RVS Agricultural College,Thanjavur

(Affiliated to Tamil Nadu Agricultural University)

THEORY MANUAL

AEN 301 PESTS OF FIELD CROPS & STORED PRODUCES AND THEIR MANAGEMENT (1+1)

III - B.Sc., (Agriculture)

Course teacher

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DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

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AEN 301 Pests of Field Crops and Their Management 1+1

Aim:

To impart knowledge on distribution, bionomics, symptoms of damage and management strategies of pests of field crops.

Theory

Unit I: Pests of Cereals and Millets

Distribution, bionomics, symptoms of damage and management strategies for insects and non-insect pests of rice, wheat, maize, sorghum, cumbu, ragi, tenai. Integrated Pest Management - case studies in rice.

Unit II: Pests of Pulses and Oilseeds

Distribution, bionomics, symptoms of damage and management strategies of insects and non-insect pests of pulses (redgram, green gram, black gram, bengal gram, cowpea.), groundnut, castor, gingelly, sunflower, safflower, jatropa, soybean and mustard. Integrated Pest Management - case studies in groundnut.

Unit III. Pests of Cotton and Sugarcane

Distribution, bionomics, symptoms of damage and management strategies of insects and non-insect pests of cotton and sugarcane. Integrated Pest Management - case studies in cotton.

Unit IV: Pests of Green Manures, Forage Crops, Stored Products and Non Insect Pests

Distribution, bionomics, symptoms of damage and management strategies of pests of green manures (Sunnhemp, Sesbania, Daicha. Glyricidia), forage crops (Lucere and Subabul) and stored products. Rodents and birds of agricultural importance and their management. Locusts and their management.

Theory schedule:

Distribution, bionomics, symptoms of damage and management strategies for insects and non-insect pests of

1. Rice – Sucking pests
2. Rice – Borers and defoliators
3. Maize, sorghum and cumbu
4. Wheat, ragi and tenai

5. Redgram, bengalgram, Blackgram, greengram and cowpea
6. Groundnut, gingelly and sunflower
7. Castor, soybean, safflower, jatropha and mustard
8. Cotton
9. Mid semester examination
10. Sugarcane
11. Green manures- sunnhemp, sesbania, daincha, lucerne, subabul and gliricidia
12. Role of physical, biological, mechanical and chemical factors in deterioration of grain
13. Stored product pests
14. Methods of grain storage and various methods of stored product pest management
15. Mites, slugs and snails, rodents and bird pests
16. Locusts and their management
17. Integrated Pest Management in rice and cotton

Practical schedule:

Identification of symptoms of damage and life stages of pests of

1. Pests of rice (sucking pests)
2. Pests of rice (borers and defoliators)
3. Pests of maize, sorghum and cumbu
4. Pests of wheat, ragi and tenai
5. Pests of redgram and bengalgram
6. Pests blackgram, greengram and cowpea
7. Pests of groundnut, gingelly and sunflower
8. Pests of castor, soybean, safflower, jatropha and mustard
9. Pests of cotton (sucking pests)
10. Pests of cotton (bollworms and defoliators)
11. Pests of sugarcane
12. Pests of green manures-sunnhemp, sesbania, daincha, lucerne, subabul and gliricidia
13. Pests of stored products

14. Gadgets for management of stored product insects
15. Rodents and Birds pests in field and storage
16. Visit to FCI godown and farmer's fields
17. Final practical examination

ASSIGNMENT:

- Collection and submission of 50 pests of field crops
- Rearing a minimum of 15 insect pests attacking field crops and preparation and submission of two riker mounts of field crop pests.

Outcome/Deliverables:

The students develop skills for the identification and management of pests of field crops

References:

A. Text Books:

1. Manisegaran, S. and R.P.Soundararajan. 2010. *Pest Management in Field Crops- Principles and Practices.* Agrobios, Jodhpur, India. 316p. {ISBN (10): 81-7754-321-0}
2. David, B.V. and V.V. Ramamurthy. 2011. *Elements of Economic Entomology*, Namrutha Publications, Chennai. 386 p. {ISBN: 978-81-921477-0-3}

B. Reference Books:

1. Awasthi, V.B. 2007. *Agricultural Insect Pests and their Control,* Scientific publishers (India), Jodhpur, 267p. {ISBN 81-7233-491-5}
2. Dhaliwal, G.S. and Ramesh Arora. 2004. *Integrated pest management Concepts and Approaches,* Kalyani Publishers, Ludhiana, 427p. {ISBN: 81-7663-904-4}
3. Regupathy, A. and R.Ayyasamy. 2013. *A Guide on Crop Pests*. Namrutha Publications, Chennai, 368 p. {ISBN: 978-81-921477-1-0}
4. Srivastava, K.P. and G.S. Dhaliwal. 2011. *A text book of Applied Entomology*. Vol. II, Kalyani Publishers, Ludhiana. 368p. {ISBN: 978-81-272-6752-0}

C. SUPPLEMENTARY REFERENCES:

1. Nair, M.R.G.K. 1995. *Insects and Mites of Crops in India.* Indian council of Agricultural Research, New Delhi, 408p.
2. Ayyar, T.V.R. 1963*. Hand Book of Economics Entomology for South India.* Govt. Press Madras.
3. Sivasubramanian, P., K.Samiayyan, N.Ganapathy, K. Bhuvaneswari and S.Jayaprabhavathi.2012. *A treatise on Integrated Pest Management.* Associated Publishing Company, New Delhi. 287 p.

D. WEB RESOURCES:

1. http://www.ncipm.org.in
2. http://agritech.tnau.ac.in/
3. http://www.nbaii.res.in/
4. http://www.nrcg.res.in/

LECTURE NO. 1 – PESTS OF RICE – SAP FEEDERS

Sucking pests

1. Thrips: *Stenchaetothrips biformis,* Thripidae: Thysanoptera

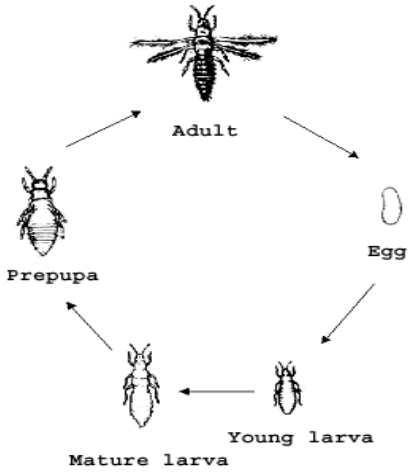
Alternate host: *Echinochloa* sp.

Distribution: Bangladesh, India, Indonesia, Japan, Malaysia, Sri Lanka, Thailand and Vietnam.

Symptoms of damage

Both nymphs and adults lacerate the tender leaves and suck the plant sap, causing yellow (or) silvery streaks on the leaves of young seedlings. Terminal rolling and drying of leaves from tip to base is the typical symptom of attack. It causes damage both in nursery and main field.

Bionomics



Adults are dark brown in colour. The female inserts the eggs singly within the leaf tissues in young leaves. Egg period is 3-5 days. Total life cycle is 13-19 days.

ETL: 60 Nos./12 passes of table tennis bat – nursery

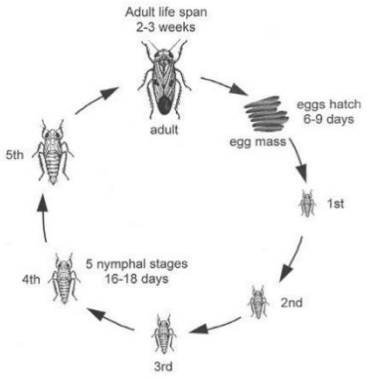
Management : Spray monocrotophos 36 WSC 40 ml/ 20-cent nursery and 1000 ml/ha in the main field.

2. Green leafhopper: *Nephotettix virescens*, *N. nigropictus*, *N. cincticeps*, Cicadellidae: Hemiptera

Symptoms of damage

Both nymphs and adults desap the leaves and cause "hopper burn" due to heavy infestation. Yellowing of leaves from tip to downwards is the typical symptom of this pest. It acts as a vector for the diseases *viz.,* Rice tungro virus, rice yellow dwarf, transitory yellowing and other viruses.

Bionomics



Adults are green with black spot and black patch on wings. The gravid female inserts the eggs in midrib of leaf blade. Each egg mass contains 8-16 eggs and a female lays 200-300 eggs. The egg period is 6-7 days. Nymphs undergo five instars and become adult in 25 days. The adult lives for about 20-30 days. The population normally increases from August onwards, reaches maximum during September - October and declines from November.

ETL:

60 Nos. / 25 sweeping – nursery

10 Nos. / hill - Flowering stage

5 Nos. / hill - Vegetative stage

2 Nos. / hill - Tungro endemic area

Management

1. Use resistant varieties like IR 50, CR 1009, Co 46, PTB 2 and PTB 18.
2. Nursery should not be raised near the lamp posts
3. Apply neem cake @ 12.5 kg/20 cent nursery as basal dose
4. Apply carbofuran 3 G @ 3.5 kg or phorate 10 G @ 1.0 kg per 20 cent nursery on 10 days after sowing.
5. Maintain the water level at 2.5 cm for 3 days (after granular application)
6. Spray fenitrothion 50 EC 80 ml (or) fenthion 100 EC 40 ml (or) quinalphos 25 EC 80 ml /20 cent nursery.
7. Spray fenitrothion 50 EC 1000 ml (or) fenthion 100 EC 500 ml (or) quinalphos 25 EC 1000 ml /ha in the main field.

3. White rice leafhopper: *Cofana spectra,* Cicadellidae: Hemiptera

Symptoms of damage

Nymphs and adults suck the sap causing yellowing of leaves and stunting of tillers.

Bionomics

Nymphs are elongate and pale green coloured. Adults are white in colour, 3-4 times larger than green leafhopper. They are biggest of rice hoppers.

4. Blue rice leafhopper: *Empoascanara maculifrons,* Cicadellidae, Hemiptera

Symptoms of damage

Nymphs and adults suck the sap of the leaves and cause "hopper burn" in the seedlings in the form of whitish waxy lines on the leaf blades in the initial stage of attack and subsequent drying.

Bionomics

Small blue leafhoppers with yellowish vertex having a black patch in the middle of pronotum.

5. Brown plant leafhopper: *Nilaparvata lugens,* Delphacidae: Hemiptera

Distribution: Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal, Maharashtra, Madhya Pradesh, Uttar Pradesh, Haryana and Punjab.

Symptoms of damage

Nymphs and adults congregate at the base of the plant above the water level and suck the sap from the tillers. The affected plant dries up and gives a scorched appearance called "hopper burn". Circular patches of drying and lodging of matured plant are typical symptoms caused by this pest. It is vector of grassy stunt, ragged stunt and wilted stunt diseases.

Bionomics

The brown plant hopper has a brown body and chestnut brown eyes. Adult measures about 4 - 4.5 mm in length. It can fly a long distance drifting with the wind. Adults are of two forms *viz.,* macropterous (long winged) and brachypterous (short winged). The female makes an incision in the leaf sheath and inserts 200-300 small eggs. Egg period -6 days; nymphal period - 15 days. Adult longevity is 18-20 days.

ETL: 1 No./tiller, 2 Nos. when spider is present at 1 No./hill

Management

1. Use resistant varieties like Aruna, Karnataka, Karthika, Krishnaveni, Makon, Abhey, Asha, Divya, Py 3, Co 42, Ptb 33 and Ptb 21.
2. Avoid close planting and provide 30 cm rogue spacing at every 2.5 m to reduce the pest incidence.
3. Avoid use of excessive nitrogenous fertilizers
4. Control irrigation by intermittent draining
5. Set up light traps to monitor pest population and to control
6. Release of natural enemies like *Lycosa pseudoannulata*, *Cyrtorrhinus lividipennis*
7. Avoid use of insecticides causing resurgence such as synthetic pyrethroids, methyl parathion, fenthion and quinalphos
8. Drain the water before the use of insecticides and direct the spray towards the base of the plants
9. Spray methyl demeton 25 EC 1000 ml (or) acephate 75 SP 625 gm (or) chlorpyriphos 25 EC 1250 ml (or) dichlorvos 76 WSC 350 ml/ha
10. Spray neem seed kernel extract 5% (25 kg/ha) (or) neem oil 2% (10 l/ha)

6. White backed planthopper: *Sogatella furcifera,* Delphacidae: Hemiptera

Distribution: Madhya Pradesh, Punjab

Symptoms of damage

Both nymphs and adults suck the sap and cause stunted growth and "hopper burn" results in yield loss. When the nymph falls on water it keeps it's legs broadly. "Hopper burn" is caused in irregular patches.

Bionomics

Nymphs are white in colour. Vertex is characteristically giving a narrow face to the hoppers - forewings hyaline with dark veins and a dark spot in the middle of posterior edge. Pronotum is pale yellow. Adult possess a diamond like marking on the thorax. The female lays eggs in leaf sheath and in the mid

rib of leaves. The ovipositional site is characterized by black streaks. One female can lay up to 758 eggs in as many as 112 egg masses with 1-24 eggs in each egg mass. Egg period is 6-7 days; Nymphal period is 12-17 days. It undergoes five nymphal instars. The longevity of female is about 2 months.

Management

1. Release of egg parasitoid, *Anagrus* sp. and adults and nymphs of the dryinid *Pachygonatopus* sp. Predators recorded on the insect are *Coccinella arcuata, Cyrtorrhinus lividipennis, Tytthus parviceps*
2. Spray dimethoate (or) phosphamidon, malathion (or) carbaryl

7. Mealybug: *Brevennia rehi*, Pseudococcidae: Hemiptera

Distribution

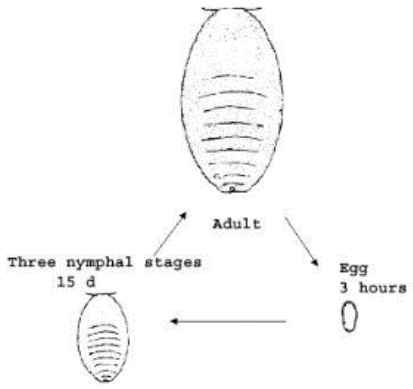
Tamil Nadu, Andhra Pradesh, Karnataka, Orissa, Madhya Pradesh, West Bengal and Kerala.

Symptoms of damage

Large number of insects remains in leaf sheath and suck the sap. The affected plants will be in circular patches. Plants become week, yellowish and very much stunted in patches. Presence of white waxy fluff in leaf sheaths is a typical symptom of damage.

Bionomics

The mealy bug is small reddish white, soft-bodied, wingless insect covered with filamentous materials. It lays 126-139 eggs in the leaf sheath. It reproduces parthenogenetically. The egg period is 3-24 hours. The nymphs remain within the leaf sheath and suck the plant sap. The nymphal period is 17-34 days.



Management

1. The mealy bug is parasitised by *Adelencyrtus* sp., *Dolihoceros* sp., *Gyranusa* sp., *Parasyrphophagus* sp., *Xanthoencyrtus* sp and predated upon by *Gitonides perspicax, Leucopis luteicomis, Scymnus* sp., *Pullus* sp., *Anatrichus pygmaeus*, *Mepachymerus ensifer*.
2. Remove the grasses from the bunds and trim the bunds during the main field preparation before transplanting.
3. Remove and destroy the affected plants.
4. Spray any one of the following insecticides in the initial stage of infestation. fenitrothion 50 EC 1000 ml, phasalone 35 EC 1500 ml and dimethoate 30 EC 500 ml/ha.

8. Rice black bug: *Scotinophora lurida* and *S. coarctata*, Podopidae: Hemiptera

Symptom of damage

Both nymphs and adults feed at the base of the plant where they suck plant sap from the culms during tillering to flowering. It also sucks the sap from leaf sheath, leaves and panicles. The affected plants turn reddish brown on yellow. During tillering stage, it causes drying up of central shoots (dead hearts), stunted growth and reduced tillers. During reproductive stage, it affects the panicle development and causes chaffy grains (white ears). In severe cases, plants wilt, dry and turn bug burned, similar to hopper burn damage of brown plant hopper.

Bionomics

Adults are brownish black bugs with a prominent scutellum and pronotum having a spine on either side. Eggs are laid in masses of varied number on the stem as well as on leaves. Eggs are greenish in colour when laid and turn pinkish during hatching and measure 1 mm long. Nymphs are brown with yellowish green abdomen with 2-3 black scent glands.

ETL: 10% damage at tillering stage (or) 5 bugs / hill

Management

1. Keep the field free from weeds and grasses
2. Drain the excess water from the field

3. Set up light trap during the full moon period to attract large number of bugs and kill
4. Conserve the predators *viz.,* spiders, coccinellids and wasps to check the pest
5. Ducks can be allowed in the field to pick up the bugs
6. Spray monocrotophos @ 1000 ml/ha (or) acephate @ 625 g per ha (or) NSKE 5% for effective control of black bug.

9. Rice earhead bug: *Leptocorisa acuta,* Alydidae: Hemiptera

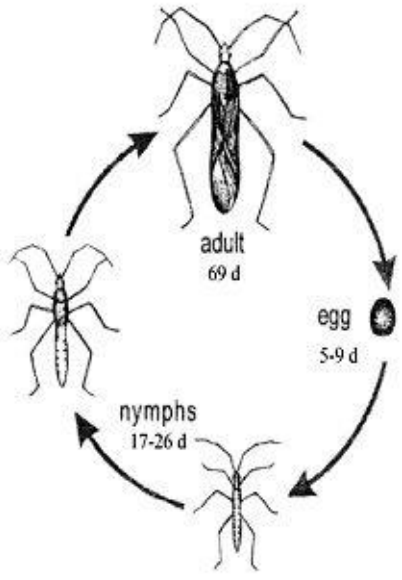
Symptoms of damage

Both nymphs and adults suck the sap from individual grains, which are in milky stage. Affected grains become chaffy and the yield loss may be 10-40%. Black spots on the grains at the site of feeding puncture. Obnoxious odour emanates on disturbing the bugs.

Bionomics

Adults are slender with long legs and antennae. They are brownish green in colour. They lay flat, dark, reddish brown eggs in rows of 10-15 on the leaves (or) panicles. About 200-300 eggs are laid by a female. The egg period is 5-8 days. Nymphs are green to brown. It undergoes five nymphal instars. Nymphal period is 17-27 days. Adults are fairly long lived (30-50 days).

ETL: 5 bugs /100 panicles-flowering stage. 16 bugs /100 panicles-milky stage.



Management

1. Dust any one of the following at 25 kg/ha twice first during flowering and second a week later. Quinalphos 1.5 D, Fenitrothion 2 D, Carbaryl 10 D and Malathion 5 D
2. Spray any of the following plant products (or) insecticides twice as above

Botanical powder formulations

1. Neem seed kernel extract 5%
2. Notchi leaf powder extract 5%
3. Ipomoea leaf powder extract 5%
4. Prosopis leaf powder extract 5%

Insecticide formulations

1. Fenitrothion 50 EC 1000 ml/ha
2. Fenthion 100 EC 500 ml/ha
3. Malathion 50 EC 500 ml/ha
4. Monocrotophos 36 WSC 500 ml/ha

10. Earhead stink bug / Shield bug / Red spotted bug: *Menida histrio*, Pentatomidae: Hemiptera

Symptoms of damage

Both nymphs and adults suck the ear heads and cause individual grains chaffy.

Bionomics

The adults lay eggs on leaves. The dark brown nymphs are also observed on the ear heads.

11. Rice striped bug: *Tetroda histeroides*, Pentatomidae: Hemiptera

Symptoms of damage

The nymphs and adults suck the sap from the stem and cause stunting and yellowing of tillers.

Bionomics

Adult is brown with a prominent "V" shaped mark on its back. It lays cylindrical eggs in rows on the under surface of the leaves. The egg period is 5-7 days. The nymphs grow feeding on the plant sap. The nymphal period is 40-50 days. The total life cycle is completed in 49-62 days. The adult longevity is about 2 months.

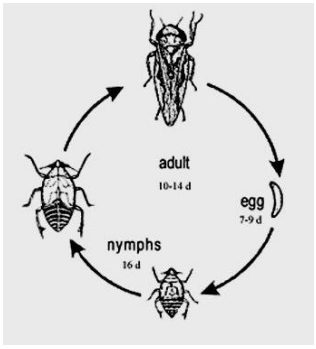
12. Zigzag striped leafhopper: *Recilia dorsalis*, Cicadellidae: Hemiptera

Symptoms of damage

Tip drying and orange discoloration of both margins of leaves.

Bionomics

Adults have white fore wings with pale brown bands forming the shape of W.



LECTURE NO. 2-PESTS OF RICE–BORERS AND FOLIAGE FEEDERS

1. Paddy stem borer: *Scirpophaga incertulas,* Pyraustidae: Lepidoptera

Distribution: Afghanistan, Bangladesh, Burma, Cambodia, China, India, Sri Lanka and Indonesia.

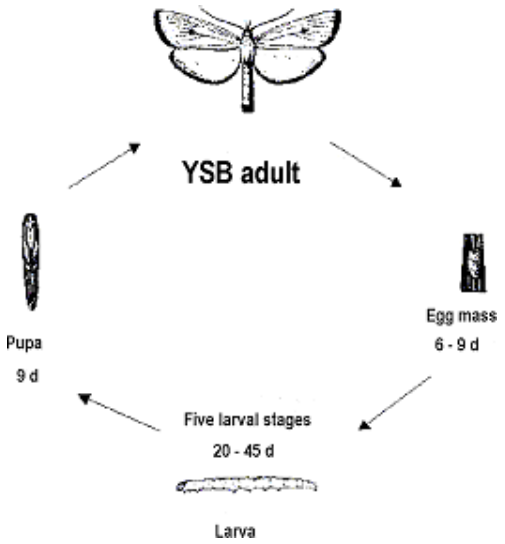
Host Plant: Rice

Symptoms of damage

Larva feeds on the stem and causes drying of the central shoot known as "dead heart" in the young seedlings; results in drying of the panicle in grown up plant called "white ear". Damage ranges from 30-80%.

Bionomics

Eggs are laid in a mass of 15-80 on the upper surface of the tip of the leaves and covered with buff coloured hairs. Each female lays 170-200 eggs. The egg period is 6-9 days. Larva is pale yellow with dark brown head. It swims in water and reach the tillers, then it enters the leaf sheath, feeds there and attack the stem near the node and bores inside. The larva migrates to other tillers also. Larval period is 20-45 days. It covers the exit hole with a thin web forms a white silken cocoon and pupates there. Pupa is dark brown in color. The pupal period lasts for 6-10 days. Female moth has bright yellowish brown fore wings with a black spot and posses a tuft of yellow anal hairs. Male moth is smaller with pale yellow forewings without black spot. Cold weather with high humidity and low temperature prevalent during October - December is conducive for multiplication.



ETL

2 egg masses / sq. meter

10% dead hearts - Vegetative stage

2% white ear - Flowering stage

Management

1. Grow resistant varieties *viz.,* Ratna, Jaya, TKM 6, IR 20 & IR 26
2. Clip the tip of seedlings before transplanting to eliminate egg masses
3. Avoid close planting and continuous water stagnation at early stages
4. Collect and destroy the egg masses
5. Pull out and destroy the affected tillers
6. Set up light traps to attract and kill the moths
7. Harvest the crop upto the ground level and disturb the stubbles with plough immediately after the harvest
8. Release the egg parasitoid, *Trichogramma japonicum*on 30 and 37 DAT twice @ 5 cc/ha/release followed by monocrotophos 36 SL spray thrice @ 1000 ml/ha on 58, 65 and 72 DAT.
9. Apply *Bacillus thuringiensis* var *kurstaki* and neem seed kernel extract in the combination of 2.5 kg/ml and 1% to reduce the oviposition by the stemborer.
10. Spray monocrotophos 36 SL @ 1000 ml/ha (or) quinalphos25 EC @ 1000 ml/ha

2. Gall midge: *Orseolia oryzae*, Cecidomyiidae: Diptera

Distribution

India, Burma, Cambodia, Srilanka, China, Indonesia, Nigeria, Sudan, Vietnam and Pakistan.

Host plants

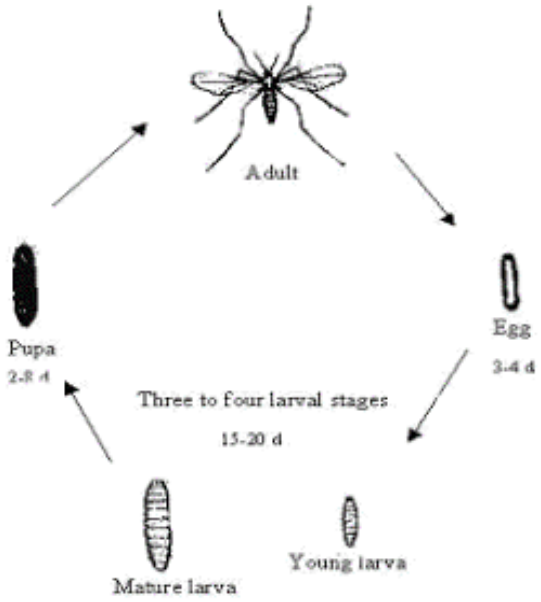
Rice, wild species of Oryza and grasses like *Phospaladium geminatum*, *Phaspalum scrobiculatum, Panicum* spp., *Ischaeum ciliare*, *Cyanodan dactylon*, *Eleucine indica*.

Symptoms of damage

The maggot feeds at the base of the growing shout causing formation of a tube like gall that is similar to "onion leaf" or "Silver-shoot". The galls are formed by the modification of leaf sheath due to larval feeding. Infested tillers produce no panicles. The infestation is fairly high from Sep - Dec.

Bionomics

Adult is orange coloured mosquito like fly. It is active during night and lays 100-300 eggs, reddish, elongate, tubular eggs just near the ligule of the leaf blade. Egg period is 3-4 days. Maggot is pale to red during feeding. Larval period is 8-10 days. It pupates at the base of the gall and moves to tip of the gall and projects outside during emergency. L.C. 15-20 days.



ETL: 10% silver shoots

Management

1. Encourage early planting of the crop to escape from infestation
2. Use resistant varieties like MDU-3, Shakthi, Vikram, Sureka
3. Harvest the crop and plough immediately
4. Remove the alternate host and adjust the time of planting
5. Use quick growing varieties
6. Optimum recommendation of potash fertilizer
7. Set up light trap @ 1 / ha as a monitoring device
8. Infra red light trap attracts gall midge effectively
9. Release larval parasitoid: Platygaster oryzae through parasitized galls @ 1 per 10 m^2 in the main field at 10 DAT.
10. The carabid beetle, Ophionia indica is an effective predator.
11. Conserve the spider predators like Tetragnatha and Argiope catenulat a in rice ecosystem to feed on the adult midge.
12. Spray fenthion 100 EC 500 ml (or) quinalphos 25 EC 1000 ml/ha.

Defoliators

3. Swarming caterpillar: *Spodoptera mauritia*, Noctuidae: Lepidoptera

Host plants: Rice, maize, jowar, wheat, barley and sugarcane

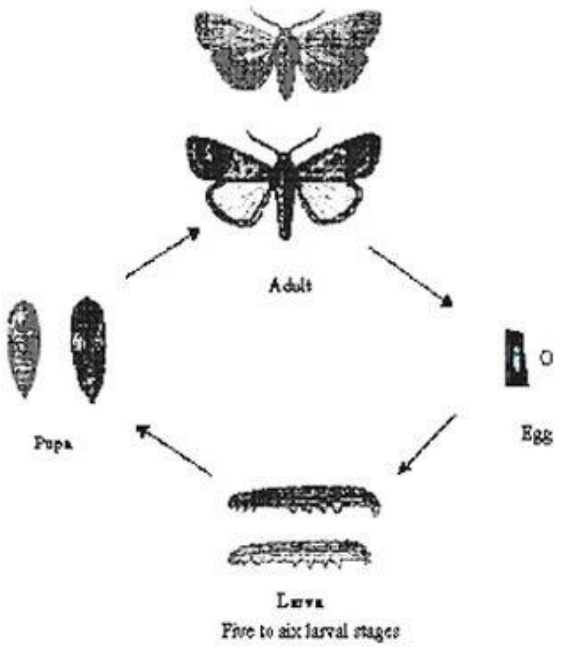
Distribution: India, South East Asia, USA, Australia, Africa

Symptoms of damage

This is a sporadic pest but causes very serious damage to young crops when it appears in large number. The caterpillars feed at night and hide during the day. Larvae cut the seedlings in large scale and present an appearance to the field, which is grazed by cattle by its nocturnal feeding. Peduncles of ears are bitten through in maturing crop. They feed gregariously and march from field to field. The damage is severe in July - September. It breeds on a variety of grasses. Yield loss ranges from 10-20%.

Bionomics

Adult moth is medium sized stoutly build, dark brown with a conspicuous triangular spot on fore wings. Eggs are laid in masses on leaves and covered with grey hairs. The egg period is 7 days. Caterpillar is cylindrical dark to pale green with lateral lines along the body. The larval period is 20-25 days. It pupates in an earthern cocoon in soil for 10-15 days.



Management

1. Release larval parasitoids *Apanteles ruficrus*, *Meteorus* sp., *Charops bicolor*, *C. dominans, Drino unisetosa, Pseudoperichaeta orientalis*,

Strobliomyia aegyptia, Pseudogonia cinerascens, Tachinia fallan, Cupho ceravaria, Sturmia inconspicua, Chelonus sp., Euplectrus euplexiae , E. spodopterae .

2. Pupa by Netelia sp., Actia s p., Drino sp. and Isomera cinerascens , Hexamermis sp. a parasitic nematode parasitises the larva.
3. The vertebrate predators of the larvae are Corvus splendens, C. macrorhynchus, Bubalcus coromandus, Arde elagrayi, Amaurovius pho enicocurus, Acridotheres tristis .
4. Flood the nursery to expose the hiding larvae to the surface and thus birds pick them up.
5. Kerosenate the water while irrigation to suffocate and kill the larvae.
6. Allow the ducks into the field to feed on the larvae.
7. Drain the water from nursery and spray chlorpyriphos 20 EC 80 ml during late evening.

4. Rice case worm: Nymphula depunctalis (Paraponyx stagnalis) Pyraustidae: Lepidopera

Distribution: India, South East Asia, Australia

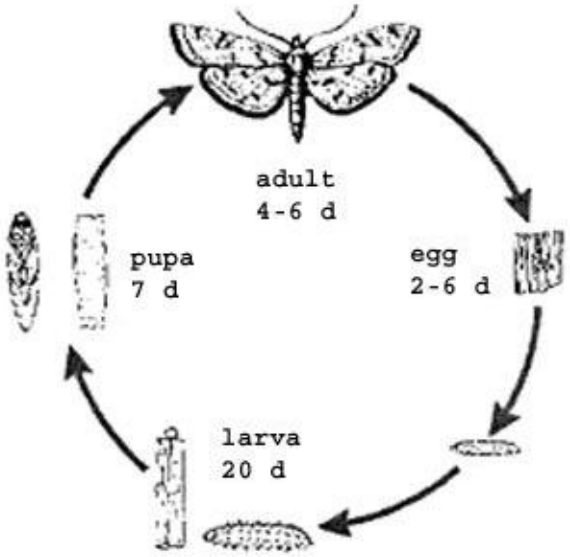
Host plant: Rice

Symptoms of damage

The caterpillars feed on green tissues of the leaves and form tubular cases around them by cutting the apical portion of leaves, which float on water. Several tubes are also seen hanging from the plants. In case of severe infestation plants are unable to grow. They damage top of the leaves. The apical portion of cut leaves bear whitish papery areas since the chlorophyll is scrapped.

Bionomics

Adult moth is delicate white moth with pale brown wavy markings. Eggs are laid on leaves. Egg period is 2-6 days. Larva is pale translucent green with orange head. Larva constructs a case. Larval period is 14-20 days. Larva has filamentous gills on the sides of the body that helps to lead a semi aquatic life. It pupates in case it self for 4-7 days. The total life cycle occupies 19-37 days.



