; and *Spodoptera litura* on oilseed and vegetable crops.



(4) Sporadic pest

- Under favorable conditions, some of the pests that occur in epidemic form often exceeds over many times DB and EIL. These pests can be controlled by suitable control measures.
- Highly sensitive to abiotic conditions.
- White grubs, hairy caterpillars, cutworms and grasshoppers, and sugarcane pyrilla.



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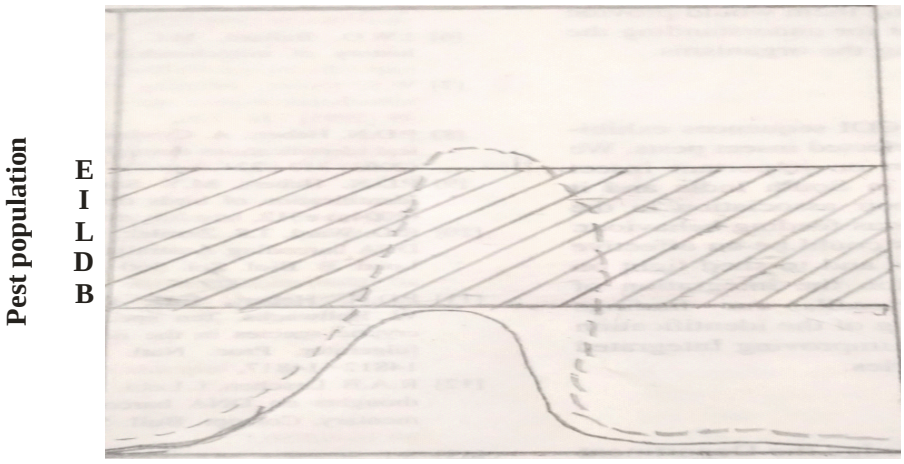
(5) Potential Pest

- These pests are not causing any economic damage and not falls under any pest category. The GEP of these pests are generally lying below the DB and does not cross EIL even under favorable abiotic conditions. Any permanent change in the ecosystem may favour the insect attains to pest status and push their GEP higher and there is a danger of economic damage from these pests.
- Eg: Spodoptera litura in cotton and sunflower; armyworm in wheat



Based on occurrence:

(1) **Regular pests:**these pests occur frequently on the crop. Eg.Rice stem borer, Brinjal fruit borer, mustard aphids.

(2) **Occasional pests:**These pests are not closely associated with the crop and infrequently occurs only in certain years due to unusual changes in the abiotic conditions and also due to injudicious use of pesticides.e.g. Caseworm on rice, Mango stem borer, painted bugs in cole crops.

(3) **Seasonal pests:**These pests are regularly occurring every year during a particular seasonie. Kharif or rabie.g. Red hairy caterpillar on groundnut, Mango hoppers

(4) **Persistent pests:**These pests are occurring throughout the year in a small number which is small, highly mobile, and has a high reproductive potential. e.g. Chilli thrips, whitefly

(5) **Sporadic pests:** Pest occurs in isolated localities under a specific period and favorable conditions. These pests are naturally maintained by natural enemies. Outbreaks occurunder changing environmental conditions which offer for reproductive potential.

Based on level of infestation:

(1) **Epidemic pest:**These pests are occurring in severe form due to the sudden outbreak in a region at a particular time.e.g. Brown plant hopper (BPH) and Red hairy caterpillar (RHC) and white fly;

(2) **Endemic pest:**These pests are occurring regularly in a low population in a few areas and confined permanently to a particular region. e.g. Rice gall midge, Mango hoppers

Integrated Pest Management (IPM)

IPM is a sustainable pest management program that focuses on strategies based on eco-system principles and this can be achieved through a combination of various control technologies like biological control, habitat manipulation, and modification of cultural practicesand use of resistant cultivars or varieties. The application of pesticides is also one of the control strategies and is applied only after proper monitoring based on the guidelines and are target specific. This target-based approach can reduce the chances of contaminating the

environment, minimizes risks to human and animal health and beneficial and nontarget organisms.

1. Applied pest control that combines and integrates biological and chemicalmeasures into a single unified pest-control program. Chemical control isused only where and when necessary, and in a manner that is least disruptiveto beneficial regulating factors of the environment. It may make use of naturallyoccurring insect parasites, predators, and pathogens, as well as thosebiotic agents artificially increased or introduced.

2. An ecological approach to pest management in which all available necessary techniques are consolidated into a unified program, so that populationscan be managed in such a manner that economic damage is avoided and adverseside effects are minimized.

IPM:

- Integrated:harmonious use of several control tactics against single or multiple pest; Pest; Management: it should be based on ecological principles, social and economic considerations

- Definitions of IPM

- Applied pest control that combines and integrates biological and chemical measures into a single unified pest-control program. Chemical control is used only where and when necessary, and in a manner that is least disruptive to beneficial regulating factors of the environment. It may make use of naturally occurring insect parasites, predators, and pathogens, as well as those biotic agents artificially increased or introduced.

- An ecological approach to pest management in which all available necessary techniques are consolidated into a unified program, so that populations can be managed in such a manner that economic damage is avoided and adverse side effects are minimized.

As per the FAO (1968), the IPM definition: "A pest management environment system, that in the context of associated and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population at levels below those causing economic injury".

Integrated pest management may be defined as the selection and use of available pest control techniques in a harmonious manner to reduce the pest population below economic injury level and to ensure suitable ecological, economic and sociological consequences.

IPM is a holistic approach to sustainable agriculture that focuses on managing insects, weeds and diseases through a combination of cultural, physical, biological and chemical methods that are cost effective, environmentally sound and socially acceptable.

History of Integrated Pest Management:

There are three to four distant phases in IPM: 1. The era of traditional approach; 2. The era of pesticides (1939 to 1975); 3. The era of IPM; 4. The era of transgenic crops

Historical Perspective of Pest Control

When an insect pest population is higher in the agricultural system and it is enough to cause significant economic damage in yield or quality of the agricultural produce. In the old days

farmers were used to control an insect-pest through cultural control like crop rotation, field sanitation, deep ploughing, mechanical (collection and removal of damaged plants/parts), physical, and biological control. Chalk and wood ash were sued to control of insect pests in godowns and insecticides from botanicals for seed treatment by the Chinese and ants were used as biological control for stored grain and defoliator pests. In India, neem leaves also used in grain bins to manage pests and in the Middle and Near East Asia, chrysanthemum flowers were used as insecticide. Inorganic compounds were developed towards the end of the 19th and the beginning of the 20th century.