Management

1. Release larval parasitoids viz., Elasmus sp., Apanteles sp., Bracon sp., Hormiues sp.
2. Release pupal parasitoids viz., Pediobius sp., Apsilops sp., Eupteromalus parnarae
3. Drain water from the field
4. Dislodge the cases by running a rope over the young crop
5. Spray of Monocrotophos 36 SL 1000 ml /ha

5. Rice skipper: Pelopidas mathias , Hesperidae: Lepidoptera

Distribution : India, South East Asia, China, Africa

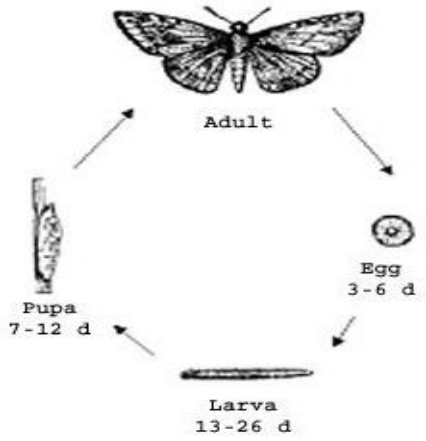
Host: Rice, Sugarcane

Symptom of damage

Edges of the leaves are fastened with webbing. Backward rolling of leaves, feeding from margin inwards are symptoms of damage.

Bionomics

Adult butterfly with brown coloured wings and curved antennae. Eggs are laid singly on the leaf blades. Larva is pale green with constructed neck.



6. Leaf folder (or) leaf roller: *Cnaphalocrocis medinalis*, Pyralidae: Lepidoptera

Distribution

India, Srilanka, China, Japan, Madagascar, New Guinea, Pakistan, Bangladesh, South East Asia, Korea.

Host range: Grasses

Symptoms of damage

The caterpillar folds the leaves longitudinally and remains inside. It scrapes the green tissues of the leaves with in the field and makes them white and dry. During severe infestation the whole field exhibits scorched appearance.

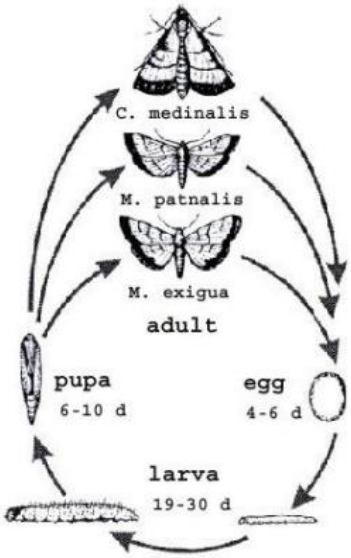
Bionomics

The adult moth is often seen in the field during daytime. The moth is brownish with many dark wavy lines in centre and dark band on margin of wings. The female moth lays eggs in batches of 10-12, which are arranged in linear row in the lower surface of leaves. The eggs are flat, oval in shape and yellowish white in colour. The egg period is 4-7 days. Larva is 15-20 mm long pale green transparent actively moving caterpillar. The larval period is 15-20 days. It pupates inside the leaf fold. The pupa is greenish brown. The pupal period is 6-8 days. Total life cycle: 25-35 days.

ETL:

10% damaged leaves - Vegetative stage

5% damaged leaves (Flag leaf) - Flowering stage



Cnaphalocrocis medinalis

Management

1. Use resistant varieties like TNAU LFR 831311, Cauvery, Akashi, TKM-6, IET 7511, IET 9225 and IET 9797.
2. Clipping of affected leaves reduces the pest population.
3. Keep the bunds clean by trimming them and remove the grassy weeds.
4. Avoid use of excessive nitrogenous fertilizer.
5. Set up light traps to attack and kill the moths.
6. Release *Trichogramma chilonis* on 37, 44 and 51 DAT thrice followed by three sprays of monocrotophos 36 SL @ 1000 ml/ha on 58, 65 and 72 DAT.
7. Spray neem seed kernel extract 5% @ 25 kg (or) fenitrothion 50 EC 1.0 lit (or) phosalone 35 EC 1.5 lit (or) chlorpyriphos 20 EC 1.25 lit/ha.

7. Rice horned caterpillar: *Melanitis ismene,* Satyridae, Lepidoptera

Distribution: Throughout the India

Host range: Rice, Millets

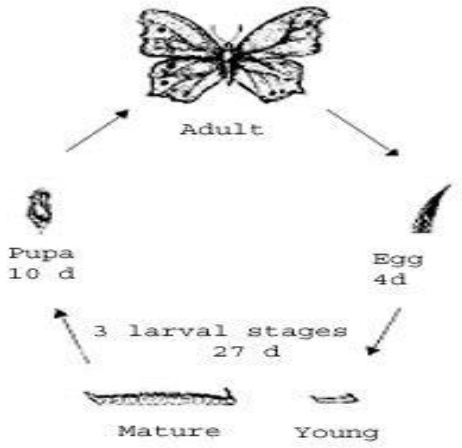
Symptoms of damage

The larva of this butterfly feeds on leaf blades of rice. Leaves are defoliated from the margin or tip irregularly.

Bionomics

The butterfly lays round white eggs singly on the leaves. The caterpillar is green, slightly flattened with two red horn processes on the head and two

yellow processes in the anal end. It pupates in a greenish chrysalis, which suspends from the leaf. The butterfly is dark brown with large wings having a black and yellow eye like spot one on each of the fore wings.



8. Yellow hairy caterpillar: *Psalis pennatula*, Lymantriidae: Lepidoptera

Distribution: Assam, Andhra Pradesh, Punjab and South India.

Host range: Rice, grasses, wheat

Symptoms of damage: Caterpillar causes defoliation

Bionomics

The caterpillar is yellowish brown with red stripes and orange head and tufts of hairs all over the body of which two in the anterior and one in the posterior regions are prominent. It pupates in a pale white cocoon of silk and frass attached to the leaf and the adult moth is stout with straw coloured forewings. It lays eggs in masses of upto 57 eggs on leaves. The egg period is 10-11 days. The larval period lasts for 25-35 days.

9. Grasshopper: *Hieroglyphus banian,* Acrididae: Orthoptera

Symptoms of damage

The nymphs and adults cause enormous losses to the crop by chewing and cutting various plant portion *viz.,* leaves, flowers and grains. They completely defoliate the plants leaving only the mid ribs and plant growth is affected.

Bionomics

Adults = Green, larger with transverse black lines on pronotum. It lays eggs in soil at a depth of 5 cm. Nymphal period = 2.5 - 3.5 months

Management

1. Expose the eggs to be picked up by birds after ploughing and trim the bunds
2. Bio-control agents such as *Cacallus* spp., *Barycomus* spp. and *Seelio* spp., which are egg parasitoids should be encouraged.
3. Dusting the crop with 5-10% BHC (or) methyl parathion 2% @ 25-30 kg/ha. fenitrothion (or) malathion 5% @ 20 kg/ha.
4. Spraying Dichlorvas 76 EC @ 200 ml/ha (or) malathion 50 EC@ 2.5 lit/ha.

10. Short horned grasshopper: *Oxya nitidula,* Acrididae: Orthoptera

Symptoms of damage

Nymphs and adults feed on leaves leaving the stalks and midribs, irregular feeding on seedlings and leaf blade and cutting of stem at panicle stage are the symptoms of damage.

Bionomics

It is green, smaller with brown band on sides. Eggs are laid in soil; hatch out in June - July and mature in August - September.

Management

Expose the eggs during summer ploughing and they will be picked up by birds.

11. Spiny beetle / Rice hispa: *Dicladispa armigera,* Chrysomelidae: Coleoptera

Distribution: Bangladesh, Burma, Southern China, India, West Malaysia, Nepal, Pakistan, Sumatra, Thailand, West Iran.

Host range: Rice

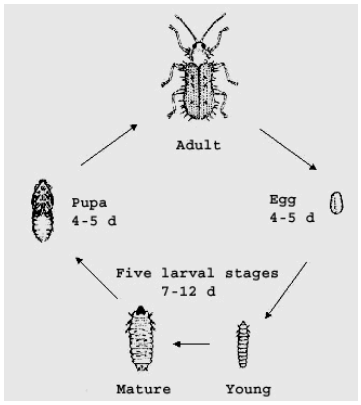
Symptoms of damage

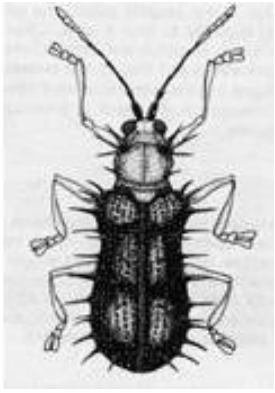
Adults feed on chlorophyll by scraping and causing white parallel streaks (or) white patches along with long axis of leaf. Grubs mine into the leaves and make blister near leaf tips.

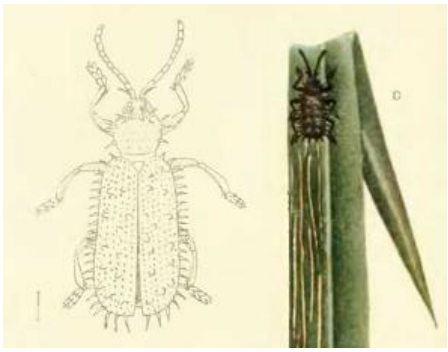
Bionomics

Adult is blue - black shiny beetle with spines on the thorax and elytra. It lays eggs singly on the leaf tip. Grub is minute, flat and yellow. It mines between the epidermal layers of leaf and pupates in leaf mines. Egg period: 4-

5 days; Larval period: 7-12 days; Pupal period: 3-5 days. There are six generations / year.







Management

1. The leaf tips containing blotch mines should be plucked and destroyed.
2. Manual collection and killing of beetles with hand nets may help in reducing the population of the pest.

3. Spraying of the crop with 0.03% phosphamidon @ 700 lit/ha

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4. Control operation in nursery is necessary.

12. Whorl maggot: Hydrellia sasakii , Ephydridae: Diptera

Distribution: Philippines

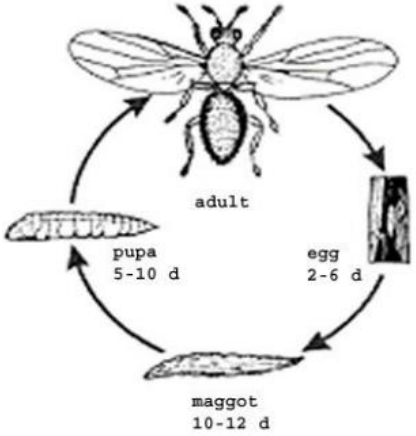
Host range: Rice, Cynodon dactylon and Echinochloa crusgalli

Symptoms of damage

Yellowish white longitudinal marginal blotching with hole in a few places on the emerging leaves. Leaves become shriveled. Plant gets stunted and maturity is delayed. Maximum damage is observed in 30 DAT.

Bionomics

The adult is a small dull grey fly. Maggot is 2 mm in length and feeds on the tender tissue inside the whorl. It is yellowish white in colour.



ETL - 25% damaged leaves

Management

1. Granular insecticides such as carbofuran applied shortly after transplanting.
2. Spray fenthion 100 EC 500 ml (or) fenitrothion 50 EC 1000 ml (or) quinalphos 25 EC 1000 ml/ha.

13. Blue beetle: *Halticia cyanea*, Chrysomelidae: Coleoptera

A medium sized steel blue beetle often found in large numbers on rice but is harmless as it breeds on the common weed, *Ammania* sp., found in wetlands.

IV. ROOT FEEDERS

14. Rice root weevil: *Echinocnemus oryzae*, Curculionidae: Coleoptera

Symptoms of damage

Grubs feed on the roots of rice plants resulting in stunting and non formation of tillers. Presence of dead plants in large patches is a typical symptom.

Bionomics

The adult weevil is shiny black with oblong body covered with greyish scales. The female lays eggs in soil near the roots of grasses. The incubation period is 3-4 days. The grub is creamy white, aquatic and feeding on root hairs. The larval period lasts for 11 months. The grub over-winters in soil at a depth of 25-30 cm, after September. It pupates some time May. The pupal period is 10-12 days.

15. Rice root weevil: *Hydronomidus molitar*, Curculionidae: Coleoptera

Symptoms of damage

Yellowing of newly transplanted seedlings and presence of dead plants in large patches.

Bionomics

Adult is shiny black weevils with oblong body covered with greyish scales. Grub is creamy white and aquatic.

16. Rice root grub: *Arthrodeis* sp., Tenebrionidae: Coleoptera

Symptoms

They feed on roots and cause yellowing and gradual wilting of entire plants.

Bionomics: Black coloured shiny beetle.

Integrated Pest Management in Rice

A. Cultural method

1. Remove / destroy stubbles after harvest and keep the field free from weeds.
2. Trim and plaster the bunds of rice field to expose the eggs of grasshoppers and to eliminate the bug breeding in grasses.
3. Form the buds narrow and short to reduce the damage by rodents.
4. Use resistant varieties wherever available.
5. Provide effective drainage wherever there is problem of BPH.
6. Clip the tip of seedlings before transplanting to prevent the carry over of egg masses of rice yellow stem borer from nursery to mainfield.
7. Organise synchronized planting wherever possible.
8. Leave 30 cm rogue space at every 2.5 m to reduce damage by BPH and rodents.
9. Avoid use of excessive nitrogenous fertilizers.
10. Use irrigation water judiciously (Alternative webbing x drying reduce BPH and case worm).
11. Remove the egg masses of stem borer in the mainfield.

B. Mechanical methods

1. Dig out the rat burrows and destroy the rats and young ones at the beginning of the season.
2. Set up light traps to monitor and control pests.
3. Set up-bow traps to kill rodents.

C. Biological methods

1. Release *Trichogramma japonicum* on 30 and 37 DAT twice 5 cc/ha/release against stem borer.
2. Release *Trichogramma chilonis* on 37, 44 and 51 DAT (thrice) @ 5 cc/ha/release against leaf folder.
3. Release of *Platygaster oryzae* parasitized galls @ 1 per 10 m^2 in the mainfield on 10 DAT against gall midge.
4. Set up owl perches to reduce rat damage.

D. Plant products

1. Spray neem seed kernel extract 5% (25 kg/ha), neem oil 3% (15 lit/ha) to control brown planthopper.
2. Spray botanical powder formulation *viz.,* NSKE, *Vitex negundo* (Notchi), *Prosopis juliflora* and *Ipomoea carnea* leaf extract 5% to control earhead bug and black bug.

E. Chemical methods

1. In BPH prone areas / season avoid use of synthetic pyrethroids, methyl parathion and quinalphos and use recommended chemical at recommended doses.
2. Use insecticides based on FTLs.

LECTURE NO. 3 – PESTS OF MAIZE, SORGHUM AND PEARL MILLET

I. PESTS OF MAIZE

I. Borers

1. Stemfly: *Atherigona orientalis,* Muscidae: Diptera

Distribution: Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka.

Host: Maize, sorghum, ragi and bajra

Symptoms of damage

The maggot feeds on the young growing shoots results in "dead hearts".

Bionomics: Small grey coloured fly.

Management: Furrow application of disulfoton, phorate granules (or) lindane wettable powder

2. Stem borer: *Chilo partellus,* Crambidae: Lepidoptera

Distribution: India, Pakistan, Sri Lanka, Indonesia, Iraq, Japan, Uganda, Taiwan, Sudan, Nepal, Bangladesh and Thailand.

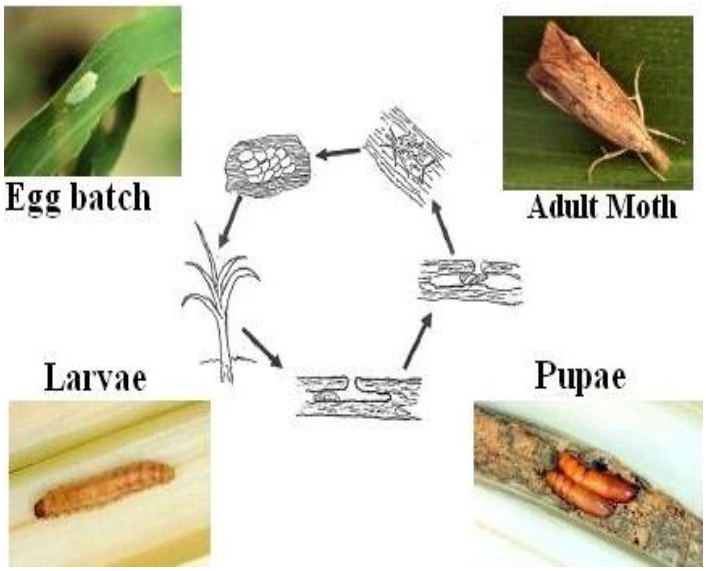
Host: Jowar, bajra, sugarcane and rice

Symptoms of damage

It infests the crop a month after sowing and upto emergence of cobs. Central shoot withering and leading to "dead heart" is the typical damage symptom. Bore holes visible on the stem near the nodes. Young larva crawls and feeds on tender folded leaves causing typical "shot hole" symptom. Affected parts of stem show internally tunnelling caterpillars.

Bionomics

The adult moth is medium size, straw coloured. It lays flat oval eggs in batches on the under surface of leaves near the midribs. The fecundity is about 25 eggs per female. The incubation period is 2-5 days. The larva is yellowish brown with a brown head which mines the midrib enter the stem and feeds on the internal tissues. The larval period is 28-50 days with 7 instars. It pupates within the stem for 2-15 days. The adult longevity is 2-12 days.



ETL: 10% dead hearts.

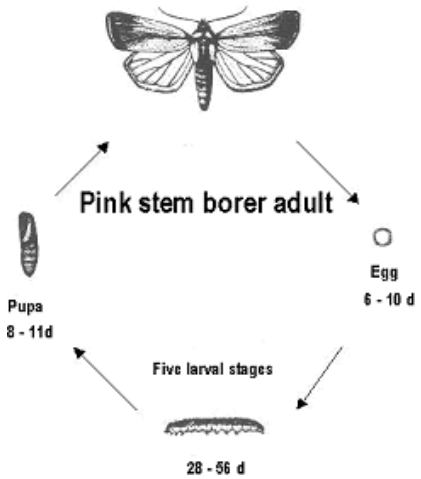
Management

1. Sow the lab or cowpea as an intercrop to minimise the stem borer damage (Maize : Lablab 4:1).
2. Set up light trap till midnight to attract and kill the stemborer moths.
3. Mix any one of the following insecticides with sand to make up the total quantity of 50 kg and apply in the leaf whorls. Phorate 10G 8 kg, carbofuran 3G 17 kg, carbaryl + lindane 4G 20 kg, (or) carbaryl 50 WP 1 kg (500 lit. spray fluid/ha).
4. Collect the stubbles after harvest and burn to destroy diapausing borers.

3. Pink stem borer: *Sesamia inferens,* Noctuidae: Lepidoptera

Distribution: India, Pakistan, Malaysia, Taiwan, Burma, Bangladesh, Sri Lanka, South East Asia, China, Korea, Japan and Indonesia.

Host: Sorghum, maize, rice, wheat, sugarcane, bajra, ragi and gunia grass.



Symptoms of damage

Pink larva enters into the stem causing dead heart symptom similar to that of stem borer.

Bionomics

The adult moth is straw-coloured moth with white wings. The larva is pinkish brown with dark head. The life cycle is completed in 45-75 days. There are 4-6 generations per year.

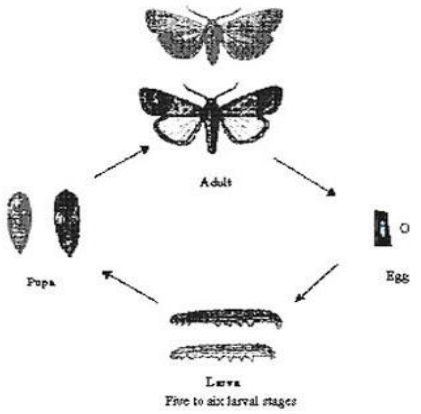
II. Leaf feeders

4. Cut worm: *Mythimna separata,* Noctuidae: Lepidoptera

Symptoms of damage: Larva feeds on leaves irregularly.

Bionomics

Adult is brown coloured moth with white hind wings. Larva is light yellowish green caterpillar.



5. Web worm: *Cryptoblabes gnidiella,* Pyraustidae: Lepidoptera

Symptoms of damage

The larva first feeds on the lemma of the flowers scraping the chlorphyll and later on the milky grains. The caterpillar causes damage by constructing webs on maize cobs and feeding on the flowers and the grains.

Bionomics: Eggs are laid singly on spikelets and grain. They hatch for 3-4 days. Larva has duration of 9-10 days. The full-grown larva is 12 mm long and dark brown. It forms silken webs on cobs and remains inside them and pupates within. Adult is 7 mm across wings with dark grey forewings. Life cycle is completed in 23-24 days.

Management: Spray monocrotophos.

6. Ash weevil: *Myllocerus* sp., Curculionidae: Coleoptera

Symptoms of damage: The larva feeds on secondary roots and adults on leaves.

Bionomics

Adult is grey coloured weevil. A female weevil lays 98-350 eggs and they hatch in 3-12 days. Larvae and pupae are in soil. Four larval instars of 23-40 days. Pupal period lasts 3-9 days. Complete life cycle lasts for 29-58 days.

7. Phadka grasshopper: *Hieroglyphus nigrorepletus,* Acrididae: Orthoptera

Symptoms of damage: Leaves defoliated from the margin; plants often bared.

Bionomics

Nymph and adults have green and brown forms the brown being the most common form. Both have a conspicuous irregular black dorsal pronotal stripe. Adults are mostly brachypterous. Eggs are laid one by one.

Management: Dusting with chlordane gives effective control of the pest.

III. Sap feeder

8. Leafhopper: *Pyrilla perpusilla,* Lophopidae: Hemiptera

9. Aphid: *Rhopalosiphum maidis,* Aphididae: Hemiptera

10. Shoot bug: *Peregrinus maidis,* Delphacidae: Hemiptera

Symptoms of damage

Injury to the plants is caused by the adults and nymphs sucking sap from them. The attacked plants become unhealthy, stunded and yellow. The leaves wither from top downwards. Panicle formation is inhibited and the plants die if attack is severe. Honeydew secreted by the bug causes growth of sooty mould on leaves.

Management: Dusting (or) spraying of any one of contact insecticide.

II. Cob feeder

11. Corn worm/Earworm: *Helicoverpa armigera,* Noctuidae: Lepidoptera

Symptoms of damage: Larva feeds on silk and developing grains.

Bionomics

Adult is brown coloured moth with a 'V' shaped speck on fore wings and dull black border on the hind wing. Larva is green with dark broken grey lines and dark pale bands shows color variation greenish to brown.

Management

Apply any one of the insecticides at silk drying stage. Carbaryl 10% D 25 kg/ha (or) carbaryl 50% WP 1.0 kg/kg. Repeat the insecticidal application 15 days latter (500 lit spray fluid per hectare).

II. PESTS OF SORGHUM

I. BORERS

1.Shootfly: *Atherigona varia soccata*, Muscidae: Diptera

Distribution: Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka

Alternative host: Maize, ragi, bajra, rice, wheat and grasses

Symptoms of damage

The maggot on hatching migrates to the upper surface of leaf and enters between the leaf sheath and stem. After reaching the soil level, the maggot bores inside the stem and cuts the growing point resulting in the drying "dead heart" symptom. The infested plant produces side tillers. The attack is severe during summer in Coimbatore and the infestation goes up to 86 per cent.

Bionomics

Adult, a whitish grey female fly lays the eggs on the lowers surface of leaf blades mostly during morning hours. The egg is white, cylindrical, distal somewhat flattened. The incubation period varies from 1-2 days. Maggot is dirty white and apodous. The larval period is 8-10 days and has four larval instars. It pupates at the base of the stem (or) in soil for 8-10 days. The life cycle is completed in 17-21 days.

ETL: 10% dead hearts or 1 egg / plant

Management

1. Use resistant varieties like Co-1, CSH 15R, Maldandi and Hagari.
2. Sow the sorghum immediately after the receipt of monsoonic rain to minimise the shootfly damage.
3. Use higher seed rate (12.5 kg/ha) and remove the shoot fly damaged seedlings at the time of thinning or raise nursery and transplant only healthy seedlings.
4. Pull out plants showing dead hearts and destroy at the time of thinning.
5. Set up hanging type of plastic fishmeal trap @ 12/ha till the crop is 30 days old.
6. Pellet the seeds with chlorpyriphos 20 EC or phosalone 35 EC or monocrotophos 36 WSC @4 ml/kg of seed.
7. Granular application of 10% phorate (or) carbofuran 3D to the furrow at the time of sowing at 2.5 kg a.i./ha.
8. Spray any one of the following insecticides for an area of 120 sq.m./

nursery. Dimethoate 30 EC 12 ml and methyl demeton 25 EC 12 ml.

9. Spray any one of the following insecticides in the main field. Dimethoate 30 EC 500 ml (250 l of spray fluid/ha).
10. Release larval parasitoids *viz., Tetrastichus nyemitavus*, *T. coimbaborensis, Callitula* sp., *Diaulinopsis* sp., Pupal parasitoid - *Cratalpiella* sp. Predator – *Abrolophus* sp.

2. Stem borer: *Chilo partellus*, Crambidae: Lepidoptera

Distribution: India, Pakistan, SriLanka, Indonesia, Iraq, Japan, Uganda, Taiwan, Sudan, Nepal, Bangladesh and Thailand.

Host range: Maize, sorghum, sugarcane, bajra, rice, *Sorghum halepense*, finger millet, etc.

Symptoms of damage

It infests the crop a month after sowing and upto emergence of ear heads. Central shoot withering and leading to "**dead heart**" is the typical damage symptom. Bore holes are visible on the stem near the nodes. Young larva crawls and feeds on tender folded leaves causing typical "**shot hole**" symptom. Affected parts of stem may show internally tunneling caterpillars.

ETL: 10% dead heart

Bionomics

The adult moth is medium size, straw coloured. It lays about 300 scale-like flat oval eggs in batches on the under surface of leaves near the midribs. The incubation period is 2-5 days. The larva is yellowish brown with a brown head and prothoracic shield measures about 25 mm long. The larval period is 28 - 50 days with seven instars. It pupates inside the stem and emerges as adult in about seven days. The total life cycle is completed in 30 to 40 days.

Management

1. Dead hearts should be pulled out and used as fodder (or) buried in manure pits.
2. The stubbles should be ploughed up during winter and burnt to destroy the hibernating larvae.
3. Resistant varieties against jowar stem borer should be encouraged.
4. Sow lab lab or cowpea as an intercrop to minimise the stem borer damage (Sorghum: Lab lab 4:1)
5. Set up light trap till midnight to attract and kill the stemborer moths.

6. Bio-control agents *viz.,Trichogramma minutum*, *Bracon chinensis* (egg parasites)and *Microbracon chilocida, Apanteles flavipes*, *Xanthopimpla* spp. (larval parasites should be encouraged).
7. Mix any one of the following insecticides with sand to make up the total quantity of 50 kg and apply in the leaf whorls. Phorate - 10G 8 kg; Carbofuran 3G 17 kg; Carbaryl + lindane 4G 20 kg; (or) Carbaryl 50 WP 1 kg (500 lit spray fluid/ha).

3. Pink stem borer: *Sesamia inferens*, Noctuidae: Lepidoptera

Distribution: India, Pakistan, Malaysia, Taiwan, Burma, Bangladesh, Sri Lanka, South East Asia, China, Korea, Japan and Indonesia.

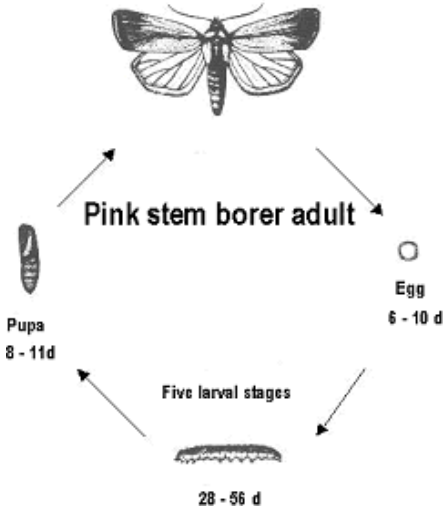
Host range: Sorghum, maize, rice, wheat, sugarcane, bajra, ragi and barley.

Symptoms of damage

The pink larva bores into the stem and damage the central shoots by producing the dead hearts.

Bionomics

The adult moth is straw coloured moth with white wings. The larva is pinkish brown with dark head. The eggs are bead like laid in rows within the leaf sheath and usually 30-100 per batch. The life cycle is completed in 45-75 days. There are 4-6 generations per year.



Management

1. Release egg parasitoids: *Telenomus* sp., *Trichogramma minutum* Larval parasitoids: *Apanteles flavipes, Bracon drinensis* Pupal parasitoids: *Tetrastichus ayyari*

II.LEAF FOLDERS

4. Slug caterpillar: *Thosea apierens*, Cochlididae, Lepidoptera

Symptoms of damage

Irregular feeding and defoliation are the symptoms of attack.

Bionomics

It is brown stout moth with a pair of white bands on forewings. Larva is green with stinging hairs.

5. Leaf roller: *Marasmia trapezalis*, Pyralidae: Lepidoptera

Symptoms of damage

Leaves are folded longitudinally especially near the tips and drying of leaves from the tip.

Bionomics

Adult is small yellow coloured moth. Wings are greyish with three dark transverse stripes and a dark wide sub terminal band. Larva is pale greenish yellow with conspicuous setae. Head and thoracic shield are reddish brown in colour.

Management

Hand picking of rolled leaves.

6. Flea beetle: *Cryptocephalus schestedii, Monolepta signata*, Chrysomelidae: Coleoptera

Symptoms of damage: Small holes on the leaves.

Bionomics

Black beetle with long antennae and four pale yellow spots on elytra.

7. Red hairy caterpillar: *Amsacta albistriga*, *A. moorei*, Arctiidae : Lepidoptera

Host range

Maize, sorghum, green gram, sesame, pearl millet, finger millet, groundnut, sunhemp, castor, cotton.

Symptoms of damage

The larvae feed on the leaves gregariously by scraping the under surface of tender leaflets leaving the upper epidermal layer intact in early stages. Later, they feed voraciously on the leaves and main stem of plants. They march from field to field gregariously. Severely affected field looks as if grazed by cattle.

Bionomics

Adults are medium sized moths. In *A. abistriga* forewings are white with

brownish streaks all over and yellowish streaks along the anterior margin and hindwings are white with black markings. A yellow spot is found on the head. In *A. moorei* all markings are red in white wings. On receipt of heavy rains, about a month after sowing in kharif season, a white moth with black markings on the hind wings emerge out from the soil in the evening hours. It lay eggs on the under surface of the leaves. The eggs are cream coloured or bright yellow and laid in groups. A female moth may lay about 600-700 eggs. Egg period is 2-3 days. Tiny greenish caterpillar feeds on the leaves gregariously. A full-grown larva measures about 5 cm in length reddish brown hairs all over the body arising on warts. The larval period is 40-50 days with the receipt of showers. The grown up larva pupate in earthern cells at a depth of 10-20 cm. They pupate mostly along the field bunds and in moist shady areas under the trees in the field and undergo pupal diapause till the next year.

ETL - 8 egg masses / 100 meter

Management

Spray fenitrothion 750 ml/ha (or) quinalphos 750 ml/ha (or) dichlorvas 625 ml/ha (or) chlorpyriphos 1250 ml/ha in 365 litres of water.

7. Weevils: *Myllocerus maculosus* and *M. discolor,* Curculionidae: Coleoptera

Symptoms of damage

Leaf margins are notched resulting in wilting of plants in patches. Plants come off easily when pulled. Roots are eaten away by grubs. Adult feeds on leaves.

Bionomics

M. maculosus - Adult weevil with greenish white elytra having dark lines. *M. discolor*- Adult weevil a brown with white spot on elytra. Grub is small, white apodous found feeding on roots.

8. Leaf beetle: *Cryptocephalus schestedti*, Cryptocephalidae: Coleoptera

Symptoms of damage: Small holes on the leaves.

Bionomics: Yellow beetle with long black streaks.

9. Wingless grasshopper: *Colemania sphenaroides*, Acrididae: Orthoptera

Symptoms of damage: Defoliation. Nymphs feed on growing plants and adult feeds on florets and ears.

Bionomics

The adult grasshopper is wingless, greenish yellow with blue-black antennae with purple band from behind the eye and laterally on thorax. It lays eggs in batches in the soil at a depth of 6 cm during October and November. The eggs hatch in the following June and July during monsoon rain.

II. Sap feeders

10. Shoot bug: *Peregrinus maidis*, Delphacidae, Hemiptera

Distribution: South India and Madhya Pradesh; Pantropical India

Host range: Sorghum and maize, rice, millets

Symptoms of damage

Injury to the plants is caused by the adults and nymphs sucking sap from them. The attacked plants become unhealthy stunted and yellow. The leaves wither from top downwards. Panicle formation is inhibited and the plants die if attack is severe. Honeydew secreted by the bug causes growth of sooty mould on leaves. The midribs of the leaves turn red due to egg-laying and may dry up subsequently.

Bionomics

The adult is yellowish brown to dark brown with translucent wings. The brachypterous female is yellowish while macropterous female is yellowish brown and male dark brown. It lays eggs in groups of 1-4 inside the leaf tissue and covered with a white waxy substance. The fecundity of the bug is 97 eggs / female. The egg period lasts for seven days. The nymphal stage undergoes five instars in 16 days. The total life cycle is completed in 18-31 days.

Management

1. Release egg parasitoids *viz., Paranagrus optabilis*, *Octetrastichus indicus.* Predators- *Coccinella septumpunctata Menochilus sexmaculatus*, *Geocoris tricolor*
2. Spray with 0.04% dimethoate (or) 0.02%, phosphamidon @ 250 ml in 450-500 lit water/ha.

11. Plant lice (Aphids): *Rhopalosiphum maidis, Longuinguis sacchari,* Aphididae: Hemiptera

Distribution: Karnataka, Maharashtra, Andhra Pradesh

Host: Sorghum, maize, ragi

Symptoms of damage: Yellowing of leaves, colonies of aphids found in central leaf whorl.

Bionomics: The adult is yellow coloured with dark green legs.

Management: Spraying the base of attacked plants with a contact (or) systemic insecticide controls the aphid.

IV. EARHEAD FEEDERS

12. Earhead bug: *Calocoris angustatus*, Miridae: Hemiptera

Distribution: South India

Host range: Bajra, maize and tenai, sugarcane and grasses

Symptoms of damage

The adults and nymphs damage the earheads by feeding on them. They suck the juice from within the grains when they are in the milky stage. The sucked out grains, shrink and turn black in colour and ill filled (or) chaffy. Presence of large number of orange and pale green nymphs and adults are seen on the earhead.

Bionomics

Adult male is green in colour and female is green with a brown margin. Blue cigar shaped eggs are laid under the glumes or into the middle of the florets. The egg period is seven days. Nymphs are slender, green in colour. First instar is orange in colour. The nymphal period is 10 days. Life cycle : 15-17 days.

ETL: 10 nos/ear head

Management

Dusting the crop with carbaryl 10% dust at the time of flowering (or) quinalphos 1.5% at 10 day interval synchronising with the milky stage of the crop has been found effective.

13. Mirid bug: *Creontiades pallidifer,* Miridae: Hemiptera

Nature of damage:

No external symptom will be visible. The earhead should be tapped either

on the palm (or) a piece of cardboard. A number of brownish (or) greenish nymphs and adults can be seen on the developing grains small brownish spots will be visible. In severe infestation, the grains get shriveled without maturing and the earheads appear uneven.

14. Sorghum midge: *Contarinia sorghicola*, Cecidomyiidae: Diptera

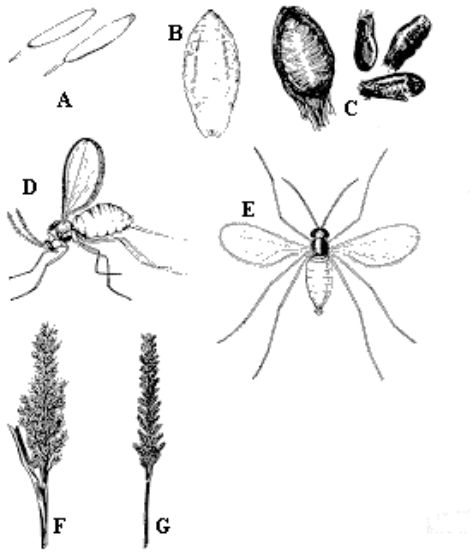
Distribution: India, Pakistan, Bangladesh, West Iran, Sri Lanka, Sudan, Java, Africa, South China, South America, West Indies, USA and Italy.

Hosts: Sorghum cultivated and wild species.

Symptoms of damage

A maggot feeds on the developing grains and pupates there. White pupal cases protruding out from the grains and chaffy grains with holes are the symptoms of damage.

Bionomics



Sorghum midge. A, Eggs. B, Larva. C, Pupae in cocoons. D, Adult female. E, Adult male. F, Normal sorghum head. G, Damaged sorghum head.

The adult fly is small, fragile with a bright orange abdomen and a pair of transparent wings. It lays eggs singly in developing florets resulting in pollen shedding. A female lays about 30-35 eggs at the rate of 6-10 in each floret. The incubation period is 3-4 days. The maggot has four instars with duration of 8-10 days. The larval stage undergoes diapause in a cocoon during December - January. The pupal period is 6-8 days.

Management

1. Release larval parasitoids *Apanteles* sp., *Eupelones popa* Larval and pupal parasitoid *Tetrastichus* spp. Predators – *Orius albidipennis; Tapinoma indicum*
2. Give first application at nearly 90% earhead emergence and repeat after 4 or 5 days. The insecticides recommended are phosalone 35 EC 1 lit (or) malathion 50 EC 1 lit (or) carbaryl 50 WP 2 kg/ha. phosalone 4% or or carbaryl 10% or quinalphos 1.5% dust at 12 kg/ha is also effective.

15. Gram caterpillar: *Helicoverpa armigera*, Noctuidae: Lepidoptera

Distribution: World wide

Host range: Cotton, sorghum, lab lab, soybean, pea, safflower, chillies, tomato, groundnut, tobacco, gram, okra, maize etc.,

Symptoms of damage

Larvae hide within the ear heads and feeds on the grains. Earheads are partially eaten with chalky appearance. Fecal pellets are visible within the ear heads.

Bionomics

Adult is brown coloured moth with a 'V' shaped speck on forewings and dull black border on the hind wing. Larva is green with dark broken grey lines and dark pale bands. It shows colour variation of greenish to brown.

16. Semilooper: *Eublemma silicula*, Noctuidae: Lepidoptera

Symptoms of damage

Extensive webbing of grains and presence of broken grains can be seen on the ear head.

Bionomics

The adult moth is small with reddish buff coloured wings having wavy lines. Eggs are laid on spikelet and grain. The egg period is four days. Larva is pale yellow. Larval period lasts for 12-13 days. It pupates within the gallery for about 12 days.

ETL: For ear head caterpillars 2 Nos. / earhead

17. Plant bug: *Dolycoris indicus*, Pentatomidae: Hemiptera

Symptoms of damage: Grains become chaffy or spotted black and shriveled.

Bionomics: Brown coloured bug with a white patch on the scutellum.

18. Stink bug: *Nezara viridula,* Pentatomidae: Hemiptera

Symptoms of damage

Grains become chaffy or spotted black and shriveled. A stinking smell emanates from the bug.

Bionomics

Adult is green in colour. Nymph is brownish red with multi colour spots.

19. Ear head web worm: *Cryptoblabes gnidiella*, Pyraustidae: Lepidoptera

Symptoms of damage

Larva remains in the rachis, web the adjacent grains and feed on them. It occurs on sorghum and maize ears.

Bionomics

The adult moth is small with brown fore wings and light brown hind wings. It lays eggs singly on spikelets and grain. The egg period is 3-4 days. The larva is light brown with dark head and dark lateral lines on the body. The larval duration is 9-10 days. It constructs silken cocoon and pupates within. The life cycle is completed in 23-24 days.

Integrated Pest Management in Sorghum

A. Cultural methods

1. Complete the sowing of sorghum in a short time as possible to avoid continuous flowering, which favours grain midge and earhead bug multiplication in an area.
2. Sow the lab lab or cowpea as an intercrop to minimize stem borer damage (Sorghum: Lab lab 4:1)
3. Take up early sowing of sorghum immediately after the receipt of South West or North East Monsoon to minimize the shoot fly incidence.
4. Use increased seed rate upto 12.5 kg per hectare and remove the shoot fly damaged seedlings at the time of thinning in case of direct sowing or raise nursery and transplant only healthy seedlings.
5. Plough soon after the harvest, remove and destroy the stubbles.

B. Mechanical method

1. Set up light traps till mid night to monitor, attract and kill adults of stemborer, grain midge and earhead caterpillars.
2. Set up sex pheromone trap at 12/ha to attract male moths *Helicoverpa* sp. from flowering to grain hardening.

C. Biological methods

1. Take up two applications of NPV at 10 days interval at 250 LE/ha along with crude sugar 2.5 kg + cotton seed kernel powder 250 g on the ear heads to reduce the larval population of *Helicoverpa* sp.

D. Chemical methods

1. Use seeds pelleted with insecticides.
2. Set up the TNAU low cost fishmeal trap @ 12/ha till the crop is 30 days old.
3. Arpocarb fishmeal formulation is more effective in attracting the shoot fly adults especially the females.

Preparation of Arpocarb fishmeal formulation for shoot fly attraction

Fishmeal powder is to be sprayed first with 2% starch dissolved in hot water as a sticking agent. The insecticide Arpocarb should then be sprayed at 50 ml/kg of fishmeal powder. The resultant mixture is shade dried and can be used at 50 g/trap. The formulated product should be moistened well before placing in the trap. The formulation

II. PESTS OF PEARL MILLET

I.BORERS

1. Shoot fly: *Atherigona approximata*, Muscidae: Diptera

Symptoms of damage

A serious pest on cumbu in Tamil Nadu during cold weather season, it attacks the crop both in seedlings and boot leaf stage. It causes dead hearts in young plants and chaffy grains in the tip and well developed grains in the lower portion of ear heads in the mature crop.

Bionomics

Adult is greyish white fly. The egg-stage of the fly lasts 37-48 hours, larval stage 7-9 days and pupal stage 6 days.

Management

1. Pre-sowing application of granules of phorate 10G @ 10 kg(2-5 kg a.i./ha)
2. Apply phorate 10G 180 g or carbofuran 3G 600 g mixed with 2 kg of moist sand, spread on the beds and work in the top 2 cm of soil to protect the seedlings from shoot fly infestation in 120 sq.m. nursery.
3. Protect the nursery by applying any one of the insecticides given below on the 7th and 14th day of sowing by mixing in 6 litres of water. methyl demeton 12 ml, dimethoate 12 ml.

2. Stem borer: *Chilo partellus,* Crambidae: Lepidoptera

Symptoms of damage

It infests the crop a month after sowing and upto emergence of earhead. Central shoot withering and leading to "dead heart" is the typical damage symptom. Bore holes visible on the stem near the nodes. Young larva crawls and feeds on tender folded leaves causing typical "shot hole" symptom - affected. Parts of stem may show internally tunneling caterpillars.

Bionomics: as seen above

Management

1. Set up light trap till midnight to attract and kill the stem borer moth.
2. Mix any one of the following insecticides with sand to make up the total quantity of 50 kg and in the leaf whorls. Phorate 10 G 8 kg, carbofuran 3G 17 kg, carbaryl + lindane 4G 20 kg, carbaryl 50 WP 1 kg (500 lit spray fluid/ha).
3. Collect the stubbles after harvest and burn to destroy diapausing borers.

3. Pink stem borer: *Sesamia inferens,* Noctuidae: Lepidoptera

Symptoms of damage

Pink larva enters into the stem causing dead heart symptom.

Bionomics

The adult moth is straw coloured moth with white wings. The larva is pinkish brown with dark head. The life cycle is completed in 45-75 days. There are 4-6 generations per year.

II. Leaf feeders

4. Leaf beetle: *Lema downsei*, Galerucidae: Coleoptera

Symptoms of damage

Grubs and adults scrape the chlorophyll. It results in withering and drying of leaves leading to burnt up appearance.

Bionomics

Grub is whitish with a small black head. Swollen humped body and has the habit of carrying its fecal matter dorsally. Adult is straw coloured beetle.

5. Black hairy caterpillar: *Estigmene lactinea,* Arctiidae: Lepidoptera

Symptoms of damage

Larva feeds on leaves voraciously and causes severe defoliation.

Bionomics

Adult is large white moth with crimson markings on head, body and wings. Larva is thick and black head and hairs.

6. Wingless grasshopper: *Neorthacris simulans,* Acrididae: Orthoptera

Symptoms of damage: Both nymphs and adults feed on leaves and cause defoliation.

Bionomics: Greenish brown in colour with red stripe on the sides without wings.

III. Ear head feeders

7. Grain midge: *Geromyia penniseti*, Cecidomyiidae: Diptera

Symptoms of damage

Maggot feeds on developing grains causing grainless glumes with white pupal case attached to the tip of the spikelet.

Bionomics: Adult is a light pink fragile fly.

Management

Dust any one of the insecticides, malathion, carbaryl, phosalone (or) carbophenothion.

8. Semilooper: *Antoba* (=Eublemma) s*ilicula*, Noctuidae:Lepidoptera

Distribution: India

Hosts: Sorghum, pearl millet, finger millet

Symptoms of damage

Extensive webbing of grains and presence of broken grains on the ear head.

Bionomics

The adult moth is small with reddish buff coloured wings having wavy lines. Eggs are laid on spikelet and grain. The egg period is 4 days. Larva is pale yellow semilooper. Larval period lasts for 12-13 days. It pupates within the gallery for about 12 days.

ETL: For ear head caterpillars 2 Nos./ear head

9. Stink bug: *Nezara viridula,* Pentatomidae: Hemiptera

Symptoms of damage

Grains become chaffy or spotted black and shrivelled. A stinking smell emanates from the bug.

Bionomics

Adult is green in colour. Nymph is brownish red with multi colour spots.

Management of ear head pests

Apply any one of the insecticides at 25 kg/ha at 50% flowering, carbaryl 10D, malathion 5D, spray carbaryl 50WP 750 g

LECTURE NO. 4 – PESTS OF WHEAT, RAGI AND TENAI

I. Pests of Wheat

1. Aphids, *Sitobion avenae, Rhopalosiphum padi,* Aphididae, Hemiptera

Distribution: All wheat growing areas, especially in NWPZ and Peninsular India.

Bionomics:

The aphids exist in different stages, *viz.,* winged (alates), wingless (apterous) sexual and asexual forms. The rapid spread takes place through asexual reproduction where females give rise directly to nymphs rather than eggs. Infestation usually occurs during second fortnight of January till crop maturity.

Management:

When feeding in sufficient numbers, they can cause considerable damage, but under normal conditions, losses are not much. Chemical pesticides are recommended for this pest in wheat if the level of aphids per tiller crosses 10 during vegetative phase and 5 during reproductive phase. However, there is need to keep watch on this pest. The spray of imidacloprid @ 20 g a.i. per ha initially on border rows and if infestation is severe then in entire field will give good protection against this pest. Generally, natural enemies present in the field help in controlling the population of this pest.

2. Army Worm, *Mythimna separate,* Noctuidae, Lepidoptera

Distribution: Mostly in the warmer climates of central India and to some extent in northern plains.

Development & Management: The larvae are found in the cracks of soil and hide during the day but feed during night or early morning. In wet and humid weather, they may feed during day time also. They survive during summer on the subsequent crops like rice and also continue to exist in rice stubbles before wheat crop comes in the field. Recently, this pest is catching attention in the northern India under Rice-Wheat rotation and where rice stubbles / straw remain in the fields.

3. Legume podborer, *Helicoverpa armigera,* Noctuidae, Lepidoptera

Distribution and Importance: This is a polyphagous insect that attacks various legumes as a pod border. It is seen damaging wheat ear heads at grain development stage when major hosts are not available. However, the damage is below economic threshold level. It is found mostly in northern and central parts of India. Wheat can serve as a bridge host for carry over of this polyphagous pest.

4. Termites, *Odontotermis obesus, Microtermis obesi,* Termitidae, Isoptera

Distribution: Mainly in the northern and central India, but also in some pockets of peninsular India.

Symptoms of Damage:

Termites attack the crop at various growth stages, from seedlings to maturity. The severely damaged plants can be easily uprooted and look wilted and dried. In case roots are partially damaged, the plants show yellowing.

Management:

For effective management, chemicals like chlorpyriphos and carbosulfan can be used both for seed treatment and for broadcast of treated soil in standing crop.

5. Ghujia weevil, *Tanymecus indicus,* Curculionidae: Coleoptera

Distribution: It is a common pest of young wheat and other crops in Uttar Pradesh, Bihar and Punjab.

Symptoms of damage:

The weevil cuts and feeds on the plumule of the young seedlings. Older seedlings of more than 6 cm in height are not attacked. In severe cases of attack, it necessitates resowing. The damage results in seedling stems severed and wilting plant lying on ground.

Bionomics:

It is grey or greyish brown weevil measuring 5 mm long. Adults hide during brighter part of the day and get active in the morning and evening hours. Adults are destructive. Adults become sexually mature by the end of October (4-5 months after emergence from soil during June-July). Eggs are

laid singly under clods of soil @ 80 eggs/ female. Eggs hatch in 15-50 days depending on climate. Larvae develop in soil in about 3 months. After 2 months of pupation, adults are formed during April – May but adults remain in soil till June and come out with rains in June and when sorghum is available in field.

Management

- Deep ploughing during April-May to destroy pupae
- Dusting the soil with carbaryl @ 10-12 kg/ac and raking it into the soil at the time of sowing is effective.

II. Pests of Ragi

I. Borers

1. Pink stem borer: *Sesamia inferens,* Noctuidae: Lepidoptera

Symptoms of damage

Pink larva enters into the stem and causes dead heart symptom.

Bionomics

The adult moth is straw coloured moth with white wings. The larva is pinkish brown with dark head. The life cycle is completed in 45-75 days. There are 4-6 generations per year.

Management

Spray of diazinon 0.07%, phosphamidon 0.1%, fenitrothion 0.05% is suggested (or) monocrotophos at 0.25 kg a.i./ha.

2. White borer: *Saluria inficita,* Phycitidae: Lepidoptera

Symptoms of damage

A potential pest on finger millet in South India. Larva bores into the stem at the base of the tiller close to the soil level and causes dead heart.

Bionomics

Adult is small moth with dark brown forewings a white band along the anterior margin and white hind wings. Larva is creamy white with yellow head.

II. Leaf feeders

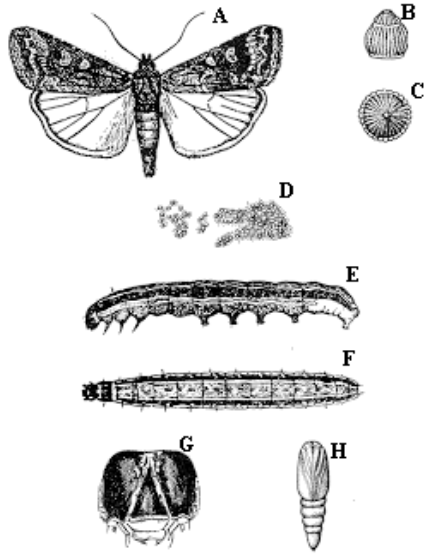
3. Cut worm: *Spodoptera exigua,* Noctuidae: Lepidoptera

Symptoms of damage: Larva defoliates in the nursery. It also attacks

onion, brinjal, cotton, cowpea, chillies, daincha.

Bionomics

Moth is brown coloured with white hind wings. It lays eggs in groups in plants. Larva is nocturnal in habit. It is brownish green with wavy lines on the dorsal surface and yellow stripes laterally. The larval period is 10-16 days. It pupates in earthern cocoons for 7-11 days.



Beet Armyworm. A, Adult. B-C, Eggs (enlarged). D, Egg mass. E-F, Larvae. G, Larval head. H, Pupa.

4. Flea beetle: *Chaetocnema pusaensis,* Alticidae: Coleoptera

Symptoms of damage

Adult beetles causes small holes in the leaves of young plants.

Bionomics: Adult is a dark blue beetle with enlarged hind femur.

Earhead feeders

5. Earhead caterpillars: *Sitotroga cerealella,* Gelechiidae: Lepidoptera

Symptoms of damage: The larva feeds on the developing grains.

Root feeders

6. Root aphid: *Tetraneura nigriabdominalis,* Aphididae: Hemiptera

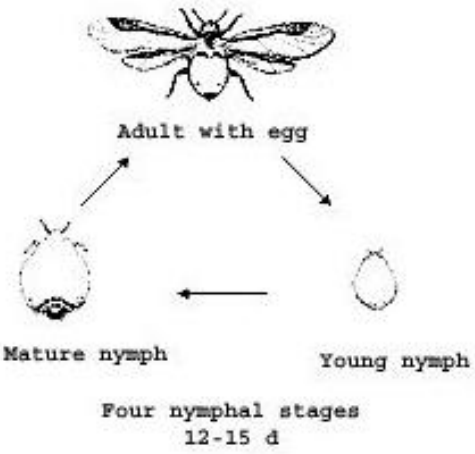
Symptoms of damage

Aphid remains at the base of the plant and suck the sap. The infested plants turn pale yellow and become stunted. Wilting and drying of plants in patches is the typical symptom. Black ants attend them for honeydew

and their presence confirm the attack. It occurs on many grasses too.

Bionomics

The aphids are pinkish and globular. It reproduces viviparously. There have 4 nymphal instars with a total nymphal duration of 7-9 days. Adult lives for 5-11 days and produces 10-35 off springs.



Management

Spraying the base of attacked plants with a contact or systemic insecticides controls the aphid.

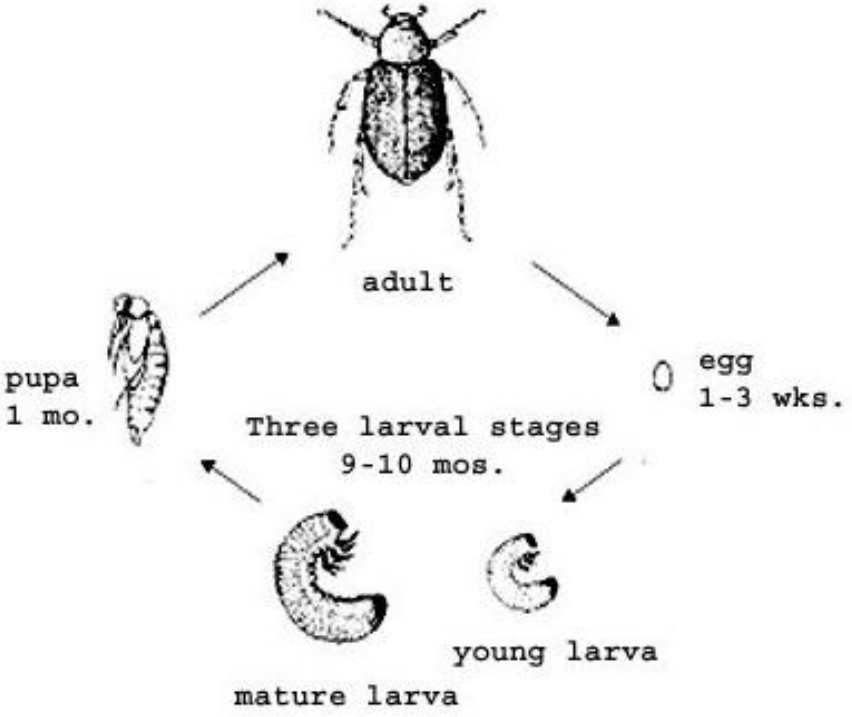
7. Root grub: *Holotrichia consanguinea,* Melolonthidae: Coleoptera

Symptoms of damage

Grubs feed on roots and results in the death of the grown up plants.

Bionomics

Grub is fleshy, 'C' shaped, whitish yellow in colour found close to the base of the dump. Adult is dark brown.



Management of finger millet pests

1. Spray any one of the following insecticides mixed in 10 lit. of water using a high volume of sprayer if dusting is not done to protect the seedling in the nursery.

   Methyl demeton 25 EC 20 ml and dimethoate 30 EC 20 ml.
2. Spray any of the following insecticides per ha for the control of stemborer, leaf feeder. Carbaryl 50 WP 1 kg.
3. Spray carbaryl 50 WP 1 kg/ha at milky stage to check ear head bug and ear head caterpillars.
4. Mix dimethoate 30EC 3 ml in one litre of water and drench the rhizosphere of the infested and surrounding plant with solution to check the root aphid.

LECTURE NO. 5 – PESTS OF REDGRAM, BENGALGRAM, BLACKGRAM, GREENGRAM AND COWPEA

I. Pests of Redgram and Bengalgram

I. Borers

1. Gram pod borer: *Helicoverpa armigera,* Noctuidae: Lepidotera

Distribution: World wide

Host: Cotton, sorghum, lablab, pea, chillies, groundnut, tobacco, okra, maize, tomato, soybean, safflower, gram, etc.

Symptoms of damage

It is a polyphagous species and is an important pest on pulses. Caterpillar first feeds on foliage; later bores into pods and feeds on seeds. Larva is seen feeding with the head alone thrust inside the parts and the rest of the body hanging out. Boreholes on pods, absence of seeds on pods and defoliation in early stages are the symptoms of attack.

Bionomics

Adult moth is greenish to brown with a 'V' shaped speck on forewings and dull black border on the hind wing. Eggs are laid on the host plants singly. The egg period is 7 days. Full grown larva is 2" long, greenish with dark brown grazy lines and dark and pale bands. It shows colour variation from greenish to brown. The larval duration is 14 days. It pupates in soil for 10 days.

Management

1. Install bird perches @ 50/ha to pickup the larvae by birds
2. Set up light trap to monitor, attract and kill the moths
3. Set up pheromone traps @12 Nos./ha
4. Inundative release of egg parasite *Trichogramma* spp. and egg larval parasites, *Chelonus blackburnii*
5. Spray nuclear polyhedrosis virus (NPV) @ 500 LE/ha in 0.1% teepol.
6. Spray NSKE 5% twice followed by triazophos 0.05%.
7. Apply any one of insecticides at 25 kg/ha. quinalphos 4D, carbaryl 5D
8. Spray monocrotophos 36 SL 625 ml/ha.

2. Blue butterfly: *Lampides boeticus*, Lycaenidae: Lepidoptera

Distribution: India

Host: Cowpea, redgram, blackgram, lablab and niger.

Symptoms of damage: The larva feeds inside flower buds and green pods with bore holes and presence of slug like caterpillar.

Bionomics

The adult moth is greyish blue with prominent black spots in the hind wings and a long tail. It lays eggs single or in group of 2-3 on flower buds, green pods, shoots and leaves. The egg period is 4-7 days. The larva is pale green with a rough skin and measures 1mm in length. The larval period is 9-27 days. It pupates in leaf, twig or pod. The pupal period lasts for 17-19 days.

Management

1. In order to bring down infestation dense or close planting may be discouraged.
2. Avoid early or late sowing.
1. Safety is granted by regular digging of the soil during the period of infesation that causes death of larva and pupa.
3. Pick the larva, pupa and adult and destroy.

Release egg parasitoid *Trichogramma* sp.

Larva parasitoids *Aploymia* sp., *Hyperencyrtus lycoonephila, Listrodromus crassipes*.

3. Grass blue butterfly: *Euchrysops cnejus,* Lycaenidae: Lepidoptera

Distribution: India

Host: Blackgram, peas, redgram and lablab.

Symptoms of damage

Buds, flowers and young pods with boreholes and presence of slug like caterpillar.

Bionomics

The adult butterfly is blue, medium sized with 5 black spots in the hind wings and two black spots in the inner margin. It lays 60-200 eggs singly on stem, pod, leaf petioles. They hatch in 2-10 days. The larva measures about

13 mm in length, pale green or yellow with a red line and short in length, pale green or yellow with a red line and short black hairs on the body. It feeds on flowers; flower stalks and enters the pod when found. The entry hole on the pod is plugged with excreta. The larval period is 10-21 days with four instars. It pupates in soil or between fallen leaves and debris on the plant for a period of 5-12 days.




4. Plume moth: *Exelastis atomosa,* Pterophoridae: Lepidoptera

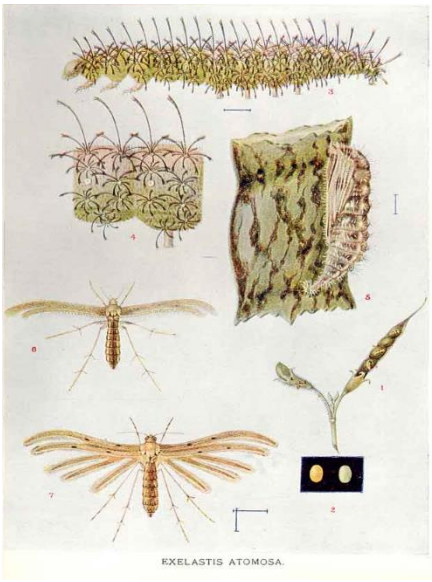
Distribution: India, Nepal and New Guinea

Host: Redgram, lablab, niger and horsegram

Symptoms of damage

The tiny larva bores into unopened buds, flowers and tender parts. 5-20% pods are damaged.

Bionomics



Adult is delicate, brown coloured small moth with plumed wings. Eggs are laidon flower buds and tender pods. Egg period is 4 days. Larva is greenish brown, 10 mm in length densely closed with short hairs and spines. Larval period is 14-30 days. It pupates on the pods itself. Pupal period is 4-8 days.

Management

1. Larval parasitoids, *Apanteles paludicolae, Diadegma* sp., *Phanerotona hendecasisella, Tropimeris monodon*

5. Spotted pod borer: *Maruca testulalis,* Pyraustidae: Lepidoptera

Distribution: Tropical and sub tropical regions of the world.

Hosts: Beans, peas, castor, groundnut, cowpea, rice, sesame, soybean,

tobacco, daincha, sugarcane, redgram, lablab, niger, greengram and blackgram.

Symptoms of damage

The larva bores the buds, flower or pods, infested pods and flowers are webbed together. The larva feeds on seeds. The assessment of pigeonpea pods has shown that 5-20% pods may get affected depending upon the locality, month and variety.

Bionomics

Female lays eggs singly on flowers, buds or pods. After hatching larva bore buds or pods and feed on seeds. The full-grown larva is 20 mm in length. It pupates in the dry leaves (or) debris.

Management

Release larval parasitoids *Bracon greeni* and *Phanerotoma hendecasisella*.

6. Spiny pod borer, *Etiella zinckenella,* Phycitidae: Lepidoptera

Distribution

India, Japan, Burma, Australia, Sri Lanka, Indonesia, USA, Mexico, West Indies, South America, Europe, Egypt, India.

Hosts: Redgram, horsegram, cowpea and greengram.

Symptoms of damage

The larva feeds inside green feeds and then on feed surface, webbing together 2-4 pods. The damage caused into 11.43%.

Bionomics

Eggs are laid singly (or) in groups preferably at the junction of the calyx and pod or on the pod surface. A female lays from 47-178 eggs, which hatch in 5-6 days. The larva bores within the green pods and feeds on seeds. Larval period lasts 10-13 days. When fully grown the larva drops to ground and forms a cocoon about 2.5 cm or so below ground or under dry leaves. Pupal duration lasts 9-20 days depending on the climate. The moths pair 24-30 hour after emergence.

Management

The caterpillar is parasitised by *Bracon* sp., *Tetrastichus* sp., *Bracon hebetor*, *Phanerotoma* sp. and *P. lenedecasisella*.

7. Field bean pod borer: *Adisura atkinsoni*, Noctuidae: Lepidoptera

Distribution: India

Hosts: Pigeonpea, lablab and niger

Symptoms of damage

The larva bores inside the pod and feeds on the seeds within.

Bionomics

Moths are yellowish brown in colour. Eggs are laid singly on flower, buds and pods. The eggs are minute in size. The egg, larval and pupal periods lasts 3, 14-15 and 11 days respectively. Full grown larva is 28-35 mm long, brownish green in colour. When full fed, caterpillar pupates in rice store.

Management

Release larvae parasitoids, *Microbracon lefroyi, Bracon hebetor, B. brevicornis, Carcelia evolans*.

8. Pod fly: *Melanagromyza obtusa,* Agromyzidae: Diptera

Distribution: India, South East Asia, Japan.

Hosts: Redgram, Okra and Safflower.

Symptoms

Maggots cause damage by boring into the soft seeds and feed on grains. The damaged seeds are unfit for dhal making as well as for germination. The extent of damage may be even upto 60-70% during severe infestation.