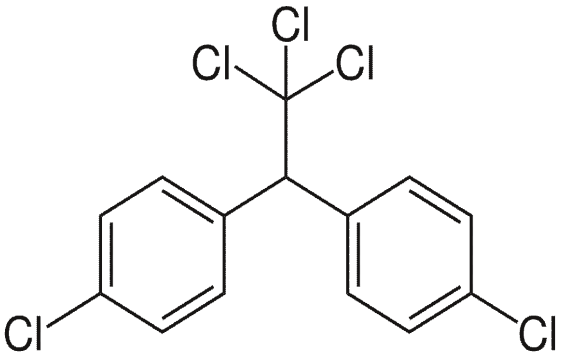
1. The era of traditional approach

- ~2500 B.C. (4500 years ago): Element sulfurused for the control of insects and mites and fungal diseases. Still, elemental sulfur is being used for the control plant disease.
- ~1500 AD (500 years): Based on the research, plant-based products were discovered and used for the control of pests.
- Eg.Pyrethrum chemicalwas extracted from the flower's heads of *Chrysanthemum* species. Extracts are used for the control of insect-pests and mosquitoes.
- The neem trees which arenative to southern Asia and neem extracts were observed to suppress insects and still now neem products are being used as insecticides.
- Late 1800 the use of inorganic compounds came into existence for the control of some potential pests and fungal problems. E.g. Paris green(copper acetoarsenate); Bordeaux mix; Lead arsenate; creosote (coal tar derivative); Sodium hypochlorite solutions (bleach)
- Paris green: toxic compound and will control many insects.
- Bordeaux mixture (copper sulfate and hydrated lime): It controls fungal diseases and was used in the grapevineyards of Europe.
- In 1892, Lead arsenate was used against gypsy moths in New England.
- Creosote (coal tar derivative): used against some insect species.
- Sodium hypochlorite: It is household bleaches and 10% solution of sodium hypochlorite can be used as a surface sterilant in homes and laboratories.
- In 1888, Classical" biological control: Control of cottony cushion scale (*Iceryapurchase* Maskell) by vedalia beetles (*Rodolia cardinalis*) imported from Australia and it was the first great success and it had benefited citrus industry.

2. The era of pesticides:

During World War II,DDT was used for the prevention of outbreaks of yellow fever and other vectors. Synthetic organic insecticides were developed to control insect pests after World War II. The term "**Dark Ages"** of pest control was introduced for the period from the late 1940s through tothe mid-1960s. In 1970s, farmers mostly rely on pesticides for the control of insect pests and fixed spray programs of spraying were developed. This leads to the development of resistance, resurgence, and residual problems.

- In the 1940s: The pest management scenario was changed after the introduction of synthetic pesticides.
- the late 1940s to mid-1960s:“the dark ages” of pest control because of high reliance on synthetic pesticides.
- In 1874, DDT (dichlorodiphenyltrichlorethane) was first described by a German chemist, OthmarZeilder and Swiss chemist Paul Muller discovered the insecticidal properties of DDT in 1939.



Paul Hermann Muller
Source: A text book on Applied Entomology Srivastava

- In 1941: DDT was used for the control of Colorado potato beetle and in 1944, used against body louse to prevent typhus fever and use to control mosquitoes that spread malaria.
- Herbicide 2 4-D for chemical weed control, and dithiocarbamate fungicides in 1930.
- In the 1940s: The complete reliance on pesticide-intensive pest management leads to several consequences that leads to agriculture on a “pesticide treadmill”.
- The 1940s: The problem of insecticide resistance in insect pests was reported due to the indiscriminate use of synthetic organic pesticides.
- In 1942: BHC (benzene hexachloride) was introduced; In 1948: Lindane; chlordane; toxaphene were come into exist.
- In cotton crop, lack of resistant cultivars, non-adoption of cultural control measures, and non-availability of effective biocontrol agents, the indiscriminate use of insecticides resulted in development of resistance in cotton pests such as American bollworm (*Helicoverpaarmigera*(Hubner)), the resurgence of pests such as spider mites (*Tetranychus*spp.) and whitefly (*Bemisiatabaci*(Gennadius)) and destruction of natural enemies, which ultimately led to crop failures in some countries.

- In 1948, Warfarin was registered as a rodenticide. The main active ingredient of this rodenticide is dicoumerol and was isolated from moldy sweet clover hay.
- Class of "modern" insecticides: Pyrethrin that is called pyrethroids
- In the late 20^{th} century, term, pest resurgence and documentation of the development of minor pests to major pests due to the killing of natural enemies.
- Smith and Smith (1949), Californian entomologists coined the concept of "supervised control", which involves the supervision of insect pest control by qualified entomologists. It involves applied ecologists and bio-control experts.
- In 1959, Stern et al.: developed a concept based on the combined and integrated biological and chemical control based on economic threshold concepts and coined the term as "integrated control". An important concept in IPM, the Economic thresholds were introduced.
- In the 1950s: Sterile male releases were tested and demonstrated against screw worm fly (*Cochliomyiahominivorax*(Fabricius).
- In 1962,a marine biologistRachel Carson wrote the book *Silent Spring* that dealt with the environmental problems caused by the use of synthetic pesticides.

She wrote in her book, **"We have put poisonous and biologically potent chemicals indiscriminately in the hands of persons largely or wholly ignorant of their potential for harm."**

3. The era of IPM

Integrated Pest Management

Over the past 40 years, the concept of IPM has been developed and the term, Integrated control (IC) was introduced by Smith and Allen (1959) in the IPM program. Integrated control combines chemical control and biological control. The early IPM concept was based on that the use of pesticides could not harm the natural enemies of the pest. Another concept, Economic threshold was introduced. The concept says that the control measures should only be used to prevent an increasing pest population from reaching the economic injury level. The "economic injury level" was defined as the lowest density that will cause economic damage. These concepts were the major theme of IPM in the 1980s. In the 1980s IPM program was shifted to non-chemical methods like cultural controls, the introduction of resistant plants, and biological control.

Genesis of IPM

The concept of Integrated Control is based on the ecological principles of the ecosystem. In any ecosystem, outbreaks of pests are naturally controlled by natural enemies. Due to the lack of resistant cultivars, beneficialll organisms and other non-chemical methods, the farmers are mostly dependent on the use of insecticides as a major component of IPM. During the green revolution, the release of high yielding varieties with pest susceptible leads to the use of synthetic insecticides as an indispensable method of control in the IPM component. This leads to several problems in the ecosystem. Then the concept of Economic Injury Level was cameinttto existence based on the ecological, economical and social principles. Stern *et al*. (1959), Stone and Pedigo (1972) demonstrated the formula for calculating economic injury level (EILs).

- Smith and van dan Bosch (1967) used the term, “Integrated Pest Management” for the first time and this term was formally recognized by the US National Academy of Sciences in 1969.
- The 1970s:In December 1972, DDT was widely banned and the establishment of the U.S. EnvironmentalProtection Agency.
- 1972: Biopesticides were developed based on the soil bacteria, *Bacillus thuringiensis*and was used against Lepidopteran pests.
- 1972: “integrated pest management” (IPM) accepted by the scientists and in November, a report on *Integrated Pest Management* was published and the report was prepared by the Council on Environmental Quality.
- In the 1980s: The focus of IPM started to shift to non-chemical tactics which includesthe use of cultural control, resistant varieties and biological control.
- Two classic examples: The cottony-cushion scale, *lceryapurchasi*Maskell, by the vedalia beetle, *Rodolia cardinalis*(Mulsant), and control of the grape *Phylloxera*, *Phylloxeravitifoliae*(Fitch), by use of American resistant rootstocks with European grape- vines, Vitisspp. The integration of biological control and plant resistance methods to control successful control of two important pests.
- In Asia, the Farmer Field School (FFS) approach was used for disseminating the IPM technology in rice (1988).
- Under Agenda 21 of the United Nations Conference on Environment and Development (UNCED, 1992), IPM is considered as the main strategy for the management of pests.
- 1996: First transgenic crops against insect-pests were developed.
- New tools and several strategies have been included in the IPM program. E.g. newer selective insecticides, development of several biopesticides; semio-chemicals (attract and kill, mating disruption); use of trap and refuge crops, the use of “push-pull” strategies, techniques to conserve and attract beneficial in systems, use of augmentative biological control and the advent of transgenic crops contains the Cry proteins from *Bacillus.*