Bionomics

Eggs are laid by them singly or in cluster inside the pod wall by piercing through the ovipositor. The fly lays about 60-80 eggs. Incubation period is 2-4 days. Larval period is about 5-18 days and pupal period varies from 7-10 days. A number of overlapping generations are found in a year.

Management

1. Release natural enemies like *Euderus lividus, Eurytoma* sp., *Euderus agromyzae*
2. Spray any one of contact insecticide in early stage of the attack.

9. Stem fly: *Ophiomyia phaseoli,* Agromyzidae: Diptera

Hosts: Red gram, bean, cowpea, soybean and lima bean

Distribution

India, Sri Lanka, Laos, New South Wales Philippines, Burma, East Indies, China, Pakistan, Indonesia, Malaysia, Africa, Fiji, Australia, Thailand, Singapore and Somoa.

Symptoms of damage

Drooping of the tender leaves and yellowing characterize serious damage of young plants. The sites where maggot and pupae are present become swollen and start rabbing. Older plants show stunting but are not usually killed.

Bionomics

The adult is small black fly. A female lays 38-79 eggs singly on pods or on flower buds. The egg period lasts about 3 days. The maggot first makes galleries just below the epidermis of the seed feeding deeper into the seeds later. Larval period lasts for 5-6 days. The larva pupates in the larval groove for 8-9 days.

Management

1. Release natural enemies like *Euderus lividus*, *Eurytoma* sp., *Euderus agromyzae*
2. Spray any one of contact insecticide in the early stages of the attack

II. Flower Feeder

10. Blister beetle: *Mylabris phalerata,* Meloidae: Coleoptera

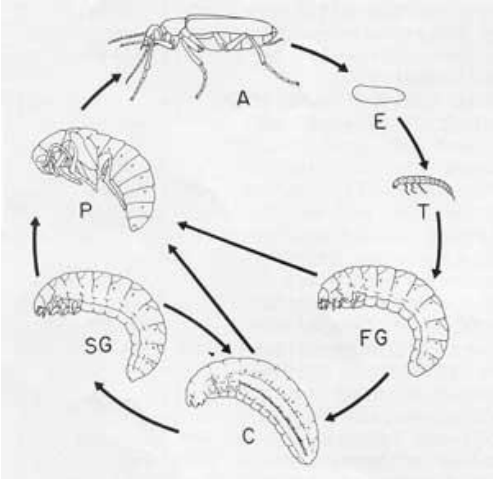
Distribution - India

Symptoms of damage

The adult feeds voraciously on buds and flowers. A single beetle can destroy as many as 20-30 flowers/day.

Bionomics

The eggs are laid by female beetle in clusters of 60-80 eggs at 2-3 cm depth in soil. Eggs are light yellowish in colour and cylindrical in shape. Incubation period is about three weeks. Young grubs are white in colour. It pupates inside the soil tunnel.



A = adult, E = egg, T = first instar or triungulin, FG = first grub phase,
C = coarctate phase in instar six or seven,
SG = second grub phase, P = pupa

11. Flower webber: *Eublemma hemirrhoda*, Noctuidae: Lepidoptera

Symptoms of damage

Larva webs together the flowers and feeds on them.

Bionomics

Adult is having yellow forewings with purple patches and white hind wings. Larva is green with a black head.

12. Pod wasp: *Tanaostigmodes cajaninae*, Tanaostigmatidae: Hymenoptera

Distribution

Andhra Pradesh, Orissa, Bihar, Maharastra and Karnataka.

Host: Red gram

Symptoms of damage

The larva feeds on young seed of basal locules of pods causing complete abortion of the seed. Larva also feeds on the pod wall after consuming the seed. When the pod is attacked immediately after flower drop it becomes dry and is shed.

Bionomics

Eggs are laid on flowers and very young pods. The white larva is apodous and 2-5 mm long when full-grown. Larval stage lasts 8-10 days. Pupation is inside pod for 5-7 days.

Management

Parapholaspis sp. parasitises the larva

II. Pests of blackgram, greengram and cowpea

I. Sap feeders

1. Bean aphid: *Aphis craccivora*, Aphididae: Hemiptera

Distribution

Cosmopolitan, India, Africa, Argentina, China, U.S.A., Europe, Australia

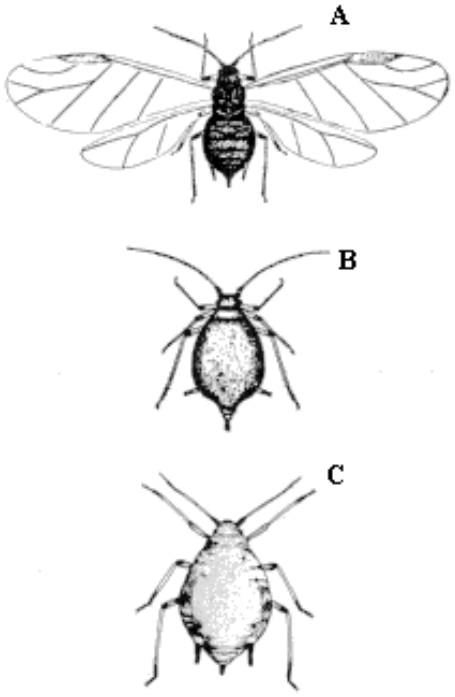
Hosts: Groundnut, red gram, peas, beans, safflower, lablab, niger

Symptoms of damage

Both nymphs and adults cause the damage by sucking the plant sap. Infested pods become deshaped, withered and malformed. Severe infestation may result into complete drying of affected pods. They also act as vector of pea viruses.

Bionomics

It is a greenish black coloured aphid. The total life cycle occupies an average of 3-8 days. It reproduces parthenogenetically and viviparously. The female may produce 8-30 young ones in a life span of 10-12 days. The nymphs transform into adult in 5-8 days after passing through four months.



Aphids. A-B, Bean aphids. C, Cowpea aphid.

Management

1. Use entomopathogenic fungus *Fusarium pallidoroseum* to cause epizootics in aphids in the cowpea field.
2. Spraying of infested crop with 0.03% methyl demeton (or)

phosphamidon @ 700 litre water per ha may effectively control aphids. As the strong point of this pest lies in its very quick multiplication the insecticidal treatment has to be repeated as soon as aphid population is found to have built up again.

2. Thrips: *Ayyaria chaetophora*, Thripidae: Thysanoptera

Symptoms of damage

The leaves are mottled with characteristic silvering due to the attack of insect especially under dry spell on lab lab, black gram, green gram, cow pea.

Bionomics Tiny yellow fringe winged adults.

Management: Spray any one of contract or systemic insecticides

3. Whitefly: *Bemisia tabaci*, Aleyrodidae: Hemiptera

Host plants: Moong, urd, lobhia, cotton, tobacco, casava

Symptoms of damage

The damage is caused by both nymphs and adults, which are found in large numbers. They suck plant sap and lower its vitality. Severe infestation results in premature defoliation, development of sooty mould or honey dew and shedding of flowers pods.

Bionomics:

Adult is a minute insect with yellow coloured body with white waxy bloom. Nymph is greenish yellow, oval in outline along with puparia on the under surface of leaves.

Management

Spraying the infested crop with 0.1% malathion (or) 0.05% phosalone or 0.03% dimethoate with 700 - 1000 lit. water per hectare.

4. Green leafhopper: *Empoasca kerri*, *Empoasca binotata,* Cicadellidae: Hemiptera

Host plants: Moong, urd, lobia, moth etc.,

Symptoms of damage

The nymphs and adults feed on tender leaves and other parts by sucking the plant sap. In cases of severe attack, leaves become brittle and dry. The plant may loose its vigour resulting into poor growth.

Bionomics

Elongate, active wedge shaped green insects found on the under surface of leaves. The female insert its eggs inside the veins of leaves. The incubation period lasts 4-8 days. There are five nymphal instars occupying 7-10 days.

Management

Spraying the infested crop with 0.07% methyl-o- demeton (Metasystox) or 0.03%, phosphamidon @ 700 litre water per hectare.

5. Pod bug: *Riptortus pedestris*, *Clavigralla horrens, Anoplocnemis phasiana*, Coreidae: Hemiptera

Host plant: Arhar

Symptoms of damage

The nymphs and adults suck the juice of unripe seeds from the green pods. In case of severe infestation the tender parts get shrivelled and later dries up. The bugs are seen clustered around on the pods.

Bionomics

Riptortus pedestris- The female bug lays on average of 115 eggs singly on pods at their base. The egg period is 3-4 days. The nymphs are brownish black and hemispherical which resembles brown ant. The nymphal stage undergoes 5 instars covered in 16 days. *Clavigralla gibbosa* **-** It is bigger than *C. horrens* in size. It lays eggs in groups of 3-15 on pods or leaves. The fecundity is 60-400 eggs per female. The incubation period is 4 days. There are 5 nymphal instars. The nymphal duration varies from 7-31 days. The adult bug lives upto 150 days. *C. horrens* **-** It is brown, flat, narrow - bodied bug with conspicuous lateral spines on the prothorax and enlarged hind femur.

Management

Spraying the infested crop with 0.03% monocrotophos 36 SL or 0.03% phosphamidon @ 1000 litre water/ha.

6. Stink bug: *Coptosoma cribraria*, Coremelanidae: Hemiptera

Host plants: Bean, lentil etc.,

Symptoms of damage

Both nymphs and adults cluster on the tender shoots and suck cell sap. Heavily infested wines dry and shed away. Moderately infested plants remain weak and stunted in growth.

Bionomics

Oval shaped greenish bugs lay ivory white sculptured eggs in double rows in batches of 35-50 on the tender pods. Incubation period is about 7 days. Total life cycle is completed in about 49 days in South India.

Management

Spraying the infested crop with 0.03% phosphomidon 85 @ 700 litre water per hectare.

Leaf feeder

7. Leaf webber: *Eucosma critica*, Eucosmidae: Lepidoptera

Host plant: Arhar

Symptoms of damage

The damage is caused by the larvae, which bores into the tender shoots of folded leaves and feed from within. Since the terminal leaves get spun together growing tip is damaged. The growth of the main shoot is affected. It is widely distributed in India.

Bionomics

The small and dark brown moth lays eggs singly or in rows on leaves, petioles (or) stems. The grooves or depressions are preferred for egg laying. Around 80-100 eggs are laid by one female. The incubation period lasts for 3-4 days. Larval period is about 14-21 days and pupal period 4-6 days. Pupation occurs within the folded buds, flowers or pods in the silken cocoon.

Management

Spraying the infested crop with 0.03% phosphomidon EC @ 700 litre water per hectare.

8.Leaf folder: *Anticarsia irrotata*, Noctuidae: Lepidoptera

Symptoms of damage

Larva folds the leaves together.

Bionomics

Adult is yellowish brown moth with oblique black lines on the wings. Larva is green coloured.

9. Lab-lab leaf miner: *Cyphosticha coerula*, Gracillariidae: Lepidoptera

Distribution: Throughout India

Host plants: Urd, Moong, Lobia, Moth etc.,

Symptoms of damage

Tiny larvae bore into the epidermis of the leaf and forms blisters through mining.

Management

Spraying the infested crop with 0.03% phosphamidon or 0.07% metasystox @ 700 litre water per ha.

Subterranean pest

10. Termites: *Odontotermes obesus*, Termitidae: Isoptera

Host plants - wheat - barley, sugarcane, pea, jowar, bajra, maize, groundnut, fruits and vegetables.

Symptoms of damage

Termite damage starts soon after sowing and continues till the growing stage. The leaves of damaged plants droop down which later wither and dry. Such plants are easily uprooted.

Bionomics

7-10 days after aerial flight the female lays the first batch of eggs numbering 100-130. These eggs hatch in 40-42 days. The female termite then swells to become queen and lays upto 30,000 eggs per day. The members of this group are social insects and are composed of workers, soldiers, king and queen.

Management

1. Where the pest is of regular occurrence the soil should be mixed with 10% BHC dust @ 35 kg/ha (or) 5% chlordane dust @ 25 kg/ha at the time of sowing.
2. If the incidence of pest is noticed in standing crop irrigate the fields with 0.1% lindane 20 EC.

Other pests

1. Redgram scale: *Ceroplastodes cajani*, Coccidae: Hemiptera

Symptoms of damage

Tender branches are covered with scales attended by ants.

Bionomics: Adults are round waxy scales.

2. Redgram leaf roller: *Caloptilia soyella*, Gracillaridae: Lepidoptera

Symptoms of damage: Leaves rolled up apically become white and dries up.

Bionomics: Adult moth is very small. Larva is creamy yellow or green with sparse hairs on the body.

3. Leaf eating caterpillar: *Azazia rubricans*, Noctuidae: Lepidoptera

Symptoms of damage: The larva causes severe defoliation.

Bionomics

Larva is slender green with ashy white band between each segment. A few narrow lines along the black and bright yellowish brown stripes along the side may or may not be present. It has looping movement in spite of the presence of all prolegs. Adult moth resembles a dry leaf.

4. Sphingid caterpillar: *Acherontia styx*, Sphingidae: Lepidoptera

Symptoms of damage: The larva feeds on leaves and cause severe defoliation.

Bionomics: Adult is large, wings grey with waxy markings. Abdomen crimson coloured with black stripes. Larva is a stout green caterpillar with yellowish oblique stripes with curved anal horn.

5. Leaf cutter bee: *Megachile anthracena*, Megachilidae: Hymenoptera

Symptoms of damage

Red gram leaves showing semi circular or circular cut out. Adults cut small bits of leaves for making larval chambers.

Bionomics: Medium sized brown coloured bees.

Integrated Pest Management in Pulses

A. Cultural methods

1. Summer deep ploughing is effective to destroy the eggs, larvae and pupae of the cut-worms, pod borers and gujhia weevil.
2. Pest population of pulses can also be suppressed to some extent by resorting clean cultivation.
3. Early sowing crop escapes the first two broods of stem fly.
4. Increase the seed rate to compensate the damage due to stem fly.
5. Soil raking through weeding may reduce the soil grubs.

6. Apply 50 kg potash/ha to the crop raised with closer spacing (20x10 cm) to reduce the stem fly and pod borer incidence
7. Remove the weeds from the field and in round field.
8. Collect and destroy egg masses and pupae.
9. Dry the seeds adequately to reduce the moisture level to 8% for the grain purpose.
10. Resistant strains of gram like G-130 & C 214 are less susceptible to *H. armigera*.

B. Mechanical methods

1. Set up light trap to monitor, attract and kill the pod borer moths.
2. Set up pheromone traps @ 12 Nos./ha to reduce gram pod borer incidence.

C. Biocontrol methods

1. Release egg parasite *Trichogramma* spp. and egg larval parasite *Chelonus blackburnii* for the control of *H. armigera*.
2. *Microbracon* sp. and *Apanteles* sp. parasitizes the caterpillars of *Agrotis ipsilon*.
3. Apply NPV @ 500 LE/ha to control *H. armigera*.

Chemical methods

1. Soil treatment against cut-worms and other insects hiding below or on the soil surface - A thin top layer of soil should be treated with 5% heptachlor or chloridane dust @ 25 kg/ha.
2. Seed pelleting with chlorpyriphos or monocrotophos 36 SL @ 4 ml/kg of seed may reduce the early pests like stem fly.
3. For sucking pests, spray methyl demeton 25 EC 500 ml (or) dimethoate 30 EC 500 ml/ha (250 l spray fluid / ha)
4. For pod borer, apply any one of the insecticides @ 25 kg/ha, quinolphos 4D and carbaryl 5D.
5. Spray monocrotophos 36 SL 625 ml/ha or NSKE 5% twice followed by triazophos 0.05% (spray fluid 500 l/ha).
6. For seed purpose: Admix 1 kg of activated kaolin or malathion 5% D for every 100 kg. Pack in polythene lined gunny bags for storage.
7. Neem seed kernel powder 3% effectively control the storage pest, bruchid beetle.

LECTURE NO. 6 – PESTS OF GROUNDNUT, GINGELLY AND SUNFLOWER

I. Pests of Groundnut

I. Sap feeders

1. Aphids - *Aphis craccivora,* Aphididae, Hemiptera

Distribution - India, Africa, Argentina, Chile, U.S.A., Europe and Australia.

Host Plants - Groundnut, beans, safflower, lablab niger, pees, pulses and some weeds.

Symptoms of damage

Both nymphs and adults suck the sap from the leaflets and tender shoots mostly up to two months after germination. It results in wilting of tender shoots during hot weather. Leaves mottled with chlorotic or dark green spots and plants stunted. Sometimes honey dew deposited on the leaves and shoots could be seen which attract the ants.

Bionomics-Reddish to dark brown coloured aphids.

Management

Spraying the infested crop with 0.03% methyl demeton (or) phosphamidon @ 700 litre water per ha may effectively control aphids. As the strong point of this pest lies in its very quick multiplication the insecticidal treatment has to be repeated as soon as aphid population is found to have built again.

2. Leaf hopper - *Empoasca kerri*, Cicadellidae, Hemiptera

Symptoms of damage

Both nymphs and adults suck the plant sap from the under surface of the leaves and cause yellowing of margins of leaflets and finally lead to hopper burn or drying of leaves. A heavy infestation of young plants can cause stunting and tip yellowing in leaves.

Bionomics - Elongate, active wedge shaped green insects found on the under surface of leaves.

Management - Spraying the infested crop with 250 ml phosphamidon 100 EC in 1000 litre of water per ha.

3. Thrips - *Scirtothrips dorsalis*, Thripidae, Thysanoptera

Symptoms of damage - Older or lower leaves showing white spot marks or streaks intermingled with black excreta on the upper surface.

Bionomics: Nymphs and adults dark coloured with fringed wings.

Management:

1. Intercrop lab lab with groundnut 1:4 ratio
2. Spray methyl demeton 25 EC 500 ml or dimethoate 30 EC 500 ml

II. Leaf feeder

4. Red hairy caterpiller - *Amsacta albistriga*, Arctiidae, Lepidoptera

This is a serious pest causing devastating damage especially in the rainfed crops. It is seasonal outbreak is largely depend upon the climatic conditions and local agricultural practices of the tract concerned. The outbreak of the pest takes place twice a year May-June and August-October.

Symptoms of damage

The larvae feed on the leaves gregariously by scraping the under surface of tender leaflets leaving the upper epidermal layer intact in early stages. Later they feed voraceously on the leaves and main stem of plants. They march from field to field gregariously. Severely affected field looks as though they are grazed by cattle. It results sometimes in the total loss of pods. They also feed on sorghum, cotton, finger millet, castor and cowpea, etc.

Bionomics

Adults are medium sized moths. In *A. albistriga* forewings are white with brownish streaks all over and yellowish streaks along the anterior margin and hind wings white with black markings. A yellow band is found on the head. In *A. moorei* all markings are red in white wings. On receipt of heavy rains, about a month after sowing in *kharif* season, a white moth with black markings on the hind wings emerge out from the soil in the evening hours. It lays eggs on the under surface of the leaves. The eggs lay about 600-700 eggs. Egg period is 2-3 days. Tiny greenish caterpillar feeds on the leaves gregariously. A fullgrown larva measures 5 cm in length, reddish brown hairs all over the body arising on warbs. The larval period is 40-50 days. With the receipt of showers, the grown up larva pupate in earthern cells at a depth of 10-20 cm. They pupate mostly along the field bunds and in moist shady areas under the trees in the field and undergo pupal diapause till the next year.

ETL: 8 egg masses/100 meter

Management

1. Organise campaign to collect and destroy the pupae after summer ploughing on receipt of showers.
2. Grow cowpea or red gram as an intercrop to attract adult moths to lay more eggs.
3. Set up 3-4 light traps and bonfires immediately after the receipt of rains at 4 weeks after sowing in the rainfed season to attract and kill the moths and to know brood emergence.
4. Collect and destroy egg masses in the groundnut and cowpea
5. Collect and destroy gregarious early instar larvae on lace like leaves of inter crops *viz*., red gram and cowpea.
6. Organise campaign by involving school children (or) general public to collect and destroy the migrating grown up caterpillars from the field.
7. Dig out a trench around the field to avoid the migration of caterpillars and to trap larvae and kill them.
8. Use nuclear polyhedrosis virus @ 250 LE/ha.
9. For young caterpillars - apply carbaryl 10 D 25 kg/ha.
10. Organize mass ground spraying in endemic areas if necessary in the case of outbreak of the pest.
11. For grown up caterpillars - spray fenitrothion 750 ml/ha (or) dichlorvos 625 ml/ha (or) chlorpyriphos 1250 ml/ha in 375 litres of water.

5. Leaf miner/Surul poochi/Soybean leaf miner - *Aproaeroma modicella*, Gelechiidae, Lepidoptera

Distribution - India, Pakistan, Sri Lanka, Burma and South Africa.

Host plants - Groundnut, soybean and redgram.

Symptoms of damage

It prefers rainfed crop and bunch varieties. The green caterpillar mines into the leaflets and feed on green tissues resulting in brownish dried up patches. The leaves are also folded together and twisted inside which the later instar caterpillars live by feeding on the green tissue of the leaves. In severe infestation, the crop presents a burnt up appearance. Caterpillars (or) pupae can be seen inside the mines and folded leaflets. It also attacks red gram and soybean.

Bionomics

Adult is dark brown with a white spot on the coastal margin of each forewing. The small hindwings are covered by fringe of minute hairs. Adults are found briskly whirling around the plants in field and lay shiny transparent eggs singly on the under surface of leaflets. A female moth lays 150-200 eggs that hatch in 2-3 days. The larvae are pale brown. Fully grown larva measures 6-8 mm. The larval period is 4-17 days. They pupate in white silken cocoons within webbed leaflets and the pupae are reddish brown. The pupal period is 5-7 days. Adult longevity is 5-6 days.

Life cycle: 20-25. They cause severe damage during September, October and November in the rainfed season and during March and April in the irrigated season.

ETL: 1 larva per meter row

Management

1. Sow groundnut early and synchronously in the rainfed and irrigated season.
2. Intercrop groundnut with cumbu @ 4:1 ratio.
3. Set up light traps between 8 and 11 PM at ground level.
4. Mulch the soil with straw within 10 days after germination wherever possible.
5. Avoid water stress in irrigated crop to avoid the pest infestation.
6. Maintain the fields and bunds free from weeds.
7. Apply any one of the following insecticides at 25 kg/ha. When the pest crosses ETL, apply phosalone 4D, carbaryl 10D.
8. Spray any one of the following insecticides - dichlorovos 625 ml/ha, quinolphos 750 ml/ha in 375 l of water.

6. Tobacco caterpillar - *Spodoptera litura,* Noctuidae, Lepidoptera

Distribution - India, Sri Lanka, Indonesia, Bangladesh, Pacific Islands, China, Pakistan, Korea and Japan.

Host plants - Groundnut, citrus, soybean, cotton, tobacco, castor, pulses, millets, safflower, banana, cabbage, tomato, bhendi, chillies, etc.

Symptoms of damage

Greenish caterpillars feed on the leaves voraciously and present an appearance to the field as if grazed by cattle. Since this pest is nocturnal in

habit it hides under the plants, cracks and crevices of soil and debris during the day time. Feacal pellets are seen on the leaves and on the ground which is the indicator of the pest incidence.

Bionomics

Adult moth is stout with wavy white markings on the brown forewings and white hind wings with a brown patch along its margin. Eggs are laid in groups and covered with hairs on the leaves. The egg period is 4-5 days. Larva is stout, cylindrical, pale brownish with dark markings. The body may have row of dark spots or transverse and longitudinal grey and yellow bands. When fully grown, measures about 35-40 mm in length. The larval period is 14-21 days. It pupates in earthern cells in soil for 15 days. Life cycle is completed 30-40 days.

ETL: 8 egg masses/100 meter.

Management

1. Grow castor as a border (or) intercrop in groundnut fields to serve as indicator (or) trap crop.
2. Monitor the emergence of adult moths by setting up of light traps.
3. Set up pheromone trap (Spherodin SL) to monitor, attract and kill the male moths @ 12 nos./ha and change the septa once in 3 weeks.
4. Collect egg masses and destroy.
5. Collect the gregarious larvae and destroy them as soon as the early symptoms of lace-like leaves appear on castor, cowpea and groundnut.
6. Avoid migration of larvae by digging a trench 30 cm deep and 25 cm wide with perpendicular sides around the infested fields.
7. Prepare a bait with following to cover/ha. Rice bran 12.5 kg, molasses or brown sugar 2.5 kg, carbaryl 50 WP 1.25 kg.
8. Apply NPV @ 250 LE/ha with crude sugar 2.5 kg/ha is as effective as that of chlorpyriphos at 200 g a.i./ha at 7 days interval.
9. Apply any one of the following insecticides per ha to control early instar larvae (1^{st} to 3^{rd} instar). Carbaryl 10D 25 kg, fenitrothion 750 ml, carbaryl 50 WP 2 kg, quinalphos 750 ml, fenitrothion 500 ml, phenthoate 1250 ml and dichlorvos 750 ml.
10. Spray any one of the following per ha to control the 4^{th} to 6^{th} instar larvae. Chlorpyriphos 2 lit, dichlorovos 1 lit, phenthoate 2 lit., fenitrothion 625 ml + chlorpyriphos 1.25 lit. in 1000 lit of water.

7. Gram pod borer - *Helicoverpa armigera,* Noctuidae, Lepidoptera

Distribution: World wide

Host plants

Cotton, sorghum, lablab, soybean, pea, safflower, chillies, groundnut, tobacco, bhendi, maize, tomato.

Symptoms of damage

Small or large irregular feeding holes on the leaves. Presence of pale green or rose or brown or chocolate colored caterpillars with dorsal and lateral stripes and hairs on the body.

Bionomics

Adult is brown coloured moth with 'V' shaped speck on forewings and dull black border on the hind wing. Eggs are laid singly on host plant. The egg period is 7 days. Larva is greenish with dark brown grey lines. Color varies with food. The larval period is 14 days. It pupates in soil for 10 days. Cannibalism is common among larvae.

Management

1. Set up light trap to attract and kill the moths.
2. Set up pheromone traps @ 12 Nos./ha to attract male moths.
3. Release of egg parasite *Trichogramma* spp. and egg larval parasite *Chelonus blackburnii*.
4. Apply *Nuclear polyhedrosis virus* (NPV) @ 250 LE/ha.
5. Combined use of NPV of *S. litura* and *H. armigera* on groundnut indicated that single application of NPV of each pest at 250 LE/ha with crude sugar 2.5 kg/ha is highly effective.
6. Spray Monocrotophos 500 ml/ha.

III. Borers

8. Bud borer - *Anarsia ephippias*, Gelechidae, Lepidoptera

Symptoms of damage

The larva bores into the terminal buds and shoots. The tender leaflets emerging from central spindle shows shot-hole symptoms initially. In severe infestation emerging leaflets have only the midribs or several oblong feeding holes. The larva also bores into the tip of the stem. The infestation causes 20-35% shoot damages and yields reduction to the tune of 5%.

Bionomics

The adult moth is buff coloured, active and hovers and around plant canopy during sun rise. The larva is chocolate brown to dark brown and 10-15 mm long.

Management

1. Conserve the hymenopteran parasitoids *Bracon gelechiiae* and *Brachymeria* sp. in the groundnut ecosystem to control the pest.
2. Spray neem oil 3% or Notochi (*Vitex negundo*) leaf extract 5%
3. Spray monocrotophos 36 WSE at 1.5 ml/lit. of water to control the pest effectively.

9. Stem borer - *Sphenoptera perotetti,* Buprestidae, Coleoptera

Host plants - Groundnut, sesame, gram and other pulses.

Symptoms of damage - Grubs bores into the stem results in wilting of plants in patches. Stem just below the soil surface and main roots are tunnelled. Tunnel contains elongate flat headed grubs.

Bionomics - The dark brown shinning beetle lays eggs on the stem of plants that hatch into plae white grub with flat anterior portion. It pupates in the stem itself.

Management

1. Apply malathion 5D (or) carbaryl 10D at 25 kg/ha to the sole prior to the sowing.
2. Repeat the same on 40 DAS during earthing up and gypsum application.

Pod feeders

10. Pod borer (Ear wig) - *Anisolabis stalli,* Forficulidae, Dermaptera

Symptoms of damage

Young pods showing bore holes plugged with excreta, sand particles or discoloured pulps. Bored pods are devoid of kernels.

Bionomics

Adult is dark brown to black with forceps like caudal cerci and white leg joints. It lays eggs in clusters of 20-100 in soil and sometimes inside damaged pods and hatch in about a week. The five nymphal instars resemble the adults which can live as long as 250 days. Their unique forked abdominal tip can easily be recognized as 'Y".

Management

1. Apply malathion 5D or carbaryl 10D at 25 kg/ha prior to sowing in areas where the ear wig is endemic.
2. Repeat the soil application of any one of the above dust formulation on 40th day of sowing and incorporate in the soil during earthing up.

11. Pod bug - *Elasmolomus sordidus*: Lygaeidae, Hemiptera

Symptoms of damage

Both nymphs and adults suck the sap from the pod in the field and storage. Freshly harvested pods have shrivelled kernels.

Bionomics

The adult is dark brown, approximately 10 mm long and 2 mm wide. In the field, the females lay their eggs singly in the soil or on groundnut haulms. But in storage eggs are laid loosely among the groundnuts. A female bug may lay upto 105 eggs. The egg period is 4-5 days. The first instar nymphs have a bright red abdomen, later instar become progressively darker. All the stages feed on kernels by piercing the pods with their rostrum. The nymphal period is 23-29 days. Since it is nocturnal in habit, it hides under weeds, cracks and crevices in soil and debris during day time.

Management

1. Set up light traps to attract and kill the bugs.
2. Keep the rubbish or crop refuse in the field along irrigation channel to attract the bugs which can be killed by dusting.
3. Dust the groundnut stored in the gunny bugs with malathion 4D.

Root feeders

12. Termites - *Odontotermes obesus*: Termitidae, Isoptera

Symptoms of damage

It feeds on roots results in wilting of plants in patches. It makes bore holes in pods and damages soft tissue in pod (scarification) leaving thicker portion intact. Termites hover in and around plants.

Bionomics

Cream coloured tiny insects resembling ants with dark coloured head.

13. White grub - *Holotrichia consanguinea,* Melalonthidae, Coleoptera

Symptoms of damage

Growth of plant is retarded. Plants wilt or die. Roots partially or fully eaten off by white and fleshy grubs with 'C' shaped curved body with distinct brown head and jaws or mandibles.

Bionomics

Grub is fleshy 'C' shaped, whitish yellow in colour found close to the base of the clump. Adult is dark brown in colour.

Management

1. Plough deep at the time of land preparation to expose grub and kill.
2. Adopt crop rotation with rice in irrigated endemic areas to bring down grub damage.
3. Ensure adequate irrigation to irrigated groundnut in endemic areas since the grub attacks roots under inadequate sole moisture condition.
4. Set up light traps or bonfires to attract and kill the adults on receipt of summer showers.
5. Apply malathion or carbaryl dust @ 25 kg per ha in the soil prior to sowing during last ploughing.
6. Repeat the same on 40 DAS and incorporate in the soil during earthing up.

II. Pests of Gingelly

I. Borers

1. Leaf webber – *Antigastra catalaunalis,* Pyralidae, Lepidoptera

Distribution - India, Africa, South Europe, Malta, Burma, Bangladesh, Indonesia, Sri Lanka and U.S.S.R.

Host plants - Sesame, *Antirrhinum* and Duranta.

Symptoms of damage - Larva webs the top leaves together and bore the tender shoots in the vegetative phase. Flowers and young capsules are bored at reproductive stage.

Bionomics

Moth is brown with yellowish brown wings. It lays eggs on tender parts of plants. The egg period is 4-5 days. Larva pale green with black head measures 20 mm in length. The larval period is 11-16 days. It pupates in leaf folds in a white silken cocoon for 4-7 days.

ETL: 2 leaves/sq.m. (or) 10% damage.

Management

1. Culture of seasame like EH7, 57, 84, 105, 106 and 156 should be encourage as these were observed to be completely resistant against *A. catalaunalis*.
2. Dusting the crop with 2% parathion or 2% fenitrothion dust @ 15 kg per hectare.
3. Spraying with 0.03% fenitrothion EC or 0.03% dimethoate EC or 0.05% methyl parathion EC or 0.1% carbaryl 50% WP @ 700 litre water per hectare.