History of Pest Management

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- "I" stands for "Integration," which is harmonious use of multiple methods to control the impact of a single pest as well as multiple pests; "P" for "Pest," which refers to any organism that is detrimental to humans including vertebrates and invertebrates or weeds or pathogens; and "M" for "Management," which refers to a set of decisions or rules based on ecological principles, economic, and social considerations.
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Year	Pest Management Events
1912	**Legislative Concept established in the US to preventintroduction of exotic pests**
1914	First time Sanjose scale, ***Quadraspidiotusperniciosus*** showed resistance against lime sulfur insecticide
1919	**Biological control term was introduced**
1939	Bacteria, ***Bacillus thuringiensis*** Berliner used as microbial biopesticide
1941	**Insecticidal activity of Hexachlorocyclohexane (HCH) discovered**
1946	Organo phosphorus insecticide parathion was developed. **House flies showed resistance to DDT. This is the first report of resistance to the new synthetic organic chemicals.**
1948	***Bacillus popilliae*Dutky and *B. lentimorbus*: developed a product called *Doom* was used against Japanese beetle**
1951	Book on ***Insect Resistance in Crop Plants*** was written by ***R. H. Painter***. Isolan first carbamate group insecticide introduced
1955	**Sterile insect technique was described by E. F. Knipling from US**
1959	**First insect sex pheromone from silkworm moth was identified by**

	Karlson and Butenandt. ***Stern et al*.: developed a concept based on the combined and integrated biological and chemical control based on economic threshold concepts and coined the term as "*integrated control*". Important concept in IPM, the Economic thresholds were introduced.**
1962	**Silent Spring book was written by Rachel Carson**
1964	**Paul Debach written a book on Biological Control of Insect pests and Weeds**
1970	**US Environmental Protection Agency (EPA) was established for the purpose of registration of pesticides**
1972	**In US First IPM project *Huffaker project* from 1972-1978 launched for the crops alfafa, citurs, cotton, pines, pome, soybean and stone fruits** **First Bt based bioinsecticide developed by using HD-1 for control of lepidopteran pests**
1973	**First photo stable synthetic pyrethroid permethrin was developed**
1975	**First nuclear polyhedrosis virus (NPV), *Elcar* registered for the control of tobacco budworm, *Helicoverpazea*and cotton bollworm.** **Synthetic pyrethroid insecticides, permethrin and cypermethrin were developed.** ***Methoprene,* insect growth regulator registered for the first time in US for commercial use.** **R. L. Metcalf and W. H. Luckmann published a book on *Introduction to Insect pest management* and this book is the first comprehensive information on IPM.**
1985	**Elucidated the structure of azadirachtin**
1987	**M. Vaeck et al developed a first transgenic tobacco plant containing Bt endotoxin gene against *Manduca sexta***
1989	**IPM task force for development and implementation of IPM programmes was established and later reconstituted as Integrated Pest Management Working Group**
1992	**L.P. Pedigo and L.G. Higley proposed the concept of Environmental Economic Injury Levels** **World Food prize awarded to E.F. Knipling and R.C. Bushland for the development of sterile insect technique.**
1992	**Under Agenda 21 of the United Nations Conference on Environment and Development (UNCED, 1992) at Brazil, IPM is**

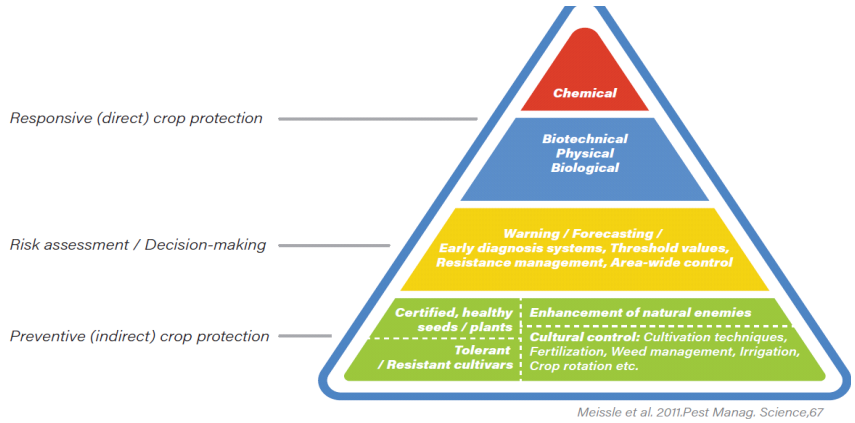
	considered as the main strategy for the management of pests. **Bt genes containing insect-resistant cotton, corn and potatoes were released.** **Dr. H. R. Harren awarded world food prize for the development and implementation of world largest biological control project against cassava mealy bug in Africa.** **Dr. R. F. Smith and Perry L. Adkisson awarded world food prize for the development and implementation of IPM concept.**
1994	**Global IPM facility was developed with help of FAO, UNDP, UNEP and World Bank.** **Coordinating, Consulting, advising and promoting agency for the advancement and popularization of IPM worldwide.**
1996	**First transgenic crops (Cotton) against insect-pests were developed.**
2002	**Bt cotton was approved for the commercial cultivation in India by Genetic Engineering Approval Committee (GEAC)**

The major principles of IPM include:

1. **Identification**–first most important step of IPM is to the identification of insect-pests and their host plants and also beneficial insects. Once pest species are identified further studies have to be carried-out to study their lifecycle.

2. **Prevention –**Pests problem can be prevented by using appropriate tactics to make the ecosystem unfit for the pest to live.

    - Crop rotation and intercropping; Cultivation practices like sanitation, sowing timings, plant density, deep ploughing, pruning, conservation tillage etc., Use of resistant/tolerant cultivars; disease free seedlings/planting materials; balanced nutrient application and irrigation management; field sanitation and hygiene; Removal of infected plants, plant parts and plant debris and regular cleaning of machinery and equipment; Protecting, conserving and enhancing beneficial organisms.



FAO, 2017

3. **Monitoring/scouting**–There should be regular monitoring of harmful pests and natural enemies with adequate scientific methods or tools. The occurrence of insect-pests and their symptoms of damage and counts have to be taken in a particular area and document the pest and beneficial insects' population. These population data can be used to develop forecasting and for sound warning system. Based on this, a control strategy can be initiated to reduce the pest population without affecting the beneficial organisms. visual inspection, pheromone and sticky traps, and sweep nets.

4. **Prediction of pest damage/action threshold–**Based on the monitoring of insect-pests, the pest damage can be predicted. A few numbers of individual insect pests can be tolerated in the crop. So, famers can be able to decide that the pest's numbers are sufficient to cause damage and decide the action threshold. The economic threshold is defined as the pest population level that produces damage equal to the cost of preventing damage by controlling the pest.

5. **Evaluate and Decisions to implicate control measures –**The decision can be taken based on the above steps and the IPM user candecide on the various tactics for the pest to control. The control measures are to be economical and should be target-specific and have lesseffect on beneficial insects and non-target species and the surrounding environment. The focus should be on non-chemical pest control tactics (physical, biological etc.,) rather than chemical tactics. The chemical method of control should be the last resort otherwise it will cause toxic to the living organisms and also it will be economical.

   Pesticide Usage in IPM program:

   Include hazards and risks to users, specific to the target pest and not on the non-target pest species, persistence in theenvironment, efficacy and development of resistance in the target pest; least effect on human health, predators, parasitoids, pollinating insects like honey bees and the environment contains water bodies, soil etc., reduce the frequency of insecticide usage; pesticideswith different modes of action.

6. **Monitoring, evaluation and documentation of results of control measures**–The various treatments under IPM program should be evaluated for their efficacy and according to their efficacy, the method of treatment can be changed or to improve the effectiveness of the pest control measures in the future. Documentation is essential to determine the efficacy of pest control tactics.

General concepts OF IPM:

1. IPM can be applied in all aspects of pest control in any ecosystem. It includes or integrates all the management aspects (cultural, mechanical, physical, biological and chemical control) in a holistic manner and ecologically based approach for all the targeted pests (insects, weeds, diseases, diseases, nematodes, vertebrates).

2. It can be applied on a large scale basis

3. IPM should manage the pest problems ie reduces the pest population to a tolerable level and not to eradicate/eliminate the whole pest population.

Agroecosystem:

1. It always has less diversity and contains two to three major components and it includes three to four field crops, with one or two major pests and diseases. This system usually experienced frequent changes due to manmade changes in the form of intercultural operations and spraying of pesticides etc. More outbreaks of pests and diseases are general phenomena in this agro-ecosystem due to the lack of diversity.

2. Any IPM program should aim to plan the agroecosystem to have fewer pest problems and use the IPM tools to reduce the pest problems in the agro-ecosystems. In the agro-ecosystem, planting of susceptible varieties should be avoided as well as the same group/related crops should be avoided.

   Example: The incidence of spotted bollworm /shoot borer increases when okra is followed by the planting of cotton. Similarly, leaf miner incidence is severe when the groundnut crop is followed by the planting of soybean.

3. In an IPM program, we always think about cost-benefit ratio analysis and risk analysis also be keep in mind while choosing a chemical method of control which will have an impact on the society and surrounding environment.

4. In an agro-ecosytem, the insect pest or disease-free condition is not necessary and these pests are existing at some tolerable limit. For example, some crops can tolerate damage up to 20-25% defoliation by defoliating insects and this will not apply for plant diseases transmitted by vectors.

5. The relationship between the density of pest population (GEP) and profitability of control measures is expressed through threshold values such as economic threshold (ETL) and economic injury levels (EIL).

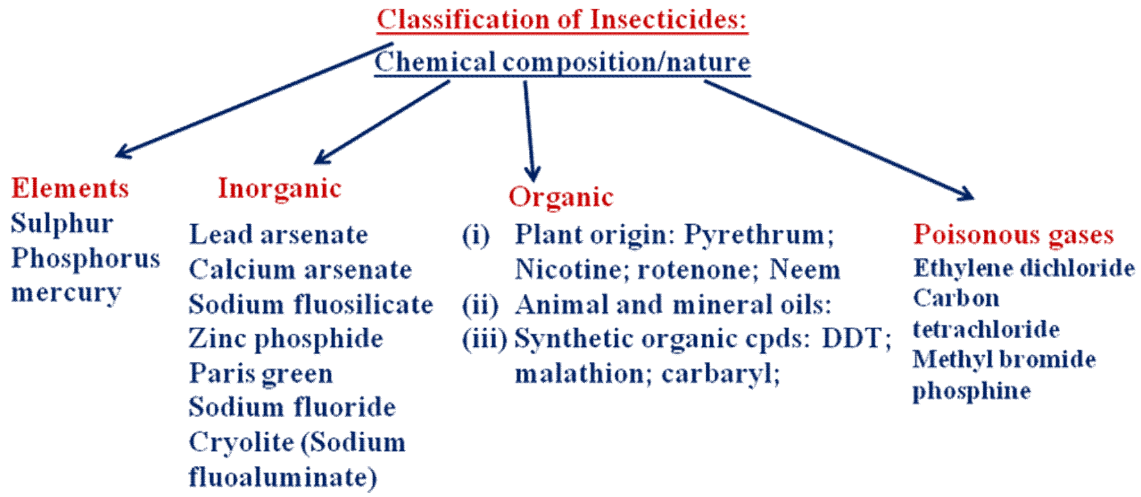
6. In any pest management program, we should not target the complete elimination of insect-pests by using indiscriminate use of insecticides. This leads to the elimination of beneficial organisms (natural enemies). The complete elimination of pests also reduces the beneficial organisms' survival because of the absence of their respective insect hosts. One of the important concepts of IPM program is to leave a permanent insect-pest residue below the economic threshold level which will helpful for the survival of their natural enemies.

7. In an IPM program, the treatment schedule has to be prepared based on the crop and their insect pests. Treatments should be given in need-based manner with judicious use of pesticides and a minimum number of sprays according to the ETL of the pests by monitoring techniques like sticky traps, light traps and pheromone traps.

8. The IPM program for various insect-pests should be well communicated in time to the farmer's community for knowing the different pest management practices and the

acceptance of the same. Of any IPM programs should be economically viable and sustainable in any eco-system.

Chemical Control



Classification of Insecticides:

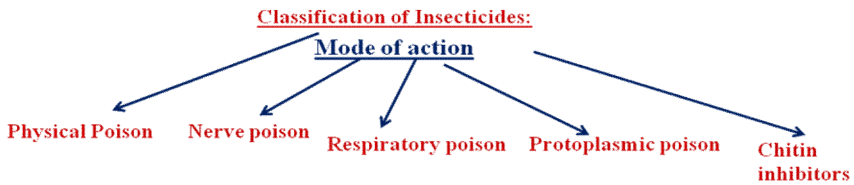
Mode of entry

1. Contact poisons; those insecticides which kills the target insect-pests by physical contact or skin absorption. Eg. DDT

2. Fumigants poisons: those chemicals which are volatile in nature, having poisonous substance used to kill insects, nematodes, and other animals.

3. Stomach poisons: those chemicals are toxic only if ingested through the mouth and are most useful against those insects that have biting or chewing mouth parts.

4. Systemic poisons: When applied to pesticides, the term systemic means that the chemical is soluble enough in water that it can be absorbed by a plant and moved around in its tissues. Movement of systemic insecticides, like all transportable chemicals in the plant, takes place principally in the plant's vascular system, which includes the phloem and xylem.



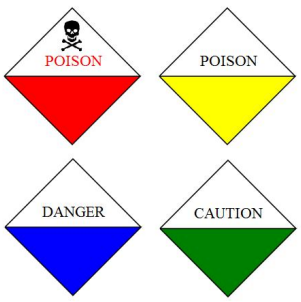
Toxicity

Extremely toxic – Color: red, symbol: skull and poison, oral LD50: 1-50

Moderately toxic – Color: blue, symbol: danger, oral LD50: 501 – 5000

Highly toxic – Color: yellow, symbol: poison, oral LD50: 51 – 500

Less toxic – Color: green, symbol: caution, oral LD50: >5000



Classification based on the basis of use

Acaricides; dicofol; carbofuran; Propoxur; abamectin; flufenoxuron; oxydemeton methyl; Phorate; Phosalone; fenpyroximate, Fipronil, bifenthrin, cyhalothrin, fluvalinate , permethrin, chlorfenapyr.