2. Gall fly – *Asphondylia sesami,* Cecidomyiidae, Diptera

Distribution: East Africa, India

Host: Sesame

Symptoms of damage

Maggots feed on the ovary and results in the malformation of pods without proper setting of seeds. Flowers and young capsules with gall like swelling is the typical symptom of attack.

Bionomics

Adult is a small mosquito like fly. It lays eggs in the flower or buds. The egg period is 2-4 days. The maggot is white, found inside the flowers. The larval period is about 2-3 weeks. It pupates inside the malformed capsules. The fly emerges from galls in 7-12 days. The total life cycle is completed in 23-27 days.

Management

1. Dust any one of the insecticides per ha on 25, 35 and 50th day of sowing. phosalone 4D 25 kg, malathion 5D 25 kg.
2. Spray any one of the insecticides on 25, 35 and 50th days of sowing phosalone 1000 ml, quinalphos 1000 ml and dichlorovos 500 ml/ha.
3. Use alternate insecticides each time

II. Leaf feeders

3. Sphinx moth – *Acherontia styx,* Sphingidae, Lepidoptera

Distribution - India, Sri Lanka, Burma, Indonesia, Philippines, Malaysia.

Host plants - Sesame, Potato, Brinjal and Jasmine

Symptoms of damage

The damage is caused by the larvae which feed voraciously on leaves and defoliate the plants. The moth is also harmful as it sucks honey from the honey combs in apiaries.

Bionomics

The adult moth is giant hawk moth, brownish with a characteristic skull marking on the thorax and violet yellow bounds on the abdomen. Hind wings yellow with black markings. It lays globular eggs singly on the under surface of leaves. The egg period is 2-5 days. The larva is stout, green with yellowish oblique stripes and curved anal horn. The larval period lasts for 60 days. It pupates in earthern cocoon in soil. The pupal period lasts 14-21 days and 7 months in summer and winter respectively.

Sap feeder

4. Leaf hopper – *Orosius albicinctus,* Cicadallidae, Hemiptera

Symptoms of damage

Both nymphs and adults suck the sap from leaves and transmit phyllody diseases.

Bionomics - Light brown coloured hoppers.

Management

1. Remove sesame phyllody diseased plants from the field.
2. Spray dimethoate 30 EC 500 ml (or) methyl demeton 25 EC 500 ml/ha.

5. Aphid - *Aphis gossypii*, Aphididae, Hemiptera

Symptoms of damage

Both nymphs and adults suck the sap from the leaves results in curling and crinkling of leaves.

Bionomics

Yellowish to dark insects mostly wingless (apterous) on the under surface of leaves. Quite often attended by ants for the sweet honey dew secretion. Wnged forms may be seen under crowded condition.

6. Pod bug – *Elasmolomus sordidus,* Lygaeidae, Hemiptera

Symptoms of damage

Both nymphs and adults suck the sap from the young capsules and seeds

in field and threshing floor condition. It results in appearance of black spots on the capsules. The damaged pods shrivel up. It causes reductions in seed weight and oil content.

Bionomics

Adults are dark brown in colour. It lays eggs singly or in batches in the soil. The egg period is 4-5 days. Nymphs are pinkish. It is noturnal in habit. It hides under the weeds, cracks and crevices in soil and debris during the day time. The nymphal period is 23-39 days.

III. Pests of Sunflower

I. Sap feeders

1. Leaf hopper - *Amrasca biguttula,* Cicadellidae, Hemiptera

Symptoms of damage

Both nymphs and adults suck the sap from the under surface of leaves. Leaves become crinkled and cup shaped, growth gets stunted, brownish red colour develops on the edges of leaves and the condition is known as "hopper burn". They also attack brinjal, bhendi, cotton and potato.

Bionomics

Adult is a small, slender green insect. Eggs are laid singly in the leaf veins. Egg period is 4-11 days. Nymphs green, wedge shaped. Nymphal period is 7 days. Breeding is noted throughout the year.

2. Stink bug - *Nezara viridula*, Pentatomidae, Hemiptera

Symptoms of damage: Both nymphs and adults suck the sap from the developing seeds in the head. Seeds shrivelled.

Bionomics: Adult is green coloured bug. Nymph is brownish red with multicolour spots.

3. Plant bug - *Dolycoris indicus*, Pentatomidae, Hemiptera

Symptoms of damage

Both nymphs and adults suck the seeds causing shrivelling of seeds.

Bionomics - Brown coloured bug with a white patch on the scutellum.

Management of sucking pest: Spray methyl demeton 500 ml (or) dimethoate 500 ml/ha.

II. Leaf feeders

4. Semi looper - *Trichoplusia ni*, Noctuidae, Lepidoptera

Symptoms of damage

Leaves are with holes and severe damage results in skeletonization and defoliation.

Bionomics

Adult is stout moth, head and thorax grey in color white with basal tufts ferruginous, grey wavy forewings with a slender mark. Larva is slender, attenuated anteriorly and green in colour with light wavy lines and broad lateral strip on either side.

5. Bihar hairy caterpillar - *Spilosoma obliqua,* Arctiidae, Lepidoptera

Symptoms of damage: Defoliation

Bionomics

Adults have crimson coloured body with black dots. Wings pinkish with numerous black spots. Larva is orange coloured with broad transverse bands with tuft of yellow hair that are dark at both end.

6. Tobacco caterpillar - *Spodoptera litura,* Noctuidae, Lepidoptera

Symptoms of damage

Greenish caterpillars feed on the leaves voraciously and present a grazed appearance to the field. Since this pest is nocturnal in habit, it hides under the plants, cracks and crevices of soil and debris during the day time. Feacal pellets are seen on the leaves and on the ground which is the indication of the pest incidence.

Bionomics

Adult moth is stout with wavy white markings on the brown forewings and white wind wings with a brown patch along its margin. Eggs are laid in groups and covered with hairs on the leaves. The egg period is 4-5 days. Larva is stout, cylindrical, pale brownish with dark markings. The body may have row of dark spots or transverse and longitudinal grey and yellow bands. When fully grown measures about 35-40 mm in length. The larval period is 14-21 days. It pupates in earthern cells in soil for 15 days.

Life cycle: 30-40 days

ETL: 8 egg masses / 100 meter

Management

1. Grew castor as a border or intercrop in sunflower fields to serve as indicator or trap crop.
2. Monitor the emergence of adult moths by setting up of light traps.
3. Set up pheromone trap (Spherodin SL) to monitor, attract and kill the male moths @ 12 nos./ha and change the septa once in 3 weeks.
4. Collect egg masses and destroy.
5. Collect the gregarious larvae and destroy them as soon as the early symptoms of lace like leaves appear on castor, cowpea.
6. Avoid migration of larvae by digging a trench 30 cm deep and 25 cm wide with perpendicular sides around the infested fields.
7. Prepare a bait with following to cover/ha. Rice bran 12.5 kg, molasses or brown sugar 2.5 kg, Carbaryl 50 WP 1.25 kg (mix the ingredients to obtain a homogenous mixture, sprinkle water gradually and bring the bait to a dough consistency. Distribute the above bait on the soil, around the field and inside in the evening ours immediately after preparation).
8. Apply NPV @ 250 LE/ha with crude sugar 2.5 kg/ha is as effective as that of chlorpyriphos at 200 g a.i./ha at 7 days interval.
9. Apply any one of the following insecticides per ha to control early instar larvae (1st to 3rd instar). Carbaryl 10 D 25 kg, fenitrothion 750 ml, carbaryl 50 WP 2 kg quinolphos 750 ml, fenitrothion 500 ml, phenthoate 1250 ml and dichlorvos 750 ml.
10. Spray any one of the following per ha to control the 4th and 6th instar larvae. Chlorpyriphos 2 lit., dichlorvos 1 lit., phenothoate 2 lit., fenitrothion 625 ml + chlorpyriphos 1.25 l in 1000 l water.

7. Black hairy caterpillar - *Estigmene lactinea,* Arctiidae, Lepidoptera

Symptoms of damage

Larva feeds on leaves voraciously and cause severe defoliation.

Bionomics

Adult is large white moth with crimson markings on head, body and wings. Larva is thick with black head and hairs.

Management

Apply any one of the insecticides at 25 kg/ha at 50% flowering. Carbaryl 10D, malathion 5D (or) spray carbaryl 50 WP 750 g/ha.

8. Capitulum borer - *Helicoverpa armigera,* Noctuidae, Lepidoptera

Symptoms of damage - Larva feeds on leaves and capitulum.

Bionomics

Adults moth is greenish to brown a 'V' shaped speck on forewings and dull black border on the hind wings. Eggs are laid on the host plants singly. The egg period is 7 days. Fully grown larva is 2" long, greenish with dark brown grey lines and dark and pale bands. It shows colour variation from greenish to brown. The larval duration is 14 days. It pupates in soil for 10 days.

Management

1. Install bird perches @ 50/ha
2. Set up light trap to monitor, attract and kill the moths.
3. Set up pheromone traps @ 12 Nos./ha.
4. Inundative release of egg parasitoid *Trichogramma* spp. and egg larval parasitoid *Chelonous blackburnii*.
5. Spray nuclear polyhedrosis virus (NPV) @ 500 LE/ha in 0.1 % teepal.
6. Spray NSKE 5% twice followed by traiazophos 0.05%.
7. Apply any one of the insecticides at 25 kg/ha. Quinolphos 4D, carbaryl 5D.
8. Spray monocrotophos 625 ml/ha.

LECTURE NO. 7 – CASTOR, SOYBEAN, SAFFLOWER, JATROPHA AND MUSTARD

I. PESTS OF CASTOR

I. Borers

1. Capsule & Shoot borer – *Conogethes puntiferalis,* Pyraustidae, Lepidoptera

Distribution

India, Australia, Burma, Sri Lanka, China, Indonesia and Malaysia.

Host plants

Castor, mango, sorghum ears, guava, peaches, cocoa, pear, avacado, cardammon, ginger, turmeric, mulberry, pomegranate, sunflower, cotton tamarind, hollyhock.

Symptoms of damage

The damage is caused by the caterpillar, which bores into the main stem of young plant and ultimately into the capsules. The borer is distributed throughout India where castor is grown.

Bionomics

Adult is medium sized with small black dots on pale yellow wings. It lays eggs on the developing capsules. Egg period is 6 days. Larva measures 24 mm when fully grown. Larva is pale green with pinkish tinge and fine hairs with dark head and prothoreic shield. Larva lives under a cover of silk, frass and excreta. Larval period is 12-16 days. It pupates in the stem or capsule.

Management

Spraying the infested crop with 0.05% phosphomidon (or) 0.2% carbaryl 50 WP @ 1000-1200 litre water per hectare proved effective in controlling the pest.

II. Leaf feeders

2. Castor semi looper - *Achaea janata,* Noctuidae, Lepidoptera

Distribution

India, Pakistan, Sri Lanka, Thailand, Laos, Malaysia, Philippines.

Host plants

Castor, rose, pomegranate, tea, citrus, mango, *Cadiospermum helicacabum*

Symptoms of damage

The damage is caused by both the caterpillar and adult moth. The caterpillars feed voraciously on castor leaves. Feeding from the edges inwards, leave behind only the mid rib and the stalk. The damage is maximum in August, September and October. The adult of this species are fruit sucking moths and cause serious damage to citrus crop.

Bionomics

Adult is a pale reddish brown moth with black hind wings having a median white spot on the outer margin. Eggs are laid on the tender leaves. Egg period is 2-5 days. Larva is a semilooper with varying shades of colour with black head and a red spot on the third abdominal segment and red tubercles in the anal region. Larval period is 11-15 days. It pupates in soil for 10-14 days.

Management

1. Dusting the infested crop with 2% parathion dust @ 20-25 kg/ha.
2. Spraying with 0.05%, phosphomidon 100 EC or 0.2%Carbaryl 50% WP @ 1000-1200 litre water/ha. *Parallelia algira*- Looks very similar to *Achaea janata* but the wings have black stripes or triangles.

3. Slug caterpillar – *Parasa lepida,* Cochilididae, Lepidoptera

Distribution

India, Malaysia, Sri Lanka, South East Asia.

Host plants

Castor, pomegranate, citrus, coconut, palm, rose, wood apple, country almond, mango palmyrah, cocoa, coffee, banana, rice and tea.

Symptoms of damage

Larva feeds on leaves voraciously leaving only the midrib and veins resulting in severe defoliation.

Bionomics

Adult moth is green with brown band at the base of each forewing. Eggs are laid in groups and covered with hairs on the leaves. Egg period is 4-5 days. Larva is stout, slug like ventrally flat, greenish body with white lines and four rows of spiny scoli tipped red or black larval period is 40-45 days. It pupates in plant as cocoons covered with irritating spines and hairs.

4. Hairy caterpillar – *Euproctis fraterna,* Lymantriidae, Lepidoptera

Distribution: India

Host plants

Castor, linseed, groundnut, grapewine, cotton, pomegranate, mango, pear and pigeonpea.

Symptoms of damage

Defoliation is the main symptom. The pest is active throughout the year but its activity is reduced in winter.

Bionomics

The adult moth is yellowish with pale transverse lines on fore wings. It lays egg in groups on lower surface of the leaves. The egg period is 4-10 days. The caterpillar possesses red head with white hairs around and a long tuft and a reddish brown body with hairs arising on warts and a long pre- anal tuft. There are six larval instars. The larval periods last for 13-29 days. It pupates in a silken cocoon in leaf folds for 9-25 days. The larva over-winters during winter season.

Management

1. Release larval parasitoids *viz*., *Helicospilus merdarius, H. horsefieldi, Apanteles* sp., *Disophrys* sp.
2. Dusting the infested crop with 2% parathion dust @ 20-25 kg per ha or 5% malathion dust @ 25-30 kg/ha (or) 5% fenitrothion dust @ 25 kg/ha (or) 10% carbaryl dust @ 20 kg/ha.

5. Hairy caterpillar - *Dasychiramendosa,* Lymantriidae, Lepidoptera

Symptoms of damage: Defoliation

Bionomics

Adult is yellowish brown moth. Larva is greyish brown with dark prothoracic and preanal tufts prolegs are crimson coloured. It also attacks red green and coffee.

6. Castor butterfly spiny caterpillar – *Ergolis merione,* Nymphalidae, Lepidoptera

Symptoms of damage

It is a serious though sporadic pest. Insect attacks the crop at an early stage. Insects feed on the leaf tissue and cause defoliation.

Bionomics

Brown butterfly with black wavy lines on the wings.Larva green coloured, spiny caterpillar with yellow stripe on the dorsal region. Pupates in a brown chrysalis. The adult lays dome shaped, shiny white eggs singly on the underside of the leaves. Single female lays 42 to 50 eggs during her life span. The eggs hatch in about a week. The duration of the pupal stage lasts 5-6 days in September to October and 8 to 9 days in December to January. The life cycle of the pest is completed in 20 to 21 days in August to September and 37 to 42 days in December to January.

Management

1. Collect and destroy promptly the affected leaves, etc., which contain larvae inside.
2. Dusting the plants with 10% BHC at 10-15 kg/acre.

7. Wooly bear – *Pericallia ricini,* Arctiidae, Lepidoptera

Symptoms of damage

The damage is caused by caterpillar. It feeds on leaves resulting in defoliation.

Bionomics

The larva is robust, greyish black or blackish brown larva with red head and thick tuft of hairs arising from the body. The adult is greyish brown or black colour and black spots on wings. Hind wings are pink or red colour with black spots.

III. Sap feeders

8. Leaf hopper – *Empoasca flavescens,* Cicadellidae, Hemiptera

Symptoms of damage

Nymphs and adults suck the sap from the under surface of the leaves cause "hopper burn". Leaves become crinkled and cup shaped.

Bionomics

Adult is green, wedge shaped hopper. It lays eggs within the leaf veins. A female lays 15-37 eggs during an oviposition period of 5-7 days. The egg period is 7-8 days. The nymphal period is 9 days.

9. Whitefly – *Trialeurodes ricini,* Aleyrodidae, Hemiptera

Symptoms of damage

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

Bionomics

The adults are pale yellow with white wings covered with waxy powder. It lays eggs in clusters on the under surface of leaves. Nymphal stage undergoes four instars. The life cycle is completed in 19-21 days during July-September.

10. Thrips – *Retithrips syriacus,* Thripidae, Thysanoptera

Symptoms of damage

Nymphs and adults feeds on the upper surface of the leaves. Affected leaves givea shiny appearance. It is also found on cotton and rose.

Bionomics: Pinkish nymph, black adult with fringed wings.

11. Castor gall fly – *Asphondylia ricini,* Cecidomyidae, Diptera

Symptoms of damage

The damage is caused by maggots. As a result of feeding by them, the buds develop into galls and produce no fruits and seeds. This pest is active from September to March.

Bionomics

Adults is a mosquito like small fly. The female lays eggs singly in the buds. Incubation period is 2-4 days. The young maggot feeds on the floral parts and cause malformation of buds which fail to develop into seeds. Larval period lasts 14-21 days. The pupal period is 7-12 days. Complete life cycle takes 23-37 days.

Management

Spraying the infested crop with 0.05% phosphamidon 100 EC or 0.05% thiometon 25 EC @ 1000-1200 litre water/ha.

Integrated pest management of castor crop

1. Cultural method

1. Resistant varieties: (a) P.C.1098 and R.C.1096 coonoo are resistant to jassid attack. (b) Varieties R.C.1066, R.C.1067, R.C.1092, R.C.1069,

R.C.1071 and R.C.1072 are resistant to mite infestation.

2. Summer ploughing: Deep summer ploughing should be followed, so that the larvae of semilooper, hairy caterpillar pupated in the soil will be killed due to scorching sunlight.

II. Mechanical method

1. Set up light trap to attract lepidopteran moths and kill
2. Collect and destroy the egg masses of *Spodoptera litura* and slug caterpillar.
3. Collect and destroy the early instar larvae of *Spodoptera litura*, semilopper and hairy caterpillar.

III. Microbial method

1. Use of bacteria: Spraying of thuricide (*Bacillus thuringiensis* 1%) is found to be effective in controlling the larvae of *A. janata* and other lepidopterous larvae.
2. Use of virus: *Nuclear polyhedrosis, Cytoplasmic polyhedrosis* and pox-like virus have been found effective against *A. moorei* and *Euproctis* spp.
3. Use of nematodes: *Mermis submigrescens* have been found effective against *A.moorei*.
4. Apply NSKE 3% + neem oil 2% for the control of semilooper.
5. Apply dimethoate 500 ml/ha or methyl demeton 1500 ml/ha to control sucking pests.
6. Spray any one of the following insecticides/ha thrice from flowering at three weeks interval to control capsule and shoot borer. Malathion 2 lit, fenthion 1 lit. and carbaryl 50 WP 2 kg in 1000 lit. of water.

II. PEST OF SOYBEAN

1. Whitefly: *Bemisia tabaci*, Aleyrodidae; Hemiptera

Symptoms of damage

Damage is caused by both nymphs and adults. Vectors of soybean mosaic virus disease.

Bionomics

Adult is a minute insect with yellow coloured body with white waxy bloom. Nymph is greenish yellow, oval in outline along with puparia on the under surface of leaves.

2. Leafhopper: *Orosius* sp. Cicadellidae; Hemiptera

Symptoms of damage - Nymphs and adults suck the sap and causes drying of leaves. Vectors of witches broom disease.

Bionomics - Brown coloured leaf hoppers.

3. Sailor butterfly: *Neptis jumbha*, Nymphalidae; Lepidoptera

Symptoms of damage - Larva causes defoliation.

Bionomics - Larvae are green in colour with processes on the sides of the third, fourth, sixth and terminal segments. Spines on the head. Butterflies have black wings with white spots.

4. Pod fly: *Melanagromyza obtusa*, Agromyzidae; Diptera

Symptoms of damage

Young pods with dark brown encrustation on the pod wall. Dry pods showing pin head size holes, seeds shriveled, striped and partially eaten by maggots.

Bionomics - Maggots are small white coloured, adults are small tiny black fly.

5. Leaf miner/ Soybean leaf miner: *Aproaeroma modicella*, Gelechiidae; Lepidoptera

Symptoms of damage

It prefers rainfed crop and bunch varieties. Caterpillar mines into the leaflets and feed on green tissues resulting in brownish dried up patches. Leaves are also folded together and twisted inside which the later instar caterpillars live by feeding on the green tissue of the leaves. In severe infestation, the crop presents a burnt up appearance. Caterpillars (or) pupae can be seen inside the mines and folded leaflets.

Bionomics

Moth is dark brown with a white spot on the coastal margin of each forewing. The small hind wings are covered by fringe of minute hairs. Larvae are bluish green to pale brown. Fully grown larva measures 6-8 mm.

III. PESTS OF SAFFLOWER

1. Gram pod borer/ Capsule borer: *Helicoverpa armigera,* Noctuidae, Lepidoptera

Symptoms of damage

In early stage of crop growth larvae feed on leaves and shoot apices. Later, the larvae shift to the developing capitula. The symptoms are perforated leaves, perforated involucral bracts, partially or completely eaten capitula in the bud stage and bored developing capitula.

Bionomics

Eggs: Spherical in shape and creamy white in colour, laid singly

Larva: Shows colour variation from greenish to brown. It has dark brown grey lines on the body with lateral white lines and also has dark and pale bands.

Pupa: Brown in colour, occurs in soil, leaf, pod and crop debris

Adult: Light pale brownish yellow stout moth. Forewings are olive green to pale brown with a dark brown circular spot in the centre. Hind wings are pale smoky white with a broad blackish outer margin

Management

- Intercropping with non host crop like wheat or barley.
- Avoid chickpea as intercrop.
- Excessive application of nitrogen should be avoided.
- Ha NPV can be applied at 250-300 larval equivalents/ha.
- Conserve *Campoletis chloridae, Enicospilus sp,* etc.
- Spray monochrotophos 750 ml/ha in 600-800 litres of water per ha.

2. Safflower caterpillar: *Perigaea capensis*

Symptoms of damage

The larva feeds on the leaves and sometimes on capitulum too. It also feeds on bracts, flowers, capsules.

Bionomics

Larva: Stout, green and smooth. The anal segment is humped and the body has some purple markings.

Adult - Dark brown in colour, medium sized moth on; Forewings are dark brown with pale wavy marks; Hind wings are light brown.

Management

- Intercropping with non-host crop like wheat.

- Excessive application of nitrogen should be avoided.
- Spraying of carbaryl 50 WP@ 2.5 - 3.00 kg/ha or fenvalerate 20 EC @ 250 ml/ha.

3. Capsule fly/Safflower bud fly: *Acanthiophilus helianthi rossi,* Tephritidae, Diptera

Symptoms of damage

Newly hatched larvae feed on the soft parts of the capsules. Affected buds show small bore holes. The infested buds rotten with a foul smelling ooze coming out of the apices

Bionomics

Larva: Maggot is dirty white in colour

Adult: Flies are ash coloured with light brown legs.

Management

Application of dimethoate 30 EC @ 600-650 ml/ha or malathion 50 EC @ 1.00 litre/ha or phosphomidon 100 EC@ 150-200 ml/ha. About 600 to 650 litre of water is needed for spraying in about one hectare area.

4. Safflower aphid: *Uroleucon carthami,* Aphididae, Hemiptera

Symptoms of damage

Curling and yellowing of tender leaves. Secrete honey dew like secretion on upper surface of the leaves and plant parts forming a black sooty mold which hinders photosynthetic activity resulting in stunted growth
Finally the plants dry up.

Bionomics

Nymphs - Reddish brown. **Adults -** Large sized, black with pear-shaped body and conspicuous cornicles

Management

- Avoid late sowing.
- If the attack is observed in the border rows take control measures.
- Avoid excess use of nitrogen.
- Maintain 2 or 3 rows of Maize and Sorghum around the fields.
- Release of Chrysoperla eggs/grubs @ 1-2/plant.
- Conserve *Aphidencyrtus aphidivorus, Micromus cinearis, Ischiodon scutellaris, Harmonia octomaculat* and *Aphelinus* sp

- Spray dimethoate 30 EC @ 750 ml/ha, 40 and 60 days after sowing monochrotophos 0.05%. Use 500 litres of spray mixture and 20 kg dust formulation/ ha.

IV. PEST OF JATROPHA

1. Leaf webber: *Pempelia morosalis (Salubria morosalis)*, Crambidae (Pyralidae); Lepidoptera

Damage symptoms:

Larva webs twigs and terminal leaves along with shoots and feeds on. At reproductive stage of the plant, Larva feeds on inflorescence and pericarp of the pods rarely bore inside the pods. Maximum incidence is observed during second fortnight of October.

Bionomics

Adult is grayish with snout like labial palp in the head with hyaline hind wing. First and second instar larva are plain, pale yellowish green colour that is changed to brown during third instar to fifth instar with dorsal longitudinal stripes.

2. Plant bugs, *Scutelleria nobilis*, Scutelleridae; Hemiptera

☐ Adult is metallic green in colour with eight black spots on the elytra and two spots on scutellum. Neonate nymphs are orange in colour. Later instar nymphs are pinkish in colour with transverse black band on the abdomen.

***Chrysocoris purpureus*, Scutelleridae; Hemipera**

Adults are stout when compared to *S.nobilis* with six black spots on the shiny green or blue elytra and two black spots each on prothorax and scutellum. Nymphs are metallic green in colour with black spots as that of adults.

3. Thrips: *Retithrips syriacus*, Thripidae; Thysanoptera

Damage symptoms

Feeding by nymphs and adults causes white speckling, crinkling, curling, silvering and withering of leaves.

Bionomics

Adults are dark black in colour. Neonate nymph at the time of hatching is pale yellow in colour which turns to red colour during later period.

4. Red spider mite: *Tetranychus urticae*, Tetranychidae; Acarina

Damage symptoms

Extensive silken webbing on the underside of leaves, yellowing, white speckling and premature falling of leaves. Two spotted mites are oval in shape and translucent colour.

V. PESTS OF MUSTARD

The important cruciferous oilseeds cultivated in India are yellow and brown sarson (*Brassica campestris* var. *sarson*), toria (*B.campestris* var. *toria*), raya (*B. juncea*) and taramira (*Eruca sativa*). These crops are damaged by a number of pests, of which mustard aphid, mustard sawfly and the painted bug are more serious. The aphid is the most serious pest on Brassica oilseeds throughout India.

1. Mustard Aphid: *Lipaphis erysimi* (Aphididae:Hemiptera)

Distribution and status: Distributed worldwide and is a serious pest

Host range: Cruciferous oilseeds like toria, sarson, raya, taramira and Brassica vegetables like cabbage, cauliflower, knol-khol,.

Bionomics

They are louse like, pale-greenish insects abundant from December to March. During summer, it is believed to migrate to the hills. The pest breeds parthenogenetically and the females give birth to 26-133 nymphs. They grow very fast and are full-fed in 7-10 days. About 45 generations are completed in a year. Cloudy and cold weather (20°C or below) is very favourable for the multiplication of this pest. The winged forms are produced in autumn and spring, and they spread from field to field and from, locality to locality.

Damage symptoms

Both the nymphs and adults suck cell-sap from leaves, stems, inflorescence or the developing pods. Vitality of plants is greatly reduced. The leaves acquire a curly appearance, the flowers fail to form pods and the developing pods do not produce healthy seeds. The yield of an infested crop is reduced to one-fourth or one-fifth.

Management

1. Sow the crop early wherever possible, preferably up to third week of October.

2. Apply recommended dose of fertilizers.

3. Apply anyone of the following insecticides when the population of the pest reaches 50-60 aphids per 10 cm terminal portion of the central shoot or when an average of0.5-l.0 cm terminal portion of central shoot is covered by aphids or when plants infested by aphids reach 40-50 per cent. Foliar sprays - 625 - 1000 ml of oxydemton methyl 25 EC, dimethoate 30 EC, quinalphos 25 EC, malathion 50 EC; 940-1500 ml of chiorpyriphos 20 EC in 600-1000 L of water per ha depending on the stage of the crop.

Granular insecticides - 10 kg of phorate lO G, 33 kg of carbofuran 30 per ha followed by a light irrigation.

4. Conserve parasitoids *Ischiodon scutellaris* (Fabricius), *Diaeretiella rapae* M'Intosh (Braconidae) and *Lipolexis gracilis* Forester (Aphididae), predators *viz*., *Syrphus serarius* (Wiedmann) (Syrphidae). *Brinckochrysa scelestes* (Banks) (Chrysopidae), *Coccinella septempunctata* Linnaeus, *Menochilus sexmaculatus* (Fabricius) (Coccinellidae) and entomopathogens viz., E*ntomophthora coronata* and *Cephalosporium aphidicola.*

2. Painted Bug: *Bagrada hilaris* (Pentatomidae: Hemiptera)

Distribution and status: Widely distributed in Myanmar, Sri Lanka, India, Arabia and East Africa.

Host range: Crucifers, rice, sugarcane, indigo and coffee

Bionomics

The full-grown black nymphs are about 4 mm long and 2.66 mm broad. Sub-ovate, black adult bugs are 3.71 mm long and 3.33 mm broad with a number of orange or brownish spots. It is active from March to December and during this period all the stages can be seen. It passes the winter months of January and February in the adult stage under heaps of dried oilseed plants lying in the fields. These bugs lay oval, pale-yellow eggs singly or in groups of 3-8 on leaves, stalks, pods and sometimes on the soil. Eggs may be laid during day or night. A female bug may lay 37-102 eggs in its lifespan of 3-4 weeks. Egg period is 3-5 days during summer and 20 days during December. There are five nymphal instars with a duration of 22 -34 days. The entire life cycle is completed in 19-54 days and it passes through 9 generations in a year.

Damage symptoms

Both nymphs and adults suck cell sap from the leaves and developing

pods, which gradually wilt and dry up. The nymphs and adult bugs also excrete a sort of resinous material which spoils the pods.

Management

1. Give first irrigation 3-4 weeks after sowing as it reduces the bug population significantly.
2. Spray 1.0 L of malathion 50 EC or quinalphos 25 EC in 500- 600 L of water per ha once in October and again in March-April.
3. Conserve egg parasitoid *Gryon sp*. (Scelionidae) and the adult parasitoid *Alophora sp*. (Tachinidae).

3. Mustard Sawfly: *Athalia lugens* (Tenthredinidae: Hymenoptera)

Distribution and status: Widely distributed in Indonesia, Formosa, Myanmar and the Indian Sub-continent.

Host range: Mustard, toria (*Brassica campestris*), rapeseed, cabbage, cauliflower, knolkhol, turnip, radish, etc

Bionomics

Dark green larvae have 8 pairs of abdominal prolegs. There are five black stripes on the back, and the body has a wrinkled appearance. A full-grown larva measures 16-18 mm in length. The adults are small orange yellow insects with black markings on the body and have smoky wings with black veins. The mustard sawfly breeds from October to March and undergoes pupal diapause during summer. The adults emerge from these cocoons early in October. They live for 2-8 days and lay 30-35 eggs singly, in slits made with saw like ovipositors along the underside of the leaf margins. Egg period is 4-8 days and the larvae feed exposed in groups of 3-6 on the leaves during morning and evening. They remain hidden during the day time and, when disturbed, fall to the ground and feign death. There are 7 instars with a larval period of 16-35 days. Pupation is in water proof oval cocoons in soil and the pupal period is 11-31 clays. Lifecycle is completed in 31-34 days. It completes 2-3 generations from October to March.

Damage symptoms

The grubs alone are destructive. They bite holes into leaves preferring the young growth and skeletonize the leaves completely. Sometimes, even the epidermis of the shoot is eaten up. Although the seedlings succumb; the older plants, when attacked, do not bear seed.

Management

1. Give first irrigation 3-4 weeks after sowing as it reduces the bug population significantly. (ii) Spray 1.0 L of malathion 50 EC or quinalphos 25 EC in 500-600 L of water per ha once in October and again in March-April.
2. Conserve larval parasitoid *Perilissus cingulator* Morby (Ichneumonidae) and the bacterium, *Serratia marcescens* Bizio (Enterobacteriaceae)

4. Green Peach Aphid: *Myzus persicae* (Aphididae: Hemiptera)

Distribution and status: Throughout India

Host range: Mustard, peaches, beans, potato, tobacco, turnip, radish, etc

Bionomics

The aphids are minute (2.0-2.5 nun long), delicate, pear shaped, yellowish-green winged or wingless insects. It remains active from December to March with peak activity during February. The nymph undergoes 4-5 instars taking 4-7 days for apterous and 5-8 days for alate forms. Apterous adults produce 5-92 young ones per female while the alate forms produce 8-49 nymphs. Longevity of adult is 15-27 days for alate and 10-25 days for apterous forms.