Antifeedants;Neem

Chemosterillant;Diflubenzuron

Insectattractants: Gossyplure, Gyplure, Muscalure

Insect repellents: Citronella oil, Permethrin

Insecticides; malathion; DDT; Spinetoram

Nematicides; abamectin, benomyl , carbofuran , carbosulfan, methyl bromide, fenamiphos, phosphamidon, chlorpyrifos; dimethoate, phorate, triazophos.

Plant activators and Plant growth regulators;

Rodenticides: Zinc phosphide

Applied Control: Chemical Control: Major Classification Of Pesticides

Insecticides:

1. Chlorinated hydrocarbons

DDT; Methoxychlor; Toxaphene; BHC (Benzene hexachloride); Chlordane; Heptachlor; Aldrin and dieldrin; Endosulfan

2. Organophosphates

Parathion; Malathion; Dichlorvos; Monocrotophos; Phorate; Dimethoate; Phosphamidon; Methyl parathion; Quinalphos; Chlorpyriphos; Acephate; Fenitrothion; Triazophos;

3. Carbamates

Carbofuran (Furadan); Carbaryl (Sevin); Thiodicarb (Larvin); Aldicarb; Carbosulfan; Methomyl

4. Synthetic Pyrethroids

Allethrin; Bifenthrin; Cypermethrin (Cymbush); Permethrin (Ambush); Fenvalerate (Sumicidin); Deltamethrin; lamda Cyhalothrin

Other Groups

Phenyl-pyrazoles : Fipronil

Neonicotinoids: Acetamiprid, Clothianidin, Dinotefuran, Imidacloprid, Nitenpyram, Thiacloprid, Thiamethoxam

Other Groups

Phenyl-pyrazoles : Fipronil

Neonicotinoids: Acetamiprid, Clothianidin, Dinotefuran, Imidacloprid, Nitenpyram, Thiacloprid, Thiamethoxam; Sulfoximines: Sulfoxaflor; Cycloxaprid

Butenolides: Flupyradifurone

Spinosyns: Spinetoram, Spinosad

Avermectins, milbemycins: Abamectin, Emamectinbenzoate,Milbemectin

JUVENILE HORMONE MIMICS

Applied in the pre-metamorphic instar, these compounds disrupt and prevent metamorphosis.

JUVENILE HORMONE ANALOGUES: Hydroprene, Kinoprene, Methoprene

Fenoxycarb; pyriproxyfen

Pyrroles: Chlorfenapyr: **Pyridine azomethine;**Pymetrozin

Nereistoxin analogues: Bensultap, Cartap hydrochloride

Oxadiazines: Indoxacarb

Semicarbazones: Metaflumizone

Tetronic and tetramic acid derivatives;Spirodiclofen, Spiromesifen, Spiropidion, Spirotetramat

Phosphides: Aluminium phosphide, Calcium phosphide, Phosphine, Zinc phosphide

Diamides: Chlorantraniliprole, Cyantraniliprole, Cyclaniliprole, Flubendiamide, Tetraniliprole

Pyridine carboxamide: Tolfenpyrad; Flonicamid

Inhibitors of chitin biosynthesis:

Benzoylureas: Chlorfluazuron, Diflubenzuron, Flufenoxuron, Hexaflumuron, Lufenuron, Novaluron, Noviflumuron, Teflubenzuron, Triflumuron; BUPROFEZIN

Moulting disruptor;cyromazine

Ecdysone receptor agonists: Mimic the moulting hormone, ecdysone, inducing a precocious moult

Diacylhydrazines: Chromafenozide, Halofenozide, Methoxyfenozide, Tebufenozide

Octopamine receptor agonists: Activate octopamine receptors, leading to hyperexcitation. Octopamine is the insect equivalent of adrenaline, the fight-or-flight neurohormone. Eg.amitraz

Insect growth regulators and their activity for insect pest control

S.No.	Activity	Name and target
1.	Chitin synthesis inhibitor	Diflubenzuron (Lepidoptera, Coleoptera and Diptera), Novaluron (Lepidoptera), Lufenuron (Lepidoptera), Diafenthiuron, Buprofezin (Sucking pests-Homoptera-brown plant hopper, white fly)
2.	JH mimics	Hydroprene, Kinoprene, Methoprene, Fenoxycarb (Lepidoptera) Pyriproxyfen (Sucking pests-white fly)
3.	Ecdysone analogues	Halofenozide, Methoxyfenozide, Tebufenozide, Diofenolan (Lepidoptera-caterpillars)

Applied Control: Chemical Control: Major Classification Of Pesticides

Fumigants:

1. Hydrogen cyanide
2. Methyl bromide
3. Ethylene dichloride and carbon tetrachloride
4. Ethylene dibromide
5. Aluminium phosphide

Nematicides

1. Dichloropropane-dichloropropene (D-D mixture)
2. Ethylene dibromide
3. Methyl bromide
4. Aldicarb
5. Carofuran
6. Dazomet
7. Phorate

Rodenticides

1. Zinc phosphide
2. Warfarin
3. Strychnine

List of insecticides commonly used for the control of different insect-pests

S.no.	Insecticide group	Trade name	Mode of action

Chlorinated Hydrocarbons			
1.	Dicofol 18EC	Kelthane	Contact
Organophosphates			
2.	Acephate 75 SP	Lancer, Asataf, Orthene	Systemic, stomach and contact
3.	Chlorpyriphos 20 EC	DUrsban;	Contact, stomach and fumigant
4.	Dichlorvos (DDVP) 76 WSC	Nuvan	Contact and fumigant
5.	Dimethoate 30 EC	Rogor	Systemic, Contact and fumigant
6.	Malathion 50 EC	Cythion	Contact and stomach
7.	Methyl parathion 50 EC/ 2D	Metacid	Contact, stomach and fumigant
8.	Monocrotophos 36 WSC/36 SL	Nuvacron	Systemic and Contact
9.	Phorate 10 G	Thimet	Systemic and Contact
10.	Profenofos 50 EC	Curocron	Stomach and contact
11.	Quinalphos 25 EC/1.5 D	Ekalux	Stomach and contact
12.	Triazophos 25 EC	Hostathion	Stomach and contact
Carbamates			
13.	Carbaryl 50% WP	Sevidol	Contact
14.	Carbofuran 3%CG	Furadan	Systemic, Contact and fumigant

15.	Methomyl 40SP	Lannate/Dunet	Systemic, Contact and fumigant
16.	Thiodicarb 75WP	Larvin	Contact
17.	Propoxur 20 EC	Baygon	-
Pyrethroids			
18.	Beta-cyfluthrin 2.45 SC	Bull-dock	Contact
19.	Bifenthrin 10EC/2.5 EC	Talstar	Contact and stomach
20.	Cypermethrin 10 EC/25 EC	Cymbush	Contact and stomach
21.	Deltamethrin 2.5 WP/2.8EC	Decis	Contact and stomach
22.	Lamda cyhalothrin 5EC	Karate	Contact
23.	Fenvalerate 20EC	Fenkil	Contact and stomach
Insect Growth regulator (IGR)			
24.	Buprofezin 25 SC	Applaud	IGR
25.	Diafenthiuron 50WP	Polo	IGR
26.	Diflubenzuron 25WP	Dimilin	IGR
27.	Novaluron 10EC	Rimon/Novo	IGR
Neonicotinoids			
28.	Imidacloprid 17.8 SL/70WS/70WG	Gaucho/Confidor	Systemic
29.	Acetamiprid 20SP	Pride/manik	Systemic
30.	Thiomethoxam 25WG/30FS	Actra/Cruiser	Systemic

31.	Thiacloprid 21.7SC	Calypso	Systemic
Pyrazole			
32.	Fipronil 0.3Gr/ 5 SC	Regent	Contact, stomach and systemic
Avermectins			
33.	Emamectin benzoate 5SG	Proclaim	Contact and stomach
34.	Spinosoids 45SC	Spinosad; Success; Tracer, Naturalyte	Contact and stomach
35.	Spiromesifen 22.9 SC	Oberon	Contact, stomach and systemic
Oxadiazine			
36.	Indoxacarb 14.5 SC/15.8EC	Avaunt/Avatar	Contact and stomach
Diamide			
37.	Chlorantraniliprole 18.5 SC/0.4GR	Coragen	Translaminar, contact and stomach
38.	Cyantraniliprole 10.26 OD	Cyazypyr	Translaminar, contact and stomach
39.	Flubendiamide 205WG/39.35 SC	Takumi	Translaminar, contact and stomach

Toxicity of insecticides:

Toxicity: The toxicity of a pesticide is its capacity or ability to cause injury or illness.