Damage symptoms

Both nymphs and adults damage plants by actively sucking their sap. After the appearance of inflorescence, the aphid congregates on terminal buds and feeds there. As a result, there is flower shedding, poor-pod formation and shriveling of grains. The insect also transmits virus diseases. The honeydew attracts sooty mould.

Management

1. Sow the crop in first week of October.
2. Spray 500 ml of dimethoate 30 EC or 625 ml of oxydemeton methyl 25 EC in 750 L of water/ha when aphids start congregating on top flower buds. Only one spray is needed.

5. Pea Leaf-miner: *Chromatomyia horticola* (Agromyzidae: Diptera)

Distribution and status: Northern India

Host range: Cruciferous plants, antirrhinum, nasturtinum, pea, linseed *(Linum usitatissimum* L.) and potato *(Solanum tuberosum* L.).

Bionomics

The adults are two-winged flies having greyish black mesonotum and yellowish frons. It is active from December to April or May and is believed to pass the rest of the year in soil, in the pupal stage. The adults emerge at the beginning of December and after mating, start laying eggs singly, in leaf tissues. The eggs hatch in 2-3 days and the larvae feed between the lower and upper epidermis by making zig-zag tunnels. Maggot after 5 days pupates within the galleries. The adults emerge in 6 days and lifecycle is completed in 13-14 days. The pest passes through several broods from December to April-May. .

Damage symptoms

The large number of tunnels made by the maggots interferes with photosynthesis and proper growth of the plants, making them look unattractive. If the attacked leaves are held against bright light, the minute slender larvae can be seen feeding within the tunnels

Management

Spray 1.0 L of dimethoate 30 EC in 750 L of water per ha and repeat spray at 15 days interval. A waiting period of 20 days should be observed for picking of pods.

6. Bihar Hairy Caterpillar: *Spilosoma obliqua* (Arctiidae: Lepidoptera)

Distribution and status: Sporadic pest widely distributed in the Orient. It is very serious in Bihar, Madhya Pradesh, Uttar Pradesh and Punjab

Host range: Sesamum, mash (*Phaseolus mungo*), mung (*P. aureus*), linseed, mustard, sunflower and some vegetables.

Bionomics

The moth measures about 50 mm across the wing spread. Adults have crimson coloured body with black dots. Wings pinkish with numerous black spots. Larva is orange coloured with broad transverse bands with tuft of yellow hair that are dark at both end.Pest breeds from March to April and again from July to November. Adult female lays 400-1000 light green, spherical eggs in clusters on the underside of the leaves. Egg period 8-13 days. Larval instars 7 and period 30-56 days. Pupation takes place in plant debris or soil and pupal period 7-15 days. Adult lives for 7 days. Early instars are gregarious and later instars disperse in search of food.

Damage symptoms

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

Management

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

7. Cabbage butterfly: *Pieris brassicae* (Pieridae: Lepidoptera)

Distribution and status: Throughout India

Host range: cabbage, cauliflower, knol-khol and it may also attack turnip, radish, sarson, toria (*Brassica campestris*) and other cruciferous plants

Bionomics

Full-grown pale yellow larva becomes greenish and measures 40-50 mm in length. In adults, the wings are pale white, with a black patch on the apical angle of each fore wing and a black spot on the costal margin of each hind wing. The females have two conspicuous black circular dots on the dorsal side of each fore wing. Males are smaller than the females and have black spots on the underside of each fore wing.

In the Indo-Gangetic plains, this pest appears on cruciferous vegetables from October to April. From May to September, the pest is not found in the plains but breeding takes place in the mountains. The butterflies are very active in the field and lay, on an average, 164 yellowish conical eggs in clusters of 50-90 on the upper or the lower side of a leaf. Egg period is 3-17 days. The caterpillars feed gregariously during the early instars and disperse as they approach maturity. They pass through five stages and are full-fed in 15-40 days. The larvae pupate at some distance from the food plants, often in barns or on trees. The pupal stage lasts 7-28 days. The butterflies live for 3-12 days and the pest breeds four times during October-April.

Damage symptoms

The caterpillars alone feed on leaves, young shoots and green pods. When young, they feed gregariously but the grown-up caterpillars migrate from one field to another. The first instar caterpillars just scrape the leaf surface,

whereas the subsequent instars eat up leaves from the margins inwards, leaving intact the main veins. Often, entire plants are eaten up.

Management

1. When in the gregarious stage, the caterpillars can be easily controlled by picking and destroying the infested leaves.
2. The grown-up caterpillars should be controlled with malathion 5 per cent @ 37.5 kg per ha or 500 ml of dichlorvos 76 SC in 600-900 L of water per ha.
3. Conserve larval parasitoid *Apanteles glomeratus* (Braconidae) in the natural populations.

Minor Pests of Brassica Oilseeds

1. Diamond backmoth: *Plutella xylostella* (Plutellidae: Lepidoptera)
2. Jassid: *Empoasca binotata Pruthi* (Cicadellidae: Hemiptera)
3. Leaf webber *Crocidolomia binotalis* Zeller and Hellula undalis (Pyralidae: Lepidoptera)
4. Noctuid caterpillars: *Agrotis ipsilon*, *Mythimna loreyi* and *Helicoverpa armigera* (Noctuidae: Lepidoptera)
5. Flea beetles: *Phyllotreta crucifereae* and *Phaedon hrassicae* (Coleoptera : Chrysomelidae)
6. Leaf-miner: *Chromatomyia horticola* (Agromyzidae: Diptera)

LECTURE NO . 8 – P ESTS OF COTTON

I. Sap feeders and leaf feeders

1. Leafhopper – Amrasca devastans , Cicadellidae, Hemiptera

Distribution: All cotton growing region of India

Host of plants: Cotton, potato, brinjal, castor, bhendi, tomato, hollyhock and sunflower.

Symptoms of damage :

Both nymphs and adults sucks the plant sap from the under surface of leaves. Tender leaves become yellow. The margin of the leaves start curling downwards and reddening sets in. In the case of severe infestation leaves get a bronze or brick red colour which is typical "hopper burn" symptom. The margin of the leaves get broken and crumble into pieces when crushed. The leaves dried up and are shed and the growth of the crop is retarded.

Bionomics:

Adult is green, wedge shaped leafhopper. It lays eggs singly within leaf veins. Incubation period is 4-11 days. The nymph is light green translucent found between the veins of leaves on the under surface. The nymphal period is 7 days. The life cycle is completed in 15-46 days.

ETL: 50 Nos. / 50 leaves

Management

i. Use resistant varieties like MCU 3, MCU 5 and MCU 9
ii. Setup light trap to monitor the broods of leaf hopper to attract and kill
iii. Release predators viz . Chrysop erl a zastrowi silemi
iv. Early sowing and close spacing of cotton reduces pest infestation particularly if the rainfall is heavy
v. Spray monocrotophos @ 1000 ml/ha and NSKE 5% @ 25 kg/ha or 250 ml phosphamidon in 1000 lit of water per hectare

2. Cotton aphid – Aphis gossypii , Aphididae, Hemiptera

Distribution: India

Host plants: Cotton, bhendi, brinjal, chillies, guava

Symptoms of damage:

It is a potential pest on cotton infesting tender shoots and under surface

of the leaves. They occur in large numbers suck the sap and cause stunted growth, gradual drying and result in death of the plants. Development of black sooty mould due to the excretion of honey dew giving the plant a dark appearance.

Bionomics:

The aphids are greenish brown, soft bodied and small insects. The alate as well as apterous females multiply parthenogenitically and viviparously. A single female may give birth to 8-22 nymphs in a day which become adult in about 7-9 days. Yellowish or greenish brown nymphs found on the undersurface of leaves. They are often attended by ants for the sweet honey dew secretion. Winged forms may be seen under crowded conditions.

ETL: 5% of infested plants.

Management

i. Release biocontrol agents *viz.,* Coccinellid beetle *Monochilus sexmaculatus* and *Coccinella septumpunctata* and *Aphelinus mali*, *A. flavipes*. Predators – *Phylloscopus tristis*
ii. Monitor the nymphs and adults of early season sucking pests from the 14th day after sowing.
iii. Spray any one of the following insecticides / ha to control aphids. Methyl demeton 500 ml, dimethoate 500 ml/ha (spray fluid 500 l/ha)
iv. Spray monocrotophos @ 1000 ml/ha and NSKE 5% @ 25 kg/ha
v. Spray Pyraclofos 50 EC @ 1.5 l/ha

3. Thrips: *Thrips tabaci*, Thripidae, Thysanoptera

Symptoms of damage:

Both nymph and adult lacerate the tissue and suck the sap from the upper and lower surface of leaves and in cases of severe infestation they curl up and become crumbled.

Bionomics:

Adult is small, slender, yellowish to brown with fringed wings, nymphs is very minute, slender, yellowish and microscopic.

ETL: 50 Nos. / 50 leaves

Management

i. Monitor the nymphs and adults of early season sucking pests from the 14th day after sowing.

ii. Spray any one of the following insecticides / ha. Methyl demeton 500 ml: Dimethoate 500 ml/ha (Spray fluid 500 l/ha)
iii. Spray pyraclofos 50 EC @ 1.5 l/ha

4. Whitefly – *Bemisia tabaci*, Aleyrodidae, Hemiptera

Distribution: India, Sri Lanka, Nigeria, Congo, West Africa, Japan and Europe

Host Plants: Cotton, tomato, tobacco, sweet potato, cassava, cabbage, cauliflower, melon, brinjal and bhendi.

Symptoms of damage:

Nymphs and adults suck the sap from leaves at the under surface of leaves. Severe infestation results in premature defoliation, development of sooty mould, shedding of buds and bolls and poor boll opening. It also transmits the leaf curl virus diseases of cotton. The insect is highly polyphagous.

Bionomics:

Adult is minute insects with yellow body covered with a white waxy bloom. Eggs are laid on leaves. Egg period is three days. Nymph is greenish yellow oral in outline, along with puparia on the under surface of the leaves. Nymphal period is 5-33 days in summer, 17-73 days in winter.

ETL: 5-10 nymphs / leaf

Management

i. Use white fly tolerant varieties like LPS 141 and Supriya
ii. Timely sowing with recommended spacing, preferably wider spacing is essential and late sowing may be avoided.
iii. Avoid the alternative, cultivated host crops of the white fly in the vicinity of the cotton crop. Cultivation of brinjal, bhendi, tomato and tobacco near the cotton field may be avoided.
iv. Grow cotton only once in a year either in winter or summer season in any cotton tract.
v. Adopt crop rotation with non-preferred host such as sorghum, ragi, maize etc., to check the build up of the pest.
vi. Remove and destroy alternate weed hosts like *Abutilon indicum*, *Solanum nigrum*from the fields and neighbouring areas.
vii. Field sanitation may be given proper attention.
viii. Judicious irrigation management and nitrogenous fertilizer application may

be followed to arrest the excessive vegetative growth and pest build up.

ix. Monitor the activities of the adult white flies by setting up yellow pan traps and sticky traps at 1 foot height and also *in situ* counts.

x. Collect and remove white fly infested leaves from the plants and those which were shed due to the attack of the pest and destroying them.

xi. Spray NSKE 5% and neem oil 5 ml or fish oil rosin soap at 1 kg in 40 litres of water (or) in combination with recommended dose of insecticide (2 ml/litre of water) is found effective.

xii. Apply methyl demeton 500 ml/ha in the early stage. Quinalphos 2 l (or) phosalone 2.5 l/ha in the mid and early stage of the crop.

xiii. The use of the synthetic pyrethroids should be discouraged / minimized to 2-3 spraying in cotton to avoid the problem of whitefly.

xiv. Avoid repeated spraying of synthetic pyrethroids.

5. Red cotton bug: *Dysdercus cingulatus*, Pyrrhocoridae, Hemiptera

Distribution: Uttar Pradesh, Bihar, Bombay, Andhra Pradesh and Tropical Africa, Australia, U.S.A., Central and South America and India.

Host Plants: Cotton, Bhendi, Maize, Pearly millet, Holly hock, Clovers, Sorghum and Kapok.

Symptoms of damage:

The damage is caused by both nymphs and adults by sucking the sap of the plant as well as that of bolls and stain the tint. They are also, therefore, termed as cotton boll stainers. The bugs are gregarious in habit. Attacked seeds become worthless for sowing. The bacterium *Nematospora gossypii* enters the site of injury and stains the fibre.

Bionomics:

The adult is a red and black bug with stripes ventrally on the abdomen. The eggs are laid in loose masses in the soil. The fecundity of the bug is 100 - 130 eggs per female. The egg period is 4-7 days. The nymph undergoes six instars to become adult. The nymphal period lasts for 26 - 89 days. The adult bug undergoes hibernation (resting period) during winter months.

Management:

Biocontrol agent *Harpactor costalis* predaceous on nymph and adult

i. Since the pest feeds gregariously, the infested leaves or bolls can be shaken in water and drowned.

ii. Plough the field to expose the eggs.
iii. Dusting the infested crop with 10% BHC dust @ 25 kg/ha
iv. Spray 250 ml phosphamidon 100 EC

6. Dusky cotton bug – *Oxycarenus hyalinipennis*, Lygaeidae, Hemiptera

Symptoms of damage:

It sucks the sap from developing seeds in open bolls and stains the lint black. Seeds discoloured and shrunken.

Bionomics:

The adult is a small flat bug with dusky brown in colour. It lays cigar shaped, white eggs in clusters of 2-10 within the half opened bolls, on the bolls, flower or buds. The incubation period is 6-10 days. The nymph undergoes five instars. The nymphal duration occupies 30-40 days.

7. Mealy bug *Ferrisia virgata*, *Pseudococcidae, Hemiptera*

Symptoms of damage:

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

Bionomics:

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

8. Black scale – *Saissetia nigra*, Coccidae, Hemiptera

Symptoms of damage: Yellowing of leaves in isolated plants. Scales on twigs shoots and leaves.

Bionomics: Adult is oval and convex in shape. Young scale is pale in colour.

9. White scale: *Pulvinaria maxima*, Coccidae, Hemiptera

Symptoms of damage: Yellowing of leaves in isolated plants. Scales are found on twigs, shoots and leaves.

Bionomics: Adult is white in colour and convex in shape about 650 - 900 eggs are laid in an ovisac by a female scale. The egg period is 12-14 days. There are 6-7 generations in one year. The total life cycle occupies 6.5 - 8 weeks.

10. Yellow stem scale: *Cerococcus hibisci,* Asterolecanidae, Hemiptera

Symptoms of damage: Yellowing of leaves in isolated plants. Sales on twigs, shoots leaves.

Bionomics: Yellow star like appearance.

11. Stem weevil – *Pempherulus affinis,* Curculionidae, Coleoptera

Distribution: India, Burma, Thailand and Philippines

Host Plants: Cotton, Bhendi, Jute, *Abutilon inolicum, Hibiscus rosasinensis, Hibiscus cannabinus* and other malvaceous and tiliaceous plants.

Symptoms of damage:

The damage is caused by grubs which tunnel into stems. The stems if young are killed in a short time, otherwise on them develop prominent gall like swellings which are really weak points where the stem breaks if the winds are strong.

Bionomics:

It is a small dirty brown weevil measuring 1/8". It lays globular or oval shaped eggs singly in the cavities scopped out by the weevil at the nodal region of the plants. A female weevil lays eggs in an average of 50 eggs with a maximum 121 eggs. The egg period is 6-10 days. The grub feeds on stem tissues. The larval period lasts for 35-37 days. It pupates in pupal chamber. The adult may live for 25 - 30 days.

Management

i. The infested plants should be removed and destroyed
ii. Use resistant variety MCU 3 against stem weevil
iii. Apply carbofuran 3G at 30 kg on 20 days after sowing and earthing up.
iv. Apply farm yard manure at 25 t or 250 kg of neem cake/ha.

12. Shoot weevil – *Alcidodes affaber*, Curculionidae, Coleoptera

Symptoms of damage: Terminal shoots with galls. Bore holes are surrounded by raised margins.

Bionomics: The weevil is double greyish brown with pale cross bands on elytra.

13. Surface weevil: *Atactogastor finitimus*, Curculionidae, Coleoptera

Symptoms of damage: Adults cut the stem of seedlings at the time of germination under rainfed condition.

Bionomics:

It is a fairly large dark-grey weevil common in South India and causes some damage to young cotton in some years. It is more abundant in the field followed rains in October and November.

14. Tobacco Cutworm: *Spodoptera litura* Fabr. Noctuidae: Lepidoptera

Symptoms of damage

The first instar larvae feed gregariously on the leaf, on which the egg mass was laid by scrapping the epidermal layer, leaving the skeleton of veins. The skeletonised leaf may dry up. Then, the larvae move to other leaves and feed by making small holes. In later stages, they consume most of these leaf tissues and because of severe attack, only the stem and side shoots will be standing in the field without any leaf or bolls. Once squares, flowers and bolls are bored they prefer these better than leaves. They bore into them, feed on the internal content completely and cause shedding of squares and young bolls. This type of feeding is seen only during early morning hours and night, and during hot sunny hours the caterpillars will be hiding in the flowers or in the cracks of the soil. This pest is found to cause damage in all stages of crop growth, but fleshy green leaves should be present for egg laying.

Biology

Larva: Pale greenish with dark markings; gregarious in the early stages. Adult: Moth with wavy white markings on a brown forewing. Hindwings white with a brown patch along the margin.

Management:

i. Use of light trap to monitor and kill the attracted adult moths. Set up the sex pheromone trap Pherodin S.L. at 12/ha to monitor the activity of the pest and to synchronise the pesticide application, if need be, at the maximum activity stage.
ii. Growing castor along border and irrigation bunds.
iii. Removal and destruction of egg masses in castor and cotton crops.
iv. Removal and destruction of early stage larvae found in clusters which can be located easily from a distance.
v. Collection and destruction of shed materials.
vi. Hand picking and destruction of grown up caterpillars.
vii. Spray any one of the following insecticides per ha using, a high volume

sprayer covering the foliage and soil surface. Chlorpyriphos 20 EC 2.0 l/ha; dichlorvos 76 WSC 1.0 l; phenthoate 50 EC 2.0 l/ha; chlorpyriphos 20 EC and fenitrothion 50 EC 1.25 l and 625 ml respectively.

viii. Spraying Nuclear Polyhedrosis Virus at 1.5 x 1012 POB per ha.

ix. Spraying of insecticide should be done either in the early morning or in the evening and virus in the evening.

x. Use of poison bait pellets prepared with rice bran 12.5 kg, jaggery 1.25 kg, Carbaryl 50%WP 1.25 kg and water 7.5 litres. This bait can be spread in the fields in the evening hours so that the caterpillars coming out of the soil, feed and get killed.

15. Leaf roller *Sylepta derogata*: Pyrausidae, Lepidoptera

Larva is glistening green with dark head, rolls the leaf in the form of trumpets and remains inside. It is fastened by silken threads on marginal portion. In severe cases, defoliation occurs. Adult is a medium sized moth with wavy markings.

16. Semiloopers

Semiloopers	***Anomis flava***	***Xanthodes graelsi***	***Tarache nitidula***
Damage	Defoliation	Defoliation	Defoliation
Larva	Green with five longitudinal white stripes and red prolegs	Green with horseshoe markings and warts	Dark brown
Pupa	Leaf folds	In soil among the dry leaves	In leaf
Adult	Reddish brown wings with markings	Bright lemon yellow forewing with a lunar streak	Bright white wings with dark markings

17. Cotton Stem Weevil: *Pempherulu saffinis* Fab. (Curculionidae: Coleoptera)

Symptoms of damage:

The damage to cotton starts when plants are young and are about three weeks old. The grubs bite into the region between the bark and the main stem, resulting in swellings on the stem just above the ground level. Young plants are

invariably killed on account of the attack of the pest and the older plants that survive, lack vigour and strength, and when strong winds blow, these plants sometimes break at the nodes.

Biology

Grub: white, apodous. Adult: very small weevil; dark in colour with two small white patches on the elytra.

Management:

Soil application of Carbofuran 3 G at 30 kg or Aldicarb 10 G at 10 kg/ha, may be done on 20 days after sowing and earthed up. Basal application of FYM 25 t/ha or 250 kg/ha of neem cake.

II. Bollworms and stem weevil

1. Cotton Bollworms

Cotton bollworms are the most destructive group of insects found on cotton in all cotton growing areas of the world. There are three kinds of bollworms, viz., spotted bollworm, green bollworm and pink bollworm. Among the three, the spotted bollworm is the earliest to occur, as soon as the cotton plant is about 15 to 20 cm in height and continues to feed on bolls. The other two occur from square formation stage, and pink bollworm continues till picking of kapas and goes even to ginning mills.

a. Spotted bollworms: *Earias vittella* & *E. insulana,* (Noctuidae: Lepidoptera)

Symptoms of damage

In the beginning of the season, when the crop is a few weeks old, the small caterpillar on hatching out from the egg leads a free life for a few hours. Then it bores into top tender shoot, the portion of the shoot above the damage withers, droops and dries up, depending upon the locality upto 50 per cent of the crop may be damaged in this manner. When the squares and bolls begin to develop, these caterpillars move from the shoots and start damaging bolls by making conspicuous holes into them. The squares and small bolls injured by the larvae drop away from the plants. The developing bolls are also damaged and some of the damaged bolls fall to the ground. The infested bolls, which are not shed, are destroyed by the larvae eating the seeds and filling them with excrement. Such affected bolls may open prematurely and badly.

Biology

Larva: brown with dorsum showing a white median longitudinal streak; the last two thoracic segments and all the abdominal segments have two pairs of fleshy tubercles (finger shaped processes), one dorsal and the other lateral. *E. vittella* without finger shaped processes.

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

Symptoms of damage:

The caterpillars feed on leaves, squares, flowers and small bolls. When the squares, flowers and bolls are attacked, they feed the internal content completely by thrusting their head inside leaving the rest of the body outside. The damaged squares and young bolls drop away from the plants. The developed bolls and open bolls are not attacked.

Economic threshold level: 10% of affected fruiting parts or bolls

Biology

Adult: Brown coloured moth with a 'V' shaped speck on forewing and dull black border on the hind wing. Larva: Green with dark broken grey lines and dark pale bands. Shows color variation- greenish to brown.

c. Cotton pink bollworm: *Pectinophora gossypiella* (Gelechiidae: Lepidoptera)

Symptoms of damage:

The caterpillars feed on flower buds, flowers and bore into bolls. When they bore into flower buds, they feed on developing anther and style and occasionally on ovary. When they are found in flowers, the flowers do not open and give rosette appearance. The young bolls, when attacked, are shed after a few days, but the larger bolls remain on the plant. Seeds are destroyed and lint gets stained. The aperture through which they make their entry into the boll is closed, and it becomes difficult to differentiate between a healthy and infested boll.

Biology

Larva: varies in general color; young larva white and late instar almost black, brown or green to pale or pink with several dark and light alternating bands running the entire length. Adult: small moth, brown or dull yellow or olive grey with dark spots on the forewing.

INTEGRATED PEST MANAGEMENT

The intensive and indiscriminate use of insecticides for control of cotton insect pests lead to various problems at field level by the farmers and the farmers noticed that they were losing most of their cotton crop to bollworm especially by *Helicoverpa armigera.* Hence the concept of IPM was developed by the entomology department and work on this line was carried out intensively from 1960 onwards. The IPM technologies for cotton bollworms, tobacco cutworm, cotton whiteflies and in general for cotton insect pest management were standardised and recommended for adoption. Integrated ecology based pest management was given thrust by this department as a result or the outbreak of *Spodoptera litura* on cotton (1978-80) and whitefly *Bemisia tabaci* (1985*)* and cotton stem weevil, *Pempherulus affinis* (1988) were controlled by the development of IPM strategies specific for these pests. Need based application of safer insecticides formed an important part of the IPM and many selective insecticides were identified for insect control which were recommended to the farmers for adoption. Continued efforts on this line resulted in the recommendations of imidacloprid 70 WS at 7g/kg seed and imidacloprid 200 SL foliar spray at 100 ml/ha for sucking pests control in cotton during 2000. Intensive research by the entomologists resulted in development of an IPM package for cotton pest management which is being adopted by the farmers currently.

Integrated pest management of cotton pests

- Remove cotton crop and dispose off the crop residues as soon as harvest is over.
- Avoid staking of stalks in the field.
- Avoid ratoon and double cotton crop.
- Adopt proper crop rotation. Use optimum irrigation and fertilizers.
- Synchronise the sowing time in the villages and complete the sowing within 10 to 15 days.
- Grow one variety throughout the village as far as possible.
- Avoid other malvaceous crops in the vicinity of cotton crop.
- Timely earthing up and other agronomic practices should be done.
- Hand pick and burn periodically egg masses, visible larvae, affected and shed squares, flowers and bolls and squash pink bollworm in the rosettes.

- Use locally fabricated light traps (modified Robinson type) with 125 Watt mercury lamps to determine the prevalence of pests and their population fluctuation.
- The magnitude of the activity of the moths of the cotton pink bollworm, the cutworm (*Spodoptera litura*) and the American bollworm can be assessed by setting up the species-specific sex pheromone trap each at the rate of 12 per ha.
- Apply chemical insecticides only when it is absolutely necessary and when pest population damage crosses ET level.
- Intercropping with pulses viz., cowpea, greengram, blackgram and soybean reduce the population of sucking pests of cotton, viz., aphid and leaf hopper. Also, the bollworm incidence is low. Besides, the highest activity of natural enemies viz., spiders and predatory lady bird beetles are significant.

IPM for *Helicoverpa armigera*:

a. Monitoring:

Pest monitoring through light traps, pheromone traps and in situ assessments by roving and fixed plot surveys has to be intensified at farm level, village level, block level, regional and state levels. For bollworm, *H. armigera* management, an action threshold of one egg per plant or 1 larva/ plant may be adopted.

b. Cultural practices:

- Synchronised sowing of cotton preferably with short duration varieties in each cotton ecosystem.
- Avoiding continuous cropping of cotton both during winter and summer seasons in the same area as well as ratooning.
- Avoiding monocropping. Growing of less preferred crops like greengram, blackgram, soyabean, castor, sorghum etc., along with the cotton as intercrop or border crop or alternate crop to reduce the pest infestation.
- Removal and destruction of crop residues to avoid carry over of the pest to the next season, and avoiding extended period of crop growth by continuous irrigation.
- Optimise the use of nitrogenous fertilisers which will not favour the multiplication of the pest.

Judicious water management for the crop to prevent excessive vegetative growth and larval harbourage.

c. Biological control

Application of nuclear polyhedrosis virus (NPV) at 3 x 10 12 POB /ha in evening hours at 7th and 12th week after sowing.

Conservation and augmentation of natural predators and parasites for effective control of the pest.

Inundative release of egg parasite, Trichogramma spp., at 6.25 cc/ha at 15 days interval 3 times from 45 DAS egg-larval parasite, Chelonus blacksburnii and the predator Chrysoperla 1,00,000/ha at 6th, 13th and 14th week after sowing.

ULV spray of NPV at 3 x 10 12 POB /ha with 10% cotton seed kernel extract, 10% crude sugar, 0.1% each of Tinopal and Teepol for effective control of Helicoverpa.

NOTE: Dicofol, methyl demeton, monocrotophos and phosalone are comparatively safer to Chrysoperla larva recording low egg mortality.

d. Chemical con trol

Discourage the indiscriminate use of insecticides, particularly synthetic pyrethroids.

Use of proper insecticides which are comparatively safer to natural enemies such as phosalone, etc., at the correct dosage and alternating different groups of insecticides for each round of spray.

Avoiding combination of insecticides as tank mix.

Adopting proper delivery system using spraying equipments like hand compression sprayer, knapsack sprayer and mist blower to ensure proper coverage with required quantity of spray fluid and avoiding ULV applications.

Proper mixing and preparation of spray fluid for each filling of spray fluid tank.

LECTURE NO . 10 – P ESTS OF SUGARCANE

I. Borers and root feeders

1. Early shoot borer , Chilo infuscatellus , Crambidae: Lepidoptera

Symptom of damage:

Dead heart in 1-3 month old crop, which can be easily pulled out, rotten portion of the straw coloured dead-heart emits an offensive odour. A number of bore holes at the base of the shoot just above the ground level.

Bionomics

Larva: Larva is dirty white with five dark violet longitudinal stripes and dark brown head. Adult: Pale greyish brown moth with black dots near the costal margin of the forewings and with white hind wings.

Management

1. Resistant varieties: CO 312, CO 421, CO 661, CO 917 and CO 853!
2. Planting – December – January escapes the incidence
3. Intercrop: Daincha – low shoot borer incidence
4. Trash mulching : 10 – 15 cm thickness on 3 days after planting
5. Earthing up – 30th day
6. Ensure adquate moisture
7. Remove and destroy dead hearts
8. GV 1.1 x 105 twice on 35 and 50 DAP
9. Tachinid parasite: Sturmiopsi sinferens @ 125 gavid females ETL: 15 % dead heart
10. Whorl application: Carbaryl + sevidol (Lindane) 4 G 12.5 kg or Lindane 10 G 12.5 kg + 37.5 kg of sand / ha
11. Soil application: Carbofuran 3G 33 kg/ ha
12. Monocrotophos 36 SL 1000 ml or chlorpyriphos 20 EC 1000 ml / ha

2. Internode borer, Chilo sacchariphagus indicus; Crambidae: Lepidoptera

Symptom of damage: Internodes constricted and shortened, with a number of boreholes and fresh excreta in the nodal region. Affected tissues reddened.

Bionomics : Larva: White larva with four violet longitudinal stripes and light brown head. Adult: Pale brown with white hind wings.

Management

- Resistant varieties: CO 975, CO 7304 and COJ 46!
- Collect and destroy the eggs periodically
- Detrash: 150 and 210 DAP
- Avoid use of excessive nitrogen fertilizers
- Egg parasitoid: *Trichogramma chilonis* @ 2.5 m.l / ha – 6 releases – 4th month onwards at 15 days intervals
- Larval parasitoids: *Steno bracondeesae, Xanthopimpla nursei, Apanteles flavipes,*
- Pupal parasitoids: *Tetrastichus ayyari, Trichopilus diatraeae, Xanthopimpla stemmator*

3. Top borer, *Scirpophaga excerptalis*; Pyralidae: Lepidoptera

Symptom of damage:

Dead heart in grownup canes, which cannot be easily pulled; dead heart reddish brown in colour; parallel row of shot holes in the emerging leaves and red tunnels in the midribs of leaves; bunchy tip/top due to the growth of side shoots. Larva bores into the unfolded leaves (into the midrib) and mine their way to the base.

Bionomics

Larva: Smooth, white or cream coloured with a red coloured mid-dorsal line and yellow head. Adult: White coloured moth (with a buff coloured anal tuft in the abdominal tip of female).

Management

- Resistant varieties: CO 419, CO 745 and CO 6516!
- Tolerant varieties: CO 859, CO1158 and CO 7224
- Collect and destroy the egg masses
- Ichneumonid parasitoid: *Isotima javensis* @ 100 pairs/ ha (prepupal parasitoid)
- Egg parasitoids: *Telenomus beneficiens, Tetrastichus schoenobi, Trichogramma minutum*
- Larval parasitoids: *Goniozus indicus, Chelonus* sp.,
- Pupal parasitoid: *Tetrastichus ayyari*

SUBTERRANEAN PESTS

1. Termites, ***Odontotermes obesus*, Termitidae, Isoptera**

Symptom of damage:

Poor germination of setts (after planting), characteristic semi-circular feeding marks on the margin of the leaves in the standing crop. Entire shoot dries up and can be pulled out. Setts hollow inside and may be filled with soil. Cane collapses if disturbed; rind filled with mud.

Bionomics: Adult: Creamy coloured tiny insects resembling ants with dark coloured head.

Management

- Locate and destroy the termite colony!
- Fumigation: Aluminium phosphide 2 tablets / meter dia mounds
- Destroy the affected setts from the field
- Soil treatment: Lindane 1.6 D @ 50 kg / ha

2. Whitegrub, ***Holotrichia consanguinea*; Melolonthidae; Coleoptera**

Symptom of damage:

Drying of crown, preceded by yellowing and wilting of leaves. Affected canes come off easily when pulled. Cause extensive damage to roots.