Acute toxicity of a pesticide refers to the chemical's ability to cause injury to a living organism from a single exposure, generally of short duration.

LD50 is defined as the lethal dose at which 50% of the population if killed in a given period of time.

LC50 is the lethal concentration required to kill 50% of the population.

ED50/ EC50: Chemicals that gives desirable effects in 50% of test animals.

KT50: Dose/ Time required for 50% of population having knockdown effect.

Toxicity Categories for Active Ingredients:

Routes of Exposure	Category I	Category II	Category III	Category IV
Oral LD50	Up to and including 50 mg/kg	50-500 mg/kg	500-5,000 mg/kg	>5,000 mg/kg
Inhalation LC50	Up to and including 0.2 mg/l	0.2-2 mg/l	2-20 mg/l	>20 mg/l
Dermal LD50	Up to and including 200 mg/kg	200-2,000 mg/kg	2,000-20,000 mg/kg	>20,000 mg/kg
Signal Word	DANGER POISON	WARNING	CAUTION	CAUTION

INSECTICIDE FORMULATION:

A pesticide formulation is a mixture of chemicals which effectively controls a pest. It consists of mixture of active ingredient and inert ingredients.

Different Types of Formulations

Dusts (D) are made up of a finely ground mixture of active ingredient combined with clay, talc, or other powdered materials. Dusts are intended for dry use and should never be mixed with water. The percentage of active ingredient in a dust is generally quite low. Dusts are commonly used for interior wall void and perimeter treatments, as well as for crop-dusting.

Granules (G) are hard, dry particles made up of porous materials and active ingredient. The percentage of active ingredient in a granule formulation is higher than that of a dust but lower than that of an EC. Granules are usually more safe to apply than dusts or ECs. Granular formulations are used most often for soil treatments. Granules will not cling to plant foliage, so that they may be directly applied over plants or soil.

Aerosols are sold in cans and contain one or more active ingredients under pressure. Aerosols pesticides are sold most often for home and garden use, not for agricultural use. The percentage of active ingredient in aerosols is usually very low. One of the main advantages of aerosols is that they are convenient and easy to use. Many aerosols are used for killing pests on contact, or for time-released control of flying pests.

Wettable powders (WP) are dry and powdery. They appear similar to a dust but contain additional wetting and dispersing agents so that water may be added for maximum effectiveness. Wettable powders are also more highly concentrated than dusts to contain more

active ingredient. Wettable powder formulations do not form a true solution when water is added, so frequent agitation of the spray tank is required to keep the formulation in suspension.

Emulsifiable concentrates (EC) are liquid formulations where the active ingredient is dissolved in oil and an emulsifier is added so that the formulation may be mixed with water or oil for spraying. ECs are among the most widely used formulations, along with wettable powders. ECs typically contain two to six pounds of active ingredient per gallon. Unlike wettable powders, ECs require very little agitation and are easy to handle.

Flowable liquids (F or L) are made with active ingredients that can not be dissolved completely in water or oil, so the active ingredient is ground up and suspended in a liquid with other suspending agents. The formulation is then ready to mix with water for application. Flowables are easy to handle, will not clog spray nozzles, and require only moderate agitation.

Solutions and water soluble concentrates (S) are liquids in their original state and are fully soluble in water and any other solvent. Solutions that are prepared the right way will not leave unsightly residues or clog spray nozzles.

Encapsulated pesticides are a new kind of formulation in which the active ingredient is held in a very small capsule. These capsules are then suspended in a liquid. This formulation of suspended capsules is then mixed with water and maybe applied with a sprayer. Encapsulated pesticides are safe and easy to use, but may pose a threat to bees when they carry the capsules back to their hive.

Soluble powders (SP), are dry formulations similar to wettable powders, but the difference is that when added to water a soluble powder will dissolve completely and form a genuine solution (whereas a wettable powder does not). Some agitation may be required to dissolve the soluble powder initially, but once a solution, agitation is not needed. The percentage of active ingredient in a soluble powder is high compared to ECs and WPs.

Dry flowables are very similar to granules in appearance, but behave in the same way as wettable powders. Dry flowables have several advantages over WPs because of their shape: they can be easily "poured" and measured just like liquid, and are safer to use because very little dust is released into the air when they are mixed and measured. Dry flowables contain very high percentages of active ingredient.

Insecticide Mixtures involve combinations of two or more insecticides in the right concentration into a single spray solution. Insecticide mixtures are widely used in green house and field production systems due to the savings in labour costs. Furthurmore, the use of insecticide mixtures may result in synergism or potentiation and sometimes mitigate the resistance.

Poisonous baits are food-like substances mixed with a pesticide specifically designed to attract and be eaten by insects or other pests and eventually poison them to death. Baits are commonly used for rodent control, including mice and rats. However, baits are also used to control roaches, ants, flies, and other insects. Bait formulations can be used indoors or outdoors. When compared to ECs or other formulations, the percentage of active ingredient in a bait is low.

Chemical control: The use of chemicals to kill pests is called as Chemical control.

Importance :

Insecticides are the most powerful tools available for use in pest management due to the following advantages.

(1) Relatively low cost.

(2) Effectiveness, ease of availability and stability is the major advantage.

(3) Generally fast-acting, which limits the damage done to crops.

(4) Adaptable to most situations.

(5) Flexible in meeting different agronomic and ecological conditions.

(6) For many pest problems, chemical control is the only acceptable solution.

Insecticides are the only tools available when pest is crossing threshold level.

Chemical hazards:

A chemical hazard is the risks involved with using a chemical during its manufacture, transport or during its handling.

Limitations:

(1) Chemical hazards produce by chemical synthesis or manufacturing, processing, transportation and thatNon-target effects and toxicity.

(2) They promote pests evolution.

(3) Individual pests that are resistant to the chemical develop resistance to that particular chemical and it can no longer be used in controlling them.

(4) Environmental contamination.

(5) Damage natural enemy population.

(6) Many pesticides bring about the secondary infestation of non target pests and resurgence of target pests.

(7) Some pesticides cause phytotoxicity.

(8) Some insecticides accumulate in body tissue become dangerous even without any prior indications.

RECENT METHODS OF PEST CONTROL:

Insect repellent:

Chemicals which cause insects to move away from their source are referred to as Insect repellent.

Desirable traits of a good repellent:It should be effective for a long time and on a wide range of insects; Weathering effects on it should be the least; Should not be toxic or irritating to man and animals; Should be cost effective.

Types of repellants:

Physical repellants: These produce repellance by physical means and are of following kinds.

Contact stimuli repellents: These are substances (dusts, granules, oils, leaf hairs, spines and waxes) that influence the surface texture of the plants to produce a disagreebale effect on the tactile sense of the insects.

Auditory repellents: These employ sound to ward off insects.Amplified sound has been effective in repelling mosquitoes, pyralid moths and flies.

Visual repellents: Normally light attracts insects, but in particular yellow colour light is the least attractive and to some extent repells the insects.

Excitoryrepellents: Chemicals such as pyrethrum, DDT, BHC etc., which excite the insect tarsi by stimulating the sensory nerves and forcing them to leave the surface.

Feeding Repellants: Subsatnce that inhibit feeding in insects are called as Feeding Repellants or anifeedants.

Chemical repellants: These are the chemicals which affect tactile, olfactory, or gustatory receptors of insects.

Repellants of plant origin: Oil of citronella, lemon grass, pyrethrum.

Synthetic origin: Diethyl toluamide against mosquitoes, ticks, fleas and biting flies.

Uses of Repellants:

They can be used on the body in some formulation to ward off insects.

They can be used as fumigants in an enclosed area of insects.

They can be used as dusts and sprays on domestic animal to protect them.

They can be used to drive insects from their natural breeding grounds to areas treated with an insecticide.

Antifeedants:

Antifeedants are chemicals that inhibit feeding but does not kill them directly. They are three main sites for the sense of taste in insects, mouth, tarsi and on the antennae.

Groups of antifeedants:

Triazenes: Acetanilide

Organitins: Triphenyltin acetate

Botanical extracts: Pyrethrum, Margosa, Apple factor (Phlorizin).

Advantages of antifeedants:

Affect the phytophagous insects, so do not harm beneficial parasitiods, predators and pollinators.

As the pest is not killed immediately, its parasites and predators continue to feed on it, thrive and keep it under control.

Produce no phytotoxicity.

Disadvantages:

Only the chewing type of insects are effected by antifeedants.

New growths of plants are not affected.

As the insects are not immediately killed, they could mov*e to untreated plant parts.

Antiffedants are not effective enough as sole control measure.

Insect Attractants:

Chemicals that cause insects to make oriented movements towards their source are called as Insect Attractants.

They influence both gustatory and olfactory receptors.

Types of Attractants:

Pheromones: Pheromones are chemicals produced as messengers into the environment that affect the behavior of other individuals of insects or other animals.

Depending on their mode of action, they are divide into 2 major classes.

Releaser effect: pheromones that cause an alteration in the behavior of the recipient.

Primer pheromones: These take longer to get a response. They can influence the physiology of insects.

a)Sex pheromones: Sex pheromones are pheromones released by an organism to attract an individual of the same species.

Gyplure, cuelure, looplure.

Sex pheromones in insect pest management:

1. **Monitoring :** Useful for estimating the pest population and detecting the early stages of pests.
2. **Mass trapping:** Used to capture male moths of newly emergrd and to reduce the number of males for mating.
3. **Mating disruption:** By permitting the atmosphere with higher concentration of the pheromone the opposite sex is rendered and confused to locate the opposite sex.

Aggregation pheromones attracts the both sexes of a species and are particularly common among insects and other arthropods that exploit food sources that are patchy in distribution and sporadically available.eg.scolytid beetles.

Trial marking pheromone: At low concentrations mostly used by foraging ants and white ants.

Alarm pheromones: These substances are elaborated by mandibular glands, sting apparatus, anal glands which typically results in fight or aggression eg., Dolichoderine ants.

Natural food lures: These are chemicals present in plant and animal hosts that attract insects for feeding. They stimulate olfactory receptors.

Eg., Essential oils for phytophagous insects, Carbondioxide, lactic acid for mosquitoes.

Oviposition lures: Chemicals that govern the selection of suitable sites for oviposition by adult female.eg., P- methyl acetophenone of yellow stem borer.

Advantages:

Attractants donot disrupt the ecosystem.

Target specific.

Used to mastrap the insects instead of killing them.

Environmentally friendly.

Disadvantages:

1. Insects can always find untreated hosts, so their number is unaffected most of the times.

2. Attractants are not the sole option for insect control.

Gamma radiation:

Gamma rays, high-energy electrons, and X-rays are among the ionizing radiation sources utilized practically in sterile insect releasing programs for controlling insect pests.

Eg., Screw worm (Cochliomyiahominivorax) a cattle pest was completely eradicated from curacao islands and south eastern parts of USA by male sterilization by irradiation with gamma rays (CO60).

THE INSECTICIDES ACT, 1968

An Act to regulate the import, manufacture, sale, transport, distribution and use of insecticides with a view to prevent risk to human beings or animals. All the provisons of the Insecticide Act was brought into force with effect from 1st Aug, 1971.

Rules Framed :-

There is compulsory registration of the pesticides at the Central level and licence for their manufacture, formulation and sale are dealt with at the State level. With the enforcement of the Insecticides Act in the country pesticides of very high quality are made available to the farmers and general public for house-hold use, for protecting the agricultural crops from the ravages of their pests, humans from diseases and nuisance caused by public health pests and the health hazards involved in their use have been minimised to a great extent.

Central Insecticide Board:-

The Government has constituted Central Insecticides Board under the Chairmanship of Director General of Health Services with 29 members from different speciality and government organisations.

Functions:

1. To advise the Central and state Governments on technical matters.

2. To specify the uses of the classification of insecticides on the basis of their toxicity.

3. To advise tolerance limits for insecticides, residues.

4. An establishment of minimum intervals between the application of insecticides and harvest in respect of various commodities.

5. To specify the shelf-life of insecticides.

Registration Committee:

Registration Committee consisting of a Chairman and other five persons who shall be members of the Board. The main objective the committee is to register insecticide after scrutinizing their formulae and verifying claims made by the importer or the manufacturer, as the case may be, as regards their efficacy and safety to human being and animals. The function of the registration committee is to specify the precautions to be taken against poisoning through the use or handling of insecticides. For import and manufacture of insecticides, registration certificate is essential and a separate certificate for each insecticide.

Types of registration:

A) **Provisional registration:** Provisional registration for 2 years for data Generation but not for commercialisation

B) **Regular or full registration:** is done when committee satisfy on the data produce.

C) **Repeat registration:** Registration for already registered product for a subsequent applicant. Data requirement is less.

Functions of Central Insecticide Laboratory:

1. To analyze samples of insecticides and submission of certificates of analysis to the concerned authority; 2. To analyze samples of materials for insecticide residues 3. To carry out such investigations as may be necessary for the purpose of ensuring the conditions of registration of insecticides; 4. To determine the efficacy and toxicity of insecticides

APPLICATION TECHNIQUES OF SPRAY FLUIDS:

Main purpose of pesticide application technique is to cover the target species and safety to the non target organisms and the environment.

Spraying is classified on the basis of the droplet size of the spray as :-

Spray Type	Droplet size (µ - microns)
Very Coarse spray	> 500 µ
Coarse spray	400 µ – 500 µ
Medium spray	250 µ – 400 µ
Fine spray	100 µ – 250 µ
Mist	50 µ – 100 µ
Fog	05 µ – 50 µ
Aerosol	0.1 µ – 5 µ

On the basis of Volume of spray fluid per unit area, Spraying is classified as:-

High volume sprays : These are used to spray fluid of 450 to 1000 liters.