Bionomics: Grub: Fleshy 'C' shaped, whitish yellow in colour found close to the base of the clump. Adult: Dark brown.

Management

- Set up light trap attract and destroy the adults!
- Provide adequate irrigation
- Crop rotation in endemic areas
- Collect and destroy the adult beetles – neem, Ailanthus and Acacia
- Lindane 1.6 D @ 50 kg /ha near the root zone

3. Root aphid, ***Tetraneura javensis*; Aphididae; Hemiptera**

Symptom of damage: Root colonized with aphids; movement of black ants.

Bionomics Adult: Spherical yellowish aphids.

Management

- Pull out the stunted plants and destroy them with root aphids!
- Mix dimethoate 30 EC @ 3 ml in one litre of water and drench the rhizosphere

II. Sap and foliage feeders

1. Whiteflies: *Aleurolobus barodensis,* Aleyrodidae: Hemiptera

Symptom of damage:

Yellowing of leaves, turn pinkish and later gradually dry. Infested leaves look white, while those below are black due to the growth of sooty mould on the honeydew.

Bionomics:

Nymph: Neonate nymphs are pale yellow in colour, flat and oval in shape, later turn shiny black. Its body is surrounded by fringes of wax. Adult: Pale yellow body with hyaline wings dusted with waxy bloom, exhibit brisk fluttering movements.

2. Whiteflies*: Neomaskellia bergii*, *Neomaskellia andropogonis*, Aleyrodidae, Hemiptera

Symptom of damage:

Black, grey or white dot like pupae on the undersurface of leaves.

Bionomics

Nymph: Oval in shape and brownish in colour. Their bodies surrounded by white wax. Adult: Pale brown with black bands on wings.

Management

- Avoid excessive use of nitrogenous fertilizers!
- Nymphal parasitoids: *Azotus delhiensis, Encarsia isacci*
- Predators: *Chilocorus nigritus, Scymnus nubilus*
- Fenitrothion 50 EC @ 2 lit or moncrotohphos 36 SL @ 2 lit /ha

3. Leaf hopper: *Pyrilla perpusilla*, Lophopidae: Hemiptera

Symptom of damage:

Yellow leaves, covered with black sooty mould; top leaves gets dried up and lateral buds germinate.

Bionomics

Nymph: Soft pale brown dorsally and pale orange ventrally with two characteristic anal filaments. Adult: Soft, straw coloured with the head pointing forward as snout. Wings fold over the abdomen like hood; they are densely veined and transparent.

Management

- Avoid excessive use of nitrogenous fertilizers!
- Set up light trap
- Detrash: 150 and 210th DAP
- Lepidopteran parasitoid: *Epiricrania melanoleuca*
- Predators: *Brumus suturalis, Chilomenes sexmaculatus, Coccinella septumpunctata*
- Malathion 50 EC 2 lit

4. Mealybug: *Saccharicoccus sacchari*, Pseudococcidae: Hemiptera

Symptom of damage:

Pinkish oval insects beneath leaf sheath on the nodes, with whitish mealy coating, main cane stunted also attack roots. Sooty mould develops on the plant.

Bionomics

Nymph: Newly emerged nymphs are quite active with a pinkish transparent body. Adult: White with mealy coating, sessile.

Management

- Use resistant varieties: CO 439, CO 443, CO 720, CO 730 and CO 7704!
- Detrash: 150 and 210 DAP
- Drain excess water
- Methyl parathion 50 EC @ 1000 ml or malathion 50 EC 1000 ml /ha

5. Scale insects*: Melanaspis glomerata*, Diaspididae: Hemiptera

Symptom of damage: Dark encrustations on the internode.

Bionomics

Nymph: Females multiply ovo-viviparously. The nymphs that hatch out from the eggs within the female's body come out through the genital aperture. They are called 'crawlers'. They settle after selecting suitable site for feeding.Adult: Greyish black or brown circular scales, they cover the nodal region forming a thick encrustation.

Management

- Use resistant varieties like CO 439, CO 443, CO 453, CO 671, CO 691 and CO 692!
- Select scale insect free setts

- Bunds free from weeds
- Avoid repeated rations
- Presoak the setts in 0.1% malathion solution!
- Avoid water stagnation
- Predators: *Chilcorus nigritus,Pharascymnus horni*
- Dimethoate 30 EC @ 750 ml or methyl demeton 25 EC @ 750 ml /ha – 120 and 150 day after detrashing

6. Sugarcane woolly aphid: *Ceratovacuna lanigera*, Aphididae: Hemiptera

Symptoms of damage:

Congregation of large number of white coloured nymphs and adults on the undersurface of the leaves, honeydew excretion with sooty mould on upper surface of the leaf. Canes with short internodes and narrow leaves with reduced girth.

Bionomics

Nymph: Alataenymphs yellowish white in colour with less powdery substance. Adult: Two forms of adult viz., apterate and alate occurs. Alate forms predominantly white in colour. Apterate often possesses crenulated margins of wax glands in rows. Such wax glands are absent in alate. *C. lanigera*reproduces parthenogenetically and has an holocyclic (absence of sexually producing generation) life cycle.

OTHER PESTS

1. **Black winged bug**, *Proutista moesta*; F: Derbidae; O: Hemiptera
2. **Aphid**, *Melanaphis sacchari*; F: Aphididae; O: Hemiptera
3. **Skipper,** *Telicota augias*; F: Hesperiidae; O: Lepidoptera
4. **Gurdaspur borer**, *Bissetia steniellea*; F: Crambidae; O: Lepidoptera
5. **Grasshopper**, *Oxya velox*; F: Acrididae; O: Orthoptera
6. **Spiny beetle**, *Asmangulia cuspidate*; F: Hispidae; O: Coleoptera
7. **Sugarcane mite**, *Schizotetranychus andrapogoni*; F: Tetranychidae; O: Coleoptera

LECTURE NO. 11 – GREEN MANURES-SUNHEMP, SESBANIA, DAINCHA, LUCERNE, SUBABUL AND GLIRICIDIA

I. SUNHEMP

1. Hairy caterpillar: *Utethesia pulchella,* Arctiidae: Lepidoptera

Symptom of damage: Defoliation of the plant. Larva feeds on leaves and also cause severe damage by feeding on the contents of developing pods.

Bionomics:

Larva: Hairy caterpillar with brown head. Yellow lines on the dorsal and dorso-lateral side with black stripes and orange patches. Body has long brownish hairs arising on warts. Pupa: Pupates in the soil. Adult: Red and black spots on the white forewings.

Management

- Set up light trap
- Fenthion 100 EC 1 ml or monocrotophos 36 SL 2 ml / lit of water

2. Hairy caterpillar: *Argina cribraria*, *Argina syringa,* Hypsidae, Lepidoptera

Symptom of damage: Defoliation.

Bionomics:

Egg: Yellowish eggs laid in clusters on the undersurface of the leaves.

Larva: Hairy caterpillar with black transverse markings and white spots.

Pupa: Pupates on the plant or the surface of the soil.

Adult: *A. cribraria* has black spots on yellowish wings. *A. syringa* has black spots on reddish brown wings.

3. Flea beetle: *Longitarsus belgamensis*, Alticidae: Coleoptera

Nature of damage:

Adult makes minute holes on leaves, grub feeds on the roots by mining.

Bionomics:

Egg: Laid in soil. Grub: Yellowish grub. Pupa: Pupates in earthen cells in the soil. Adult: Yellowish brown small beetle with enlarged hind femur.

4. Sunhemp mirid: *Ragmus importunitas,* Miridae: Hemiptera

Symptom of damage:

Minute chlorotic spots, later coalescing to cause yellowing of leaves.

Bionomics: Egg: Eggs laid singly into plant tissue. Adult: Greenish bug.

Minor pests

5. Stem borer, *Enarmonia tricentra*, Eucosmidae: Lepidoptera

6. *Etiella zinckenella*

II. SESBANIA AND DAINCHA

a. Borers

1. Sesbania stem borer, *Azygophleps scalaris*, Cossidae, Lepidoptera

Symptom of damage: Drying of sesbania plants. Stoutly built larva bores into the stem and feeds, the faecal matter getting accumulated at the entrance hole

Bionomics:

Egg: Laid in masses attached to the leaflets.

Larva: Robust larva of 7 cm length, light brown with a reddish brown head.

Pupa: Pupa has spines anteriorly with the help of which it moves up and down inside the tunnel in the stem.

Adult: Sluggish yellowish brown moth.

Management

- Neem seed kernel extract 5% or neem oil 2 %
- Carbofuran 3G at 1.5 kg a.i/ ha + 3 parts of sand – 20th & 50th DAS
- Splash water on the leaves
- Do not pluck the leaves for 40 days

2. Stem weevil, *Alcidodes bubo,* Curculionidae, Coleoptera

Symptom of damage:

Drying of the terminal branches or whole plant, lodging of the plants during monsoon seasons; affected stem with numerous bore holes and swelling symptoms. Presence of apodous grub inside the stem. Grubs riddle into stem and cause

thickenings on stem. The growth and vigour of the plants are impaired to a great extent.

Bionomics: Egg: Laid on the stem. Grub: Apodous whitish grub.

Adult: Reddish brown weevil with white transverse markings on the elytra.

Management

- Neem cake @ 500 kg / ha at the time of last ploughing
- Carbofuran 3G @ 30 kg or phorate 10 G @ 10 kg / ha

b. Leaf feeders

3. Green semilooper, *Pericyma glaucinans*, Noctuidae, Lepidoptera

Symptom of damage: Defoliation of plants preceding with leaflets damage. Caterpillar feeds on the leaflets remaining along the ribs of leaves.

Bionomics:

Larva: Pale green, semilooper with broad yellow lateral stripes.

Adult: Dark brown with black lines

Management

- Collect and destroy the grown up caterpillars
- Carbaryl 10 D @ 25 kg or malathion 5D @ 25 kg/ ha

4. Green looper: *Semiothisa pervelgata, Semiothisa emersaria*, Geometridae: Lepidoptera

Symptom of damage: Defoliation of plants preceding with leaflets damage.

Bionomics:

Egg: Oval greenish eggs laid singly on leaves.

Larva: Pale green looper with white lines and when full grown becomes pink with horizontal bands of violet patches dorsally on the abdominal segments.

Pupa: Pupates in the soil.

Adult: White colour with three dark lines and spots on the wings.

Management

- Collect and destroy the grown up caterpillars
- Carbaryl 10 D @ 25 kg or malathion 5D @ 25 kg/ ha

5. Brown looper: *Hyposidra succesaria*, Geometridae: Lepidoptera

Symptom of damage: Defoliation of plants preceding with leaflets damage.

Bionomics:

Egg: Deposited in clusters. Larva: Reddish brown in colour with spots.

Pupa: Pupates in soil. Adult: Reddish in colour with faint lines.

Management

- Collect and destroy the grown up caterpillars
- Carbaryl 10 D @ 25 kg or malathion 5D @ 25 kg/ ha

6. **Leaf webber: *Striglina scitaria*, Thyrdidae: Lepidoptera**

Symptom of damage: Webbing of terminal leaflets into conical structures. In the early stage the larva twists the terminal portion of the leaflet in the form of a small cone and lives inside scraping the green matter. As it grows, it webs together the leaflets and lives inside the tunnel of the web and ultimately pupates inside it.

Bionomics:

Egg: Laid in groups of 2-4 in a row on the edges of leaflets.

Larva: Greenish caterpillar with black head.

Pupa: Pupates within the leaf web itself.

Adult: Light brown moth with oblique lines on wings.

Management

- Collect and destroy the grown up caterpillars
- Carbaryl 10 D @ 25 kg or malathion 5D @ 25 kg/ ha

7. **Pierid butterflies: *Eurema hecabe var. contubernalis,* Pieridae: Lepidoptera**

Symptom of damage: Defoliation of the leaflets.

Bionomics:

Egg: White spindle shaped eggs laid singly on leaves.

Larva: Greenish caterpillar with white lateral lines.

Pupa: Chrysalis pupa attached to the stem with a girdle.

Adult: Yellow coloured butterfly with black margins.

8. **Mottled emigrant**: ***Catopsilia pyranthe,*** **Pieridae, Lepidoptera**

Symptom of damage: Defoliation of the leaflets.

Bionomics:

Larva: Greenish caterpillar with lateral yellow stripes and black dots.

Adult: Male forewing chalky white or greenish with apical and terminal black border. Female: Black markings broader than in male.

9. Semilooper: *Grammodes stolida*, Noctuidae: Lepidoptera

Symptom of damage: Defoliation.

Bionomics:

Larva: Velvety black larva with a row of red spots.

Adult: Forewing with a large black patch occupying the whole wing except the basal, coastal and outer areas. Hind wings with medial pale band.

Management

- Collect and destroy the grown up caterpillars
- Carbaryl 10 D @ 25 kg or malathion 5D @ 25 kg/ ha

c. Sap feeders

12. Stink bug: *Piezodorus rubrofasciatus* and *Cyclopelta siccifolia*, Pentatomidae: Hemiptera

14. Stink bug: *Brachyplatys vauhli*, Plataspidae: Hemiptera

15. *Coptosoma cribraria*

16. *Riptortus pedestris*

17. *Clavigrella horrens*

18. *Clavigrella gibbosa*

19. *Aphis craccivora*

FORAGE CROPS

IV. LUCERNE

1. Spotted alfalfa aphid: ***Therioaphis maculata*, Aphididae: Hemiptera**

Nature of damage: Nymph and adult suck the sap.

Bionomics: Adults yellow coloured aphids with series of spots.

2. Lucerne weevil: ***Hypera variabblis,* Curculionidae: Coleoptera**

Symptom of damage: Leaves with irregular holes. Affected plants remain stunted.

V. SUBABUL

1. Jumping lice: ***Heteropsylla cubana*, Psyllidae: Hemiptera**

Symptom of damage: Wilting of growing shoots resulting in die back; plants unable to put forth new growth. Honeydew deposition and sooty mould development.

Bionomics: Nymphs minute yellow. Adult: Pale greenish yellow.

LECTURE NO. 12 – ROLE OF PHYSICAL, BIOLOGICAL, MECHANICAL AND CHEMICAL FACTORS IN DETERIORATION OF GRAIN

Storage deterioration is any form of loss in quantity and quality of bio-materials. The major causes of deterioration in stored could be physical, biological, mechanical and chemical in nature. It is advisable to start storage with quality food product. Storage only preserves quality. It never improves quality. Product with initial poor quality quickly depreciates.

Physical factors:

Temperature (Heat): Atmospheric, grain and inter granular air temperature

Causes:

- Heat from external source (sun) due to unsuitable storage structures
    - False location
    - Insufficient shade
    - Poor ventilation facility
    - Lack of heat insulation
- Metabolic heat produced due to mass reproduction of storage pests and fungi
- High moisture content of the grain
    - Metabolic heat produced by the grain
        - Dry grain-$1x10^{-7}$ cal/sec/cm^3
        - Damp grain-$1.3x10^{-5}$ cal/sec/cm^3
- Lack of aeration of store

Effects

- Losses in weight and losses in quality (nutritional value, germination power)
- Improved conditions for pest development
- Condensation with subsequent development of fungi
- Loss in germination and vigor

Moisture (=Relative humidity)

Causes

- Insufficient drying before storage (high grain moisture)
- Effect of high relative humidity

- Constructional faults and damage to the store (unsuitable materials, unsealed floor, walls and roof, holes, gaps, etc.)
- Imbalances in temperature (eg. Day/night) in storage facility with subsequent condensation
- Produce stored on the floor or next to the walls
- Mass reproduction of pests

Effects

- Losses in quality and weight
- Development of fungi and formation of mycotoxins
- Improved conditions for the development of pests
- Swelling and germination of seeds
- Damage to storage structures

Biological factors:

Insect pest:

Causes of infestation:

- Cross infestation from neighboring lots or stores
- Migration from waste or rubbish
- Hiding places in stores (cracks, fissures)
- Use of infested bags
- Introduction of infested lots

Effects

- Losses in weight and quality (impurities such as droppings, cocoons and parts of insects, reduction of nutrition value, reduction in germination ability)
- Increase of temperature and moisture

Microorganisms:

Causes of infection

- High moisture content of stored produce
- High relative humidity in store
- Condensation
- Humidity and moisture produced by insects

Effects

- Loss of weight (mould) and loss of quality (smell, taste, color, nutritional value and germination power)
- Formation of mycotoxins
- Further increase in temperature and moisture
- Further condensation

Rodents

Causes of infestation

- Penetration through badly closing doors, windows, ventilation openings and holes
- Lack of barriers and lack of hygiene in store and surrounding area (possible breeding and hiding places)

Effects

- Loss of weight
- High loss in quality due to contamination of produce with faeces and urine
- Contamination of produce with pathogenic agents (typhoid, rabies, hepatitis, plague, etc.)
- Damage of material and facilities (bags, doors, electric cables)

Birds

Causes of infestation

- Open or broken doors, windows, ventilation openings and roofs

Effects

- Losses in weight and damage to bags
- Contamination of stored produce with droppings and pathogenic agents

Mechanical factors:

Mechanical damage and poor storage facilities

Causes

- Incorrect harvesting methods
- Poor handling, threshing, shelling, cleaning, sorting, drying

- Bad transport and loading practices (eg. Use of hooks)
- Defective storage facilities
    - No temperature insulation
    - No moisture proofing
    - No rat and bird proofing
    - Not disinfected

Effects

- Losses in weight and quality (nutritional value and germination power)
- Increased vulnerability to infestation from pests, fungi and rodents

Chemical factors:

Causes

- Chemical changes accelerated by
    - High temperature
    - High moisture
    - Development of microorganism
- Mycotoxins
- Pesticides
    - Insecticides-prophylactic treatment
    - Fumigants-curative treatment

Effects

- Degradation of nutrients
- Losses in weight and quality (germination power, nutritional value)
- Increased vulnerability to infestation from pests, fungi and rodents
- Pesticide residue

**** The interaction is more important than the factors alone***

**** The interaction of all these factors decide the fate of grain during storage***

LECTURE NO. 13 – STORED PRODUCT PESTS

Primary pests

I. Internal feeders

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

Symptoms

Presence of irregular holes of 1.5 mm diameter on grains of rice, sorghum, wheat, barley, maize before harvest and in store.

Biology

Grub: White, apodous with yellowish brown head. Adult: Small weevil reddish brown or chocolate colour to almost black and the elytra have 4 yellow spots.

2. Lesser grain borer: *Rhyzopertha dominica*, Bostrychidae, Coleoptera

Symptoms - Presence of round tunnel (1 mm) in grains and root crops.

Biology

Grub: White apodous with brown head. Adult: Dark brown beetle with head bent under the thorax and the posterior abdominal end blunt.

3. Cigarette beetle: *Lasioderma serricorne*, Anobiidae, Coleoptera

Symptoms

Circular, pin head sized bore holes on processed tobacco, wheat flour, cereal bran, peanuts, cocoa beans, cotton seed, spices and even insecticides containing pyrethrum, meat and fish meal, ginger, turmeric and chillies.

Biology

Adult: light brown round beetle with its thorax and head bent downward; gives the insect a humped appearance. Grub: Whitish hairy grub.

4. Drug store beetle: *Stegobium paniceum*, Anobiidae, Coleoptera

Symptoms

Circular pin-head sized bore hole on turmeric, coriander, ginger, dry vegetable and animal matter.

Biology

Adult: Reddish brown small beetle with striated elytra and clubbed antenna. Grub: Similar to cigarette beetle but not hairy.

5. Pulse beetle: *Callosobruchus maculatus* (*chinensis*), Bruchidae, Coleoptera

Symptoms

Pulse seed with round exit holes and cigar like eggs cemented on them.

Biology

Adult: Brownish grey colored beetle with truncate elytra, having elevated ivory like spots near the middle of dorsal side.

6. Tamarind beetle: *Pachymeres gonagra*, Bruchidae, Coleoptera

Symptoms- Circular holes on fruits of tamarind both in tree and storage.

Biology -Adult: Small grey colored beetle.

7. Sweet potato weevil: *Cylas formicarius*, Apionidae, Coleoptera

Symptoms

Grubs and adults bore into the tubers and make them unfit for consumption.

Biology

Grub: whitish apodous with brown head. Adult: slender ant like with a long snout and shiny black with reddish brown thorax and legs.

8. Angoumois grain moth: *Sitotroga cerealella*, Gelechiidae, Lepidoptera

Symptoms

Exit holes of 1 mm diameter with or without a trap door on the affected cereal grains especially of paddy, sorghum, maize, wheat, barley before harvest and also in store.

Biology

Adult: yellowish moth with pale forewings and uniformly grey; pointed hindwings with fringes of hairs.

9.Potato tuber moth: *Phthorimoea operculella*, Gelechiidae, Lepidoptera

Symptoms

Tubers bored by caterpillars associated with fungal or bacterial infection.

Biology

Larva: pale greenish. Adult: small moth with narrow fringed wings; forewings grey brown with dark spots and hindwings dirty white.

10. Arecanut beetle: *Araecerus fasciculatus*, Anthribidae, Coleoptera

Symptoms

Internal content is eaten leaving outer coat intact. Causes more contamination than the actual damage. Coffee, cocoa, spices, maize, groundnut, brazilnut, dried cassava roots and processed foods.

Biology -Adult: dark or grey brown beetle.

II. External feeders

11. Red flour beetle: *Tribolium castaneum*, Tenebrionidae, Coleoptera

Symptoms

Adult beetles are readily observed even in moderately infested stored foods. They construct tunnels as they move through flour and other granular food products. In addition they release gaseous quinones to the medium which may produce a readily identifiable acid odour in heavy infestations.

Biology

Adult: reddish brown, flat small beetle having eleven segmented antenna with a feebly differentiated club of 5 segments.

12. Khapra beetle: *Trogoderma granarium* (Dermestidae, Coleoptera)

Symptoms

Seed coat chewed up in an irregular manner on all cereals especially wheat, wheat products, oil cakes and peanuts.

Biology -Adult: reddish brown beetle.

13. Indian meal moth: *Plodia interpunctella*, Phycitidae, Lepidoptera

Symptoms

Dense webbing on the surface of affected products like dried fruits and vegetables cereals especially maize, farinaceous products, nuts and sweets.

Biology - Adult: Brown colored moth with a white band on forewings.

14. Fig moth: *Ephestia* (=*Cadra*) *cautella*, Phycitidae, Lepidoptera

Symptoms

Larval pellets webbed into the commodity by silk and silk strands on the surface of the commodity or the packages containing cereal grains, cocoa,

animal feeding stuff, nuts, spices, dried fruits, oilseeds, milled cereals, coffee beans, pulses, hides and skins.

Biology -Adult: small moth with greyish forewings.

15. Rice moth: *Corcyra cephalonica* (Galleriidae, Lepidoptera)

Symptoms

Dense webbing on peeled rice, maize, other cereals, milled products, cocoa beans, peanuts, cotton seeds and raisins.

Biology

Adult: moth with pale-yellowish green forewings and grey white hind wings.

Secondary pests

1. Saw toothed grain beetle: *Oryzaephilus surinamensis, Cucujidae, Coleoptera*

Symptoms –It feeds on grains, dried fruits, etc. by scarving of grain surface of burrowing holes in them. Generally it does not cause serious damage

Biology

Slender dark brown much flattened beetle has a row of saw like sharp teeth on each side of the prothorax.

2. Long headed flour beetle: *Latheticus oryzae*, Tenebrionidae, Coloeptera

Symptoms -Occurs as secondary infestation in stored sorghum, wheat, etc.

Biology

Resembles *Tribolium*. Head is longer in proportion to the body than that of *Tribolium*, paler and brighter than *Tribolium*.

3. Flat grain beetle: *Cryptolestes minutus*, Cucujidae, Coleoptera

Symptoms -Feeds on broken grains.

Biology -Similar to *L. oryzae*. Antennae long (about half the body length)

LECTURE NO. 14 – METHODS OF GRAIN STORAGE AND VARIOUS METHODS OF STORED PRODUCT PEST MANAGEMENT

Indoor storage structures

1. Indoor metal bin

Indoor metal bin is an improved storage structure developed by Indian Grain Storage Institute, Hapur (UP). This domestic metal bin is very useful in keeping grains and specially seeds. It is made up GI Sheet which protect the bin from rusting and increases its longevity. Metal bin is cylindrical in shape. It has inlet at top and outlet at the bottom.

2. Pucca kothi

Pucca kothi is primarily an indoor structure suitable for storage of low moisture content cereals. It can be constructed in different capacities and sizes. Each compartment is provided with an outlet. It can be constructed either on an elevated floor resting on brick masonry columns or with solid floor provided with a water proofing barrier.

3. Pusa bin

This structure is just a modification of an ordinary mud bin used in villages to provide moisture-proof and air-tightness. A polythene film of 700 gauge thickness has been embedded in bottom, all sides and top of the mud bin. The embedding process provides mechanical support and safety to polythene film. The Pusa bin is constructed from unburned bricks on a brunt brick or concrete floor to avoid rat burrowing. The bin can be constructed for storing different quantities of grain ranging from 1 quintal to 80 quintals. The inner layer of roof is covered with dried mud slabs, leaving only filling hole. The inner side of roof, top and outer sides of walls is plastered. A rectangular cover of the polythene made by heat-sealing is placed over the structure and the polythene edges are sealed.

4. Aluminium bin

Indoor aluminum bins have been designed and fabricated by IGSI, Hapur for domestic use. The aluminum bins are reasonably moisture proof, rat proof and air

tight. Periodical fumigation is necessary to keep the grain free from insect damage. The cost of the aluminum bin is more but are have longer life.

5. Circular steel bin (anaj kothi)

For storing small quantities of grain indoors up to 3 tonnes, circular steel bins are very convenient. Such bin has an opening at the top for filling and spouts at the bottom for taking out grain. It has a flat top and bottom made of plain M.S. sheets. Circular side is made of corrugate M.S.sheets. It is in 4-6 pieces which can be assembled on site. The bin is made air-tight by use of neoprene washers with bolts. Grain stored in the bin can be fumigated whenever required. Seeds also can be safely stored in this bin.

6. Plastic bin

This is a low cost structure suitable for indoor storage of all types of cereals, pulses etc. The grains can be taken out either from the top or through a sliding door at the bottom of the metal base. It is a stable and compact structure that can be dismantled when not in use. Erection and dismantling are easy.

7. Polythene plastic silos

This is an economical storage made up of high molecular weight plastic suitable for tropics. It weighs between 4.5 to 9 kg depending on the capacity and can easily be handled and transported. It is moisture proof and the food grains stored are easily fumigated.

Out-door structures

1. Flat bottom metal bin

This structure is available in five different capacities ranging from 20 to 50 quintals in terms of wheat. This module type bins are fabricated using 20 GI sheets. The designs are suitable for erection either on brick masonry base or on a pre-fabricated elevated steel base. The structure is suitable for storage of wheat, paddy, maize and pulses.

2. Hopper bottom metal bin

The hopper bottom type out door metal bins have different hopper angles to facilitate quick discharging of different commodities of food grains like wheat, paddy, and maize.

3. Kanak kothi

This is a fabricated steel bin with hopper bottom. This outdoor structure has a sloping roof and a manhole for filling and a hopper bottom with a sliding door for discharging of grain. Natural aeration is provided in the bin, which prevents the building of temperature gradient and consequent problems of moisture and deterioration of grains.

VARIOUS METHODS OF STORED PRODUCT PEST MANAGEMENT

Maintain store house hygiene

- Clean the store before stocking the seeds or grains.
- Clean the cracks, crevices and corners with a brush to get rid of the hiding insects.
- Prevent the entry of rats by rat-proofing (e.g. rat proof doors; wire meshes on to windows, ventilators, gutters, drains, etc.; plastering the cracks, crevices and rat holes on the walls and floor).

Reduce the moisture content of the seeds to prevent insect build up

- Bring down the moisture content to 10-2% by sun drying.
- Expose to the sun all the bags and bins that were used previously.

Eliminate conditions that favour storage pests

- Sieve off all broken grains before packing as broken grains favour pest build up. Loose bags should be filled or stitched to make them tight.

Surface treatment of the store house before storage

Treat the walls, ceiling and floor of the empty store rooms or godowns with any one of the following chemicals before the bags are stocked:

Malathion 4D 25 g/sq.m or Malathion 50 EC 10 ml/litre of water and 3 litres of spray solution per sq. m. or DDVP 76 SC 7 ml/litre of water and 3 litres of spray solution per 100 sq. m.

Follow proper methods of storage to minimize insect infestation

- Provide proper dunnage (wooden blocks or bamboo poles) or spread thick polythene sheets on the floor.
- Treat the dunnage materials with one of the above chemicals suggested for surface treatment.
- Arrange one layer of bags length-wise and the next layer of bags breadth-wise without touching the walls.
- Leave a gangway or alley of 0.75-1 metre around and at convenient intervals for inspection, aeration, prevention of moisture seepage and for fumigation and chemical spraying, if necessary.
- Arrange the bags only up to 15 bag high or as specified.
- Leave adequate space between the roof and the top layer of the bags.
- Stack the bags containing different seeds or grains separately.

Prophylactic treatment of seeds/grains and bag surface

- If the produce is meant for seed purpose, mix 1 kg of activated kaolin or malathion 5 D for every 100 kg of seed and pack in gunny or polythene lined bags.
- If the produce of cereals is meant for grain purpose, mix kg of activated kaolin for every 100 kg of grain, and store mix activated kaolin at the above dosage or any one of the edible oils at 1 kg for every 100 kg to protect the pulses grains, or 1 kg of neem seed kernel for every 100 kg cereal or pulse.
- Apply one of the following pesticides at the specified dosage over the bags.

Malathion 5% D	25 g per sq. m.
Malathion 50% EC	10 ml per litre of water and 3 litres of spray solution per 100 sq. m.
DDVP 76% SC	7 ml per litre of water and 3 listres of spray solution per 100 sq. m.

- Mix no synthetic insecticides with the grains which are meant for consumption.

- Treat the alleys or gang ways with one of the following chemicals:

  Malathion 50% EC 10 ml/litre of water

  DDVP 76% SC 7 ml/litre of water

  Apply one litre of spray solution for every 270 cu. m. or 10,000 cu.ft.

  The chemicals have to be sprayed on the walls and floors.

Monitor the pest population at periodical intervals

- Draw samples of seeds or grains at fortnightly interval and classify the infestation as follows based on insects found per 1 kg of sample.

When there is no pest	Free
Up to 2 insects	Mild
More than 2 insects	Severe

- Spear probe sampling is the traditional method developed for use with bagged grains. The spear probe (also called spear, probe, trier, or thief) is often a piece of hollow bamboo stem.
- In vacuum sampling, the vacuum samplers are used to take samples at different depths from bulk grains.
- Trapping is another method that relies upon the mobility of insect e.g. light traps, sticky traps, pheromone traps, suction traps, water traps, pitfall traps and bait bug traps
- Decide the need for shed fumigation (entire store house or godown) or cover fumigation (only selected blocks of bags).
- Check the store houses/godowns and the black polythene sheets or rubberized aluminium covers for holes and get them ready for fumigation.
- Choose the fumigant and the requirement based on the following guidelines:

i) <u>Aluminium phosphide</u>

a. For cover fumigation 3 tablets of 3 grams each per tonne of grain

b. For shed fumigation 21 tablets of 3 grams each for 28 cu. metres.

c. Period of fumigation 5 days.

ii) <u>Ethylene dibromide</u>

a. Shed fumigation 22 grams per cu. m.

b. Small fumigation 3 ml per quintal of grain

c. Period of fumigation 7 days

d. Not to be used for oil seeds, moist grains and milled products.

- In case of cover fumigation get ready the clay or red earth plus water a paste for plastering all around fumigation cover or sand snakes.
- Infect the required number of aluminium phosphide tablets in between the bags in different layers
- Cover the bags should be covered immediately with fumigation cover.
- Plaster the edges of cover all round with wet red earth or clay plaster or use sand snakes to make it leak proof.
- The bags are kept airtight for a period of 5 or 7 days under fumigation based on the fumigant chosen.
- Remove the mud plaster after specified fumigation period and lift the cover in a corner to allow the residual gas to escape. Lift the cover after a few hours.
- Follow similar steps to ensure leak proof condition, fumigation period, aeration etc., in case of shed fumigation also.
- Fumigants are used for curative treatments and they have no residual action on new immigrant insects which can infest grains.
- Sample the grains periodically and fumigate the stored materials based on the need. Fumigants should be handled with utmost care as per specifications.