These are categorized into:- Manually Operated, Power Operated

Pesticide is diluted with water and droplet size is larger.

Advantages:

1. Meant for chewing insects; 2. Drift is very less;

Disadvantages:1.Less area is covered; 2. More water is used; 3. Labour and cost of application is high.

Manually Operated

1.Knapsack Sprayer :

This type of sprayer has a flat or bean shaped tank.

The tank has a capacity of 10 to 20 liters and is made of galvanized iron, brass stainless steel or plastic.

It is used for spraying field crops vegetables and nurseries. ϖ The area covered per day is 0.8 to 1ha.

Rocker Sprayer :

It consists of a pump assembly, a rocking lever, pressure chamber, and suction hose with a strainer, delivery hose, cut-off valve and spray lance with nozzle.

By rocking movement of the lever pressure can be built in the pressure chamber and this helps to force the liquid through the nozzle.

There is no built in tank.

It can be used for spraying trees and tall field crops. It covers about 1.5 to 2 hectares of area in a day.

Power Operated:

1. POWER OPERATED KNAPSACK SPRAYER :

Stroke, easy start engines for heavy work.

18 Feet height of spray for orchards and also used for field crops .

Upto 125 mtrs hose can be attached with different type of nozzles available.

2. Tractor Mounted Boom Sprayer :

Boom sprayer connected to the three point linkage of tractor and getting drive from are used for multipurpose plant protection.

With these sprayers all kind of field crops could be sprayed.

Full UV & chemical resistant virgin polyethylene tank. Solid color means no algae growth inside the tank.

Spring loaded boom sections which avoid deflection of plants.

2. Low Volume Sprayers

Since in these sprayers the spray fluid is atomized with the help of an air stream at high velocity. These are called mist blowers or power sprayers.

The tank in these is made of a thick polyethylene and has a capacity of 10 liters.

The fuel tank capacity is 1.0 to 1.5 liters. It is provided with 1.2 to 3.0 hp petrol engine.

The area covered by these sprayers is about 2 ha in a day.

1.Power Operated Mist blower:

Mist blower allow to effortlessly and precisely spread pesticides over large and difficult areas.

Vines, fruit trees and vegetable patches are all tended to in a short time.

Ultra-Low Volume Sprayers :

The pesticide in ULV formulation is used undiluted at a quantity less than 6 liters/ha and usually at 0.5 to 2.0 liters/ha for field crops.

The droplet size varies from 20-150 micron with ground spraying equipment for ULV spray an area of 5 ha can be covered in a day.

E.g. Controlled Droplet Applicator (CDA).

Controlled Droplet Applicators (CDA)

These applicators use a spinning disk (or cup) that breaks the liquid into uniformly sized droplets by centrifugal force.

The droplets may be carried to the target by gravity or by an airstream created by a fan.

Power to spin the disk or cup is provided by a small electric or hydraulic motor.

Most CDA's do not use a pump.

CDA's range in size from a small hand-held type to large tractor- mounted units.

Aerial Spraying :

Aerial air crafts have been employed for application of agricultural and public health pesticides.

It is used for spraying, dusting and application of baits. However, Spray formulations are more suitable than dusts because of wind speed should not be more than > 5 KMPH.

It has to be done at low heights and in the early hours of the days to ensure uniform deposition of dust particles.

SYMPTOMS OF INSECTICIDES POISONING:

Signs and symptoms of poisoning (Source: WHO):

Poisonings due to pesticides are usually acute and result from extensive skin contact or ingestion. Signs and symptoms vary with the type of pesticide and can sometimes be confused with those of other illnesses.

Indications of pesticide poisoning

General: extreme weakness and fatigue. **Skin:** irritation, burning sensation, excessive sweating, staining. **Eyes:** itching, burning sensation, watering, difficult or blurred vision, narrowed or widened pupils. **Digestive system:** burning sensation in mouth and throat, excessive salivation, nausea, vomiting, abdominal pain, diarrhoea;**Nervous system:** headaches, dizziness, confusion, restlessness, muscle twitching, staggering gait, slurred speech, fits, unconsciousness; **Respiratory system:** cough, chest pain and tightness, difficulty with breathing, wheezing.

Symptoms of mild poisoning: Headche; Nausea; Dizziness; Fatigue; Irritation of the skin, nose and throat;Perspiration; Loss of apetite.

Symptoms of moderate poisoning: Vomiting; Blurred vision; Stomach cramps; Rapid pulse; Difficulty in breathing, constricted pupils of the eyes; Excessive Perspiration; Trembling and twitching of muscles, fatigue and nervous distress; Symptoms of severe poisoning: Uneasiness; Respiratory failure; Loss of pulse;

Symptoms due to chlorinated hydrocarbon poisoining: Uneasiness; Headache; Nausea; Vomiting; dizziness and tremors; Convulsions; Respiratory arrest followed by coma; Leucocytosis and rise in blood pressure; Symptoms due to organophosphate and carbamate poisoning; Headache, giddiness, vertigo, weakness, excessive mucus discharge, from nose and signs of tightness; Nausea followed by vomiting, abdominal contraction, salivations; Loss of muscle coordination, speech defects, twitching of muscles, hypertension, jerky movements, convulsions and coma; Death may occur due to depressions of respiratory centre;

Zinc phosphide; Vomiting; Vomiting; Diarrhoea; Severe abdominal pain followed by symptom free period of 89 hours or longer.

Aluminium phosphide:Headache; Giddiness; Nausea; Diarrhea and mental confusion.

If treatment is delayed, coma, loss of reflexes may develop and death may occur from respiratory or circulatory collapse.

First aid operations:

Call local emergency response provider immediately and

1.Remove patient to free air; 2. loosen all kinds of clothes.; 3. flush eyes with cold water till irritation subsides; 4. keep the patient calm, comfortable and warm; 5. Incase of ingestion, induce vomiting by giving a glass of water mixed with 2 spoons of common salt or putting the finger at the base of palate; 6. wash the patient calm, comfortable and warm; 7. show leaflet of pesticides for identification.;

If breathing is stopped provide artificial breathing;

Swallowed poising:Remove poison from the patients stomach by inducing vomiting.Give common salt 15g in a glass of water as animatic and repeat until vomit fluid is clear.

Inhaled poisons:Carry the patient to fresh air immediately; Open all doors and windows; Loosen tight clothing; Apply artificial respiration; Prevent chilling by wrapping the patient with blanket; Do not give alcohol in any form.

Eye contamination:Hold eye lids open; Wash the eyes gently with a stream of running water; Do not use any chemicals as they increase irritation;

Antidotes:

General antidote:

Universal antidote: it is a mixture of 7g of activated charcoal, 305g of tannic acid, 3.5g of MgO.Except incase of poisoning by corrosive substances, it should be followed by gastric lavage.

Demulcents: After removal of stomach contents, give on of the following: Raw egg white mixed with water; Gelatine 9g to 18g dissolved in 570ml of warm water; Butter; Cream; Milk or mashed potato.

Specific antidotes:

Atropine for organophosphate and carbamate poisoning.

2PAM: injected intravenously in organophosphate poisoning.

Calcium gluconate for some organochlorine poisoning.

Vitamin K for anticoagulant poisoning such as warfarin.

Dimercaprol(BAL) for arsenic poisoning.