Fumigation methods

A fumigant is a chemical which at a required temperature and pressure can exist in the gaseous state in sufficient concentration to be lethal to a given organism. Fumigants are absorbed by the insect in a molecular state. Fumigants are widely used in storage.

Mode of action

In agricultural fumigation the process of insect control is by biochemical blocking of the passage of oxygen through interference of toxic fumes (gas) on the respiratory enzymes and this process is termed anoxia. Therefore, the atmospheric air enters the breathing system of the insect but cell to cell transport of oxygen is inhibited.

Commonly used fumigants

Acrylonitrile, carbondisulphide, carbontetrachloride, chloropicrin, ethylene dibromide, ethyleneoxide, ethylenedichloride, hydrogencyanide, methyl bromide, Phosphine.

Application of fumigants

Fumigants may be applied under different conditions. Fumigants may be gaseous at ordinary temperature but may be liquid or solid at the ordinary temperature.

- Sprinkling
- Open space method
- Pot method
- Impregnated discoids
- Spraying of fumigants
- Dry method
- Ampules

For Home and farm storage

a) Grain in air-tight receptacles

EDB ampules for quantities up to 5 tonnes. For quantities exceeding 5 tonnes aluminium phosphide tablets is to be used. Exposure in either case should not be less than a week.

For commercial storage

a) Grain in sack

In case infestation is localised, fumigate under cover with either methyl bromide or aluminium phosphide. For methyl bromide a dose of 48 mg/ l for exposure of 24 hours or 24 mg/1 for 48 hours is recommended. For aluminium phosphide minimum exposure is of 5 days.

When infestation is widespread and shed can be made fairly airtight, shed fumigation with EDB @ 32mg/l or aluminium phosphide @ 1.5 tablets of 3 gram each per tonne with an exposure period of 7 days is suggested. Better mortality is obtained, if

stacks are spread with malathion prior to fumigation or DDVP is used immediately after introduction of the fumigants.

b) Milled products in sacks

Fumigation to be undertaken for under cover is double the dosage of those used for grain. Use of methyl bromide for fumigation of mill product can lead to presence of off-odours after fumigation and this should be ascertained before use of methyl bromide.

c) Grain in bulk

i) Silos or bins

Ethylene dibromide is released on empty sacks on top @ 24mg/l or aluminium phosphide tablets @ 1.5 tablet per tonne, with no aeration after fumigation for a period of 7 days. In case, recirculation of air is possible, aforesaid doses can be reduced by 25 per cent and fumigation period by 90 per cent.

ii) Bulk in shed

Fumigation either with ethylene dibromide or aluminium phosphide @ 24 mg/l and 1.5 tablets per tonne respectively has to be made.

LECTURE NO. 15 – MITES, SLUGS AND SNAILS, RODENTS AND BIRD PESTS

I. MITES

1. The Rice Mite, *Oligonychus oryzae,* Tetranychidae

- It has now become a serious problem in Tamil Nadu.
- The greenish mites occur on the undersurface of leaves in nurseries and transplanted crops.
- Plants show characteristic whitish patches on the leaf surface with different stages of mites and webbings.
- The infested leaves may start drying. In severe moisture stress conditions, the entire crop may be affected/destroyed.
- It may cause loss in yield is about 25%.

Life cycle

Adults lay spherical straw-coloured eggs singly in rows along leaf midribs and veins. Eggs hatch in 4-9 days. This is followed by the three immature stages: larva, protonymph and deutonymph. Life cycle is very short during hot weather.

Management

- Follow crop rotation.
- Though there are a good number of mite-predators and insect-predators in nature to balance these mites, these predators are destroyed by the pesticides that are being used. Hence overuse of pesticides may be avoided
- The chemicals that are recommended for control of mites are:

Wettable sulphur @ 2.0g/litre or Dicofol @ 2.5 ml/litre or Profenophos @ 0.5 ml/litre

2. The jowar mite, *Oligonychus indicus,* Tetranychidae

- It is a major and serious pest of jowar in Tamil Nadu causing considerable damage. The greyish green mite is found in large number on the under surface of leaves.

Damage symptoms

- Formation of characteristic red blotches on the leaves
- Devitalisation of plants.

- The nymphs and the female adults suck the sap.
- Injured leaf shows characteristic red spots or patches which enlarge and coalesce making the whole leaf reddish and distinguishable even from a distance.
- In case of a heavy attack eaves and stem dry up resulting in considerable crop losses.
- The mites attack sugarcane and banana also.

Life cycle

- The life cycle of a tetranychid mite consists of an egg, three nymphal and an adult stage. The nymphal stages are called the protonymph, deutonymph and tritonymph. The protonymph, also called larva, has only three pairs of legs and for the absence of genital openings, they resemble the adults.
- The mite spins delicate webs on the lower surface of the leaf and lives inside the web. Though all stages are capable of spinning the web, it is usually the females which do the job. The mite is able to complete about 30 generations in a year.
- A female lays about 80 spherical, white eggs during her life-time. Egg stage lasts for 3 or 4 days.
- The emerging larva is six-legged and light amber coloured but later becomes elongate and greenish. The larval and nymphal stage lasts for three to eight days. Life cycle completed within 19 days.

Management

- Avoid monoculture. Include non-host intercrops.
- Dispose of the first attacked leaves.
- Some of the predatory mites provide an effective control over the phytophagous mites by voraciously feeding on them. The example is *Amblyseius longispinosus*.
- The insects which are voracious feeders on mites are coccinellid beetles *Brumus suturali*, *Scymnus gracilis* and *Stethourus pauperculu, Scolothrips indicus* (Thripidae), *Chrysopa* sp., anthocorid bug *Orius tantilus* and Lygaeid bug *Geocoris* sp. Of these *Scymnus gracilis* has been found to be very effective

against the jowar mite Oligonychus indicus in south India, feeding upon eggs, larva, and nymphs of this mite.

- ETL is 5 mites/cm^2 of the leaf area.
- Spray dicofol (Kelthane) 18.5 EC 600 ml / acre. It is a long lasting acaricide, non phyto-toxic, and active against all stages of mites.

3. The red gram eriophyid mite, *Aceria cajani,* Eriophyidae, Acarina

- This mite is the vector of sterility mosaic disease of red gram in India, one of the most series diseases of red gram.
- Mite infestation on the underside of the tender leaves causes yellowing of leaves and suppression of flowering and fruiting in redgram.
- The disease and mite incidence in south start from the month of October and the mite population increased (20/leaf) in February-March on ratoon crop. In northern India mite population is very high during the month of May and June.
- The eriophyid mite is about 0.2 mm long and microscopic.
- The mite can complete a generation by less than 2 weeks under optimum condition.
- The mite incidence in red gram was severe at 135 days after sowing.
- The mite is persistant and circulative.

Symptoms

- The common symptoms are reduction of leaf size, bushy growth of plants. The leaves develop yellowing in mosaic pattern and undersurface of leaf becomes velvety to touch.
- Flower formation does not take place and even if formed they wither and fall off and consequently no yield is obtained.
- Incidence of mite and disease appear 45 days after sowing.
- The mite population is more on the young leaves and buds compared to that of the middle leaves. A larger number of mites occur on top canopy compared to the middle and bottom canopy.

Management

- Rogue out the infected plants or plant parts to minimize the attack in the early stages of growth.

- Grow lines resistant or less susceptible to the pest and the disease.
- Avoid staggered sowing.
- Adjust the sowing dates. In Tamil Nadu crops sown in August and later had more incidence as compared to crop sown in June.
- Avoid monoculture. Raise non-host intercrops.
- The following plants serve as alternative hosts. Therefore they may be removed or destroyed: *Albizia odoratissim* (Mimosaceae), *Coculum hirsutum* (Menispermaceae), *Bauhinia recemosa* (Caesalpiniaceae), *Casesalpinia* sp. (Caesalpiniaceae), *Tephorosia* sp. (Fabaceae), and *Desmodium* sp. (Fabaceae).
- Spray monocrotophos 200 ml/acre on noticing initial symptom. Repeat after 15 days dicofol 600 ml/acre.

II. Slugs and Snails

Identification and biology

Both snails and slugs are members of the mollusk phylum and are similar in structure and biology, except slugs lack the snail's external, spiral shell. These mollusks move by gliding along on a muscular "foot." This muscle constantly secretes mucus, which facilitates their movement and later dries to form the silvery "slime trail" that signals the presence of either pest.

All land slugs and snails are hermaphrodites, so all have the potential to lay eggs. Adult brown garden snails lay an average of 80 spherical, pearly white eggs at a time into a hole in the soil. They can lay eggs up to 6 times a year, and it takes about 2 years for snails to mature. Slugs reach maturity after about 3 to 6 months, depending on the species, and lay clear, oval to round eggs in batches of 3 to 40 beneath leaves, in soil cracks and in other protected areas.

Snails and slugs are most active at night and on cloudy or foggy days. On sunny days they seek hiding places out of the heat and bright light. Often the only clues to their presence are their silvery trails and plant damage. In areas with mild winters snails and slugs can be active throughout the year.

During cold weather, snails and slugs hibernate in the topsoil. During hot, dry periods or when it is cold, snails seal themselves off with a parchment like membrane and often attach themselves to tree tunks fences, or walls.

Damage:

Snails and slugs feed on a variety of living plants and on decaying plant matter. They chew irregular holes with smooth edges in leaves and flowers and can clip succulent plant parts. They also can chew fruit and young plant bark. Because they prefer succulent foliage or flowers, they primarily are pests of seedlings and herbaceous plants, but they also are serious pests of ripening fruits that are close to the ground such as straw berries and tomatoes. They also will feed on foliage and fruit of some trees; citrus are especially susceptible to damage. Look for the silvery mucous trials to confirm slugs or snails caused the damage and not earwigs, caterpillars, or other chewing insects.

The Giant African snail, *Achatina fulica,* Gastropoda: Mollusca

- It is a native of East from where it has spread or deliberately taken to other parts of the world. It has now become established in many countries including India, where it is seen mainly in west Bengal, Assam, Bihar, Orissa, Kerala and Tamil Nadu and in Andaman.
- The snail is active in the rainy season. During night it comes out of its hiding places and destroys many vegetables, ornamental plants and fruit crops. It also feeds upon dry yellow leaves and bodies of dead snails of its own species.
- The snail is large in size, bisexual weighing about 250 g. The shell is about 7 to 15 cm long, chestnut brown in colour.
- Two to four weeks after mating the snail lays egg in the soil surface or just below it in batches up to 200 at a time. They hatch after about a week in the rainy season. The young ones take about nine months to mature. The adults live for three to nine years and each can lay about 100 eggs during its life time.

Management

- The snail is kept in check by the hermit crabs which kill and eat the snail and occupy its shell.

- A predatory millipede *Orthomorpha* sp. inactivates the snail and eats it. Two exotic predatory snails *Englandina rose* and *Gonaxis quadrilateralis* can be introduced for biological control of this snail.
- During off season the hiding places of the snail can be searched and the snails collected and destroyed.
- During the rainy season moist gunny sacks or leaves can be heaped near the cropped areas and the snails that collect under these can be gathered next morning and killed.
- Among the chemicals **metaldehyde** is the most effective molluscicide and 5% pellets of this compound are spread over the field. It acts as a specific attractant toxicant. It is toxic by ingestion and absorption by the food of the snail. It increases in the secretion of slime resulting in immobilization and ultimate death by desiccation.

  The snails *Helix* spp. attack seedlings of various plants during nights and *Limax* spp. feed on leaves and young stems of various crop plants.

III. Rodents

Rodents constitute the largest order of existing mammals. Management of rodents is a very intricate as well as a ticklish problem. Rodents infest an area throughout the year as compared to other pest which appear sporadically only for short period in certain seasons. Rodents continue to damage standing food crops and stored food grains.

Important specieses

House rat, Rattus rattus

Large bandicoot, *Banicota indica*

Lesser bandicoot, *B.bengalensis*

House mouse, *Mus musculus*

Field mouse, *M.booducus*

Gerbil rat, *Tatera indica*

Rats

Rats are among the most destructive pests of paddy in the field causing about 5 to 10 per cent damage. A number of vegetables and groundnut, pulses, sugarcane,

cotton boll, finger millet, seasamum and tender coconuts in the field and also stored grains in warehouses and store rooms are damaged by rats and mice. All species eat paddy at all stages of its growth. Presence of standing water does not deter them since many of them are able swimmers. Later is the crop growth, they cut off earheads and carry the grains to their burrows.

It has been estimated that there are about 2500 million rats in our country. It is easy to realize the amount of damage these animals, with such enormous population coupled with an equally enormous rate of their multiplication, are capable of inflicting upon many of our cultivated crops and crop produces in store houses.

Four species of rats and mice are important pests of cultivated crops in the field in Tamil Nadu.

1. The lesser bandicoot, mole rat or field rat, *Bandicota bengalensis*

The mole rat is dark greyish brown in colour with a greyish white belly and a bare tail; head and body 15 to 23 cm and tail 15 to 18 cm long. It makes large ramifying burrows in soil extending to a depth of 1 to 1.5 m and laterally 9 to 12m; the burrow along its course is provided with many walls or earthern blocks for protection. There are 4 or 5 openings for the burrow; the entrances are protected by heaps of excavated soil. Separate chambers for bed, breeding and food storage are provided in the burrow. It usually lives alone, one in a burrow. It feeds upon grass, grains and tubers and damage to rice crop is considerable in Tamil Nadu. The rat reproduces thrice a year synchronizing with rice harvests. The number of young produced per litter varies from 2to 18 depending upon the food supply. In rice it appears late in the cropping season and damages the crop most severely. It shot blade stage it cuts tillers and the affected area is seen as circular patches in a field. The rat revisits the same area next night and spread the damage. It cuts earheads and carries to its burrow and in a burrow up to 2 kg of hoarded grains can be noticed.

2. The grass rat, *Millardia meltada*

The grass rat is smaller in size, dark brownish grey above and pale grey below with soft fur. Head and body is about 13 cm long and tail 10 cm long. The burrows of the grass rat are similar to that of the mole rate excepting that they are smaller in length and diameter and that usually more than one adult rat occupies a single

burrow. One to 12 young are produced per litter. It attacks rice in all stages and feeds upon young germinating grains, cuts and feeds on tender seedlings and also grown up plants in the shot-blade stage. It damages green cotton bolls in black cotton soils.

3. The gerbil rat, *Tatera indica*

The Indian gerbil rat is reddish grey in colour with white underside and it equals the common house rat in size with about 18 cm long head and body and hairy tail little longer than the head and body. It generally feeds on grains, grass, roots and fruits.

4. The Indian field mouse, *Mus booduga*

The body of the Indian field mouse is about 5 to 8 cm long with 5 cm long tail. It is brown in colour with a white belly. It burrows in field bunds causing extensive damage to bunds to wastage of water. It produces 3 to 9 young ones per litter. It cuts and removes grains from rice crop.

5. The common rat, *Rattus rattus*

The common rat, *Rattus rattus* is reddish or yellowish brown with a pure white belly. It is destructive to tender coconuts. It lives and breeds inside nests specially constructed in the crowns of the plains. It closely planted gardens it can jump from palm to palm. It bites holes through the husk and drinks the sweet liquids; spoilt nuts fall down in large numbers.

Integrated Rodent Management

The poisons used for the control of rodents are either acute poisons (single dose and quick acting) or chronic poison (multiple dose and slow acting). A rodenticide must have three ideal attributes- toxicity, acceptability and safety in use. The acute poisons are better for giving a quick knockdown, but they have little selectivity and poor efficacy. They require pre baiting as rodents develop bait shyness for them. Anticoagulants have advantage as for as efficacy and safety are

concerned, but are slow in action, more laborious and hence the treatment cost is comparatively higher.

RODENTICIDES

Zinc Phosphide

It is a greyish black powder having garlic odour of phosphine. Its toxicity is due to the evolution of phosphine gas from the molecule. Zinc phosphide baits are stable in air and non-acidic media, but when ingested, the acid present in stomach releases phosphine gas, which produces necrotic lesions and kidney damage causing death from heart failure. Death may occur within two hours of bait intake. It should not be used at a concentration above 2 per cent that may reduce the bait acceptability and increase poison aversion. Zinc phosphide is equally toxic to man, animals and poultry. Hence, dead rats should be removed from the field immediately.

Anticoagulant rodanticides

Warfarin was the first compound developed. Bromadiolone was first registered in India and is in use since 1988. Anticoagulants constitute more than 95 per cent of total rodenticide usage.

Multidose anticoagulants

Warfarin and fumarin are used at 0.5 per cent concentration as fresh baits.

Singledose anticoagulants

Bromadiolone used as fresh bait (0.25%) ready to use bait (0.005%).

Plant products

Certain plant products were known to cause anti fertility effects (*Gloriosa supeprba, Cannabis sativa, Calotropis gigantia, Azadirachta indica)*

Traps and trapping

Live traps: Pot trap and wonder trap are some of the live traps in use.

Kill type: Tanjore trap, arrow trap, bamboo trap, stone trap and break back (snap trap) are some of the kill type traps. Tanjore trap is used in the wet land rice fields. Break-back is used commonly in all places. Glue boards are newer type where small boards (22 x 17.5 cm) are plastered with polybutanes and thickener for indoor use.

Owl perches may be setup in the fields to reduce the menace of rats

A. FIELD:

1. Dig burrows and kill rats at the beginning of crop season while rectifying bunds for cultivation and plan to have narrow bunds in the field which are inadequate for the rats to construct burrows.
2. Avoid keeping hay stacks near the fields as they provide excellent harbourage for rats.
3. Set up indigenous, local rat traps like bow traps at the rate of 20 to 25 per acre.
4. When rat infestation are widespread, use an acute or single dose poison like zinc phosphide.
5. Immediately followed by the baiting with a multidose or chronic anticoagulant rodenticide: Food material 450 gm, any edible oil 10gm, powdered jiggery 15gm, anticoagulant rodenticide like warfarin 0.5% @ 25 gm or bromadiolone 0.25% @ 10gm continue the baiting process with anticoagulants until the rat damage becomes negligible.
    a. Prepare the bait material with the local food material preferred by the rats: Food material 97gm any edible oil 1gm, zinc phosphide 2gm.
    b. Before providing the poisoned zinc phosphide, keep the plain or non-poisoned bait for two or three days to make the rates used to the food provided. Provide such bait stations in about 10 places in an acre. Make sure that the rats have started accepting the plain food and replenish with more food.
6. During the process of baiting with rodenticides, the rats can also be controlled by fumigating the burrows with aluminium phosphide pellets.
    a. Plug the entry holes of all rat burrows in the afternoons.
    b. On the next morning, locate the burrows which have their entrance opened by the rats and insert two pellets each of 0.5 or 0.6 g of aluminium phosphide per burrow. Insert the pellets as deep into the burrow as possible and plug the entrance with a mud ball. Ensure that all emergency exits of the burrows are also well plugged with mud balls so that the phosphine gas released from the pellets will have a good kill of the rats inside the burrows.

7. Encourage natural chock of the rats by not killing the rat snakes, water snakes and other natural enemies of the rats and by providing perches on fields bunds and fields for owls to encourage predation of rats.
8. Soon after harvest, organise campaigns to dig out rat burrows and kill them.

Note: during summer months, the food is scarce in the field and rats will accept the offered baits readily.

B. **GODOWNS:**

1. If rodents are noticed, bait them with multidose or chronic anticoagulant rodenticides as detailed above. Keep them in small cups on the rat runs, dark places etc where rats frequently move. Replace consumed bait daily. Collect the rats which begin dying after 5 or 6 days and bury them.
2. Use also water soluble bait by mixing 25g of water soluble coagulant in 475 mil or water and keep them in shallow cups or plates in a number of places inside the godown for the rats to drink the poisoned liquid and get killed.
3. Use the same material stored in the vicinity for preparing baits and to make the rats to accept and eat them without suspicion.
4. Once the rate population has been contained, discountinue the baiting or remove all the baited food and destroy.

IV. Birds

Damage

- Cause damage to many of our standing crops.
- Cause damage to sprouting seeds, seedlings, vegetables and fruits.
- Carry disease producing germs.
- Some cause nuisance by their noisy and persistent behaviour, and
- Are a constant source of danger to air traffic. They often strike against flying aircraft or get sucked into their engines.

However, they deserve to be repelled rather than killed.

Crow, *Corvus splendens*

- Omnivorous, crow feeds on kitchen waste to dead animals. It feeds on grain mixed up in refuse sweepings spillage around warehouses.
- It causes damage to earheads of maize, wheat, sorghum in the field, fruits, vegetables and flowers of silk cotton trees.
- It breeds during April-August with 4-5 eggs per brood. The eggs are light blue to greenish with dark speckles

Parrot, *Psittacula krameri* and *P. cyanocephalus*

- It cuts and feeds upon maize, sorghum, bajra, wheat, and barley grains and fruits of guava, fig mango and pomegranate.
- It is green with typical short, stout, deeply hooked red bill. It has a black and rose pink ring around the collar. The female parrot has no collar ring. It has a fine pointed tail, short legs and climbing feet. It lays 4-6 white, round and oval eggs in one brood.

House sparrow, *Passer domesticus*

- It damages wheat, sorghum, maize, bajra ear heads, and fleshy fruits of mulberry. It also damages grains in open storage, contaminating them with excreta and feathers.
- The female sparrow is brown with blackish and rufous streaks and whitish under parts. It lays 3-5 pale white greyish eggs in one brood. There are 5 broods per year.

Pigeon, *Columba livia*

- It eats food grains in stores and godown and contaminates them with excreta and feathers. It is found in goods sheds, railway stations, shops, houses and threshing yards, rice mills, flour mills, etc.
- It is grey in colour with glistening metallic green. It lays 2 elongated white eggs in one brood. It breeds rounds the year especially from January to May with 3-5 broods in a year.

Common mynah, ***Acridotheres tristis***

- It damages the food grains in fields. It feeds on insect, earthworm, fruit, vegetables, kitchen wastes and grain in refuse.
- It breeds from April to September. It lays glossy, spot free blue coloured eggs.

Integrated Management

Cultural methods

- Sow the seeds deeply into the soil.
- Cover the seeds with soil after sowing.
- Grow trap crops near the main crop.
- Use plant varieties that are physically and gustatorily unattractive to birds.
- Plant morphological features such as shed layer of anthers or awns (hybrid *bajra),* tight spathe (maize), compact or loose earheads (pearl millet), large glumes (bracts), loose panicles and gooseneck-shaped (pendant) heads (sorghum) make the crop unacceptable (resistant) to birds.
- Gustatory feature such as an extra quantity of tannins in the grains (sorghum) also make the crop unacceptable (resistant) to birds.

Scaring methods

- A conventional deterrent commonly used by farmers is 'scare crow', a human figure erected in the fields, may scare some birds like crows.
- Use throw balls made out of stores or balls and old cloth jute twine or cotton waste to scare the birds.
- Use acetylene gun to create land noise at regular intervals.
- Use tape record to record and to play alarm signals of different birds at high pitch in infested areas.

Physical methods

- Cover the window ventilators and other entries of godown with bird proof meshes to prevent even rat entry.
- Use strips of cloth, polythene or bamboo or cloth or nylon curtains in godown

to prevent the birds effectively.

* Spreads nylon net over the crops and orchards to protect against birds.

Mechanical methods

- Destroy the bird habitat, nests and eggs to reduce the population drastically.
- A preferred bird-habitat can be made unpreferred by removing food, water and shelter.
- Bird-perches could be electrified to disperse the birds or kill them by regulating the voltage.
- Use bird traps, nets, cages to trap birds.
- Destroy the birds by shooting using air gun and poison (Strychnine) baiting.

Biological methods

* Utilize the predators, i.e. hawks and owls for bird control.

Chemical methods

* Fumigate the nests, which on tree or in wall holes (mynas, parrots) using aluminium phosphide tablets.
* Mix alpha chloralose compounds with food grains or other eatables to make the birds unconscious after they consume.
* Use bird sterilant to prepare poison baits, which affect the reproduction.
* Use repellents like some insecticides (malathion) or avion feeding deterrent (Tetra methyl thiuram disulphite, TMTD) to repel birds.

LECTURE NO. 16 – LOCUST AND THEIR MANAGEMENT

Locusts are the short-horned grasshoppers with highly migratory habit, marked polymorphism and voracious feeding behavior. They are capable of forming swarms (adult's congregation) and hopper bands (nymphal congregation). They cause great devastation to natural and cultivated vegetation. They are indeed the sleeping giants that can flare up any time to inflict heavy damage to the crops leading to national emergency of food and fodder.

There are 10 important species of locusts in the world listed below.

S. No.	English Name	Scientific Name
1.	The Desert Locust	*Schistocerca gregaria*
2.	The Bombay Locust	*Nomadacris succincta*
3.	The Migratory Locust	*Locusts migratoria manilensis;* *Locusta migratoria migratoria-oides*
4.	The Italian Locust	*Calliptamus italicus*
5.	The Moroccan Locust	*Dociostaurus morocannus*
6.	The Red Locust	*Nomadacris septemfaciata*
7.	The Brown Locust	*Locustana pardalina*
8.	The South American Locust	*Schistocerca paranensis*
9.	The Australian Locust	*Chortoicetes termenifera*
10.	The Tree Locust	*Anacridium* Spp.

Only three species viz. Desert locust (*Schistocerca gregaria*), Migratory locust (*Locusta migratoria*), Bombay Locust (*Nomadacris succincta*) and are found in India. The desert locust is most important pest species in India as well as in intercontinental context.

Distribution

The invasion area of desert locust covers about 30 million sq km which includes whole or parts of nearly 64 countries. This includes countries

like North West and East African countries, Arabian Peninsula, the Southern Republic of USSR, Iran, Afghanistan, the Indian sub-continent. During recession periods when locust occurs in low densities, it inhabits a broad belt of arid and semi-arid land which stretches from the Atlantic Ocean to North West India. Thus, it covers over 16 millions sq kms in 30 countries.

History of locust invasion in India

Historically, the Desert Locust has always been a major threat to man's well-being. The Desert Locust is mentioned as curse to mankind in ancient writings viz. Old Testament-Bible and the Holy Koran. The magnitude of the damage and loss caused by the locusts is very gigantic beyond imagination as they have caused the starvation due to its being polyphagous feeder, and on an average small locust swarm eats as much food in one day as about 10 elephants, 25 camels or 2500 people. Locust do cause damage by devouring the leaves, flowers, fruits, seeds, bark and growing points and also by breaking down trees because of their weight when they settle down in masses.

Locust plagues and upsurges

The attack of the desert locust used to occur earlier in a phases of plague cycles (a period of more than two consecutive years of wide-spread breeding, swarm production and thereby damaging of crops is called a plague period) followed by a period of 1-8 years of very little locust activity called as the recession period again to be followed by another spell of plague. India witnessed several locust plague and locust upsurges and incursions.

Economic Importance:

In our country, in spite of taking control measures, damage to crops caused by locusts during 1926-31 cycles, on a conservative estimate, was about Rupees 10 crore. During 1940-46 and 1949-55 locusts cycles the damage was estimated at Rs. 2 crore each and it was only Rs. 50 lakh during the last locust cycle (1959-62). Although no locust plague cycles have been observed after 1962, however, during 1978 and 1993, large scale upsurges were reported. Damage estimated was Rs. 2 lakh in 1978 and Rs. 7.18 lakh in 1993. Thereafter, insignificant damage by locust upsurges were reported

largely due to the efforts of National, Regional and International Organizations established to prevent plague under the overall coordination of the Food and Agriculture Organisation.

Scheduled Desert Area of India:

In India the Scheduled Desert Area (SDA) is spread over an area of 2.05 sq km in the state of Rajasthan, Gujarat and Haryana

Locust Biology

Life cycle: Locust life cycle has three distinct stages (i) Egg, (ii) Hopper and (iii) Adult.

Egg: Eggs are laid in pods in moist sandy soil at a depth of about 10 cm at an interval of 7 – 10 days. Gregarious female usually lay 2-3 egg pods having 60-80 eggs in average. Solitarious female mostly lay 3-4 times having 150-200 eggs in average. The rate of development of eggs depends on soil moisture and temperature. No development takes place below 15°C. The incubation period is 10-12 days when the optimum temperature is between 32-35°C.

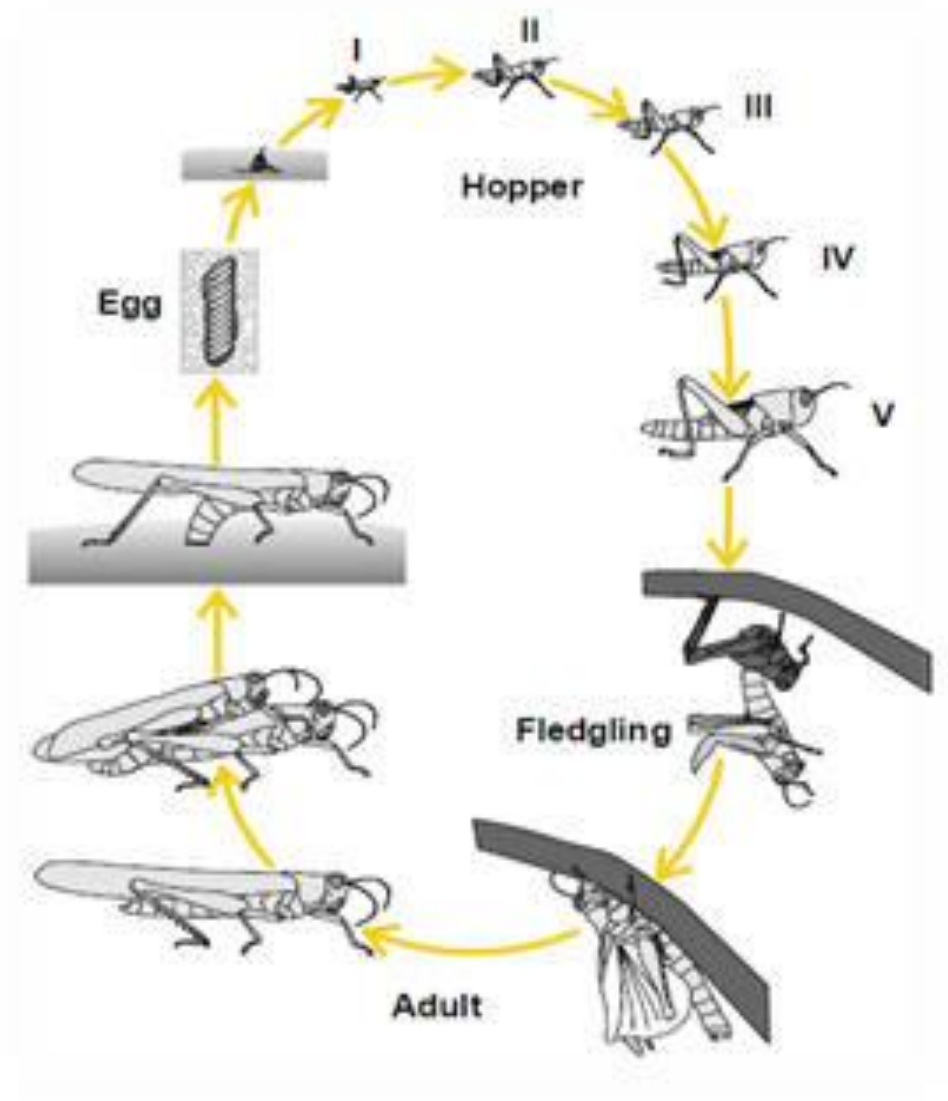
Hopper: After incubation is complete the eggs hatch and nymph (young ones) emerge. There are 5 instars in gregarious and 5-6 instars in solitarious population. In each instars there is a growth and change in characteristic coloration.

I Instar	Newly hatched are white but turns black in 1-2 hours.
II Instar	Head is larger and pale colour pattern is conspicuous.
III Instar	Two pairs of wing buds projects on each side of thorax
IV Instar	Colour is conspicuously black and yellow.
V Instar	Colour is bright yellow with black pattern.

The rate of development in hopper depends on temperature. It takes 22 days when the mean air temperature is hot say about 37°C and may be delayed up to 70 days when the mean temperature is cold say about 22°C.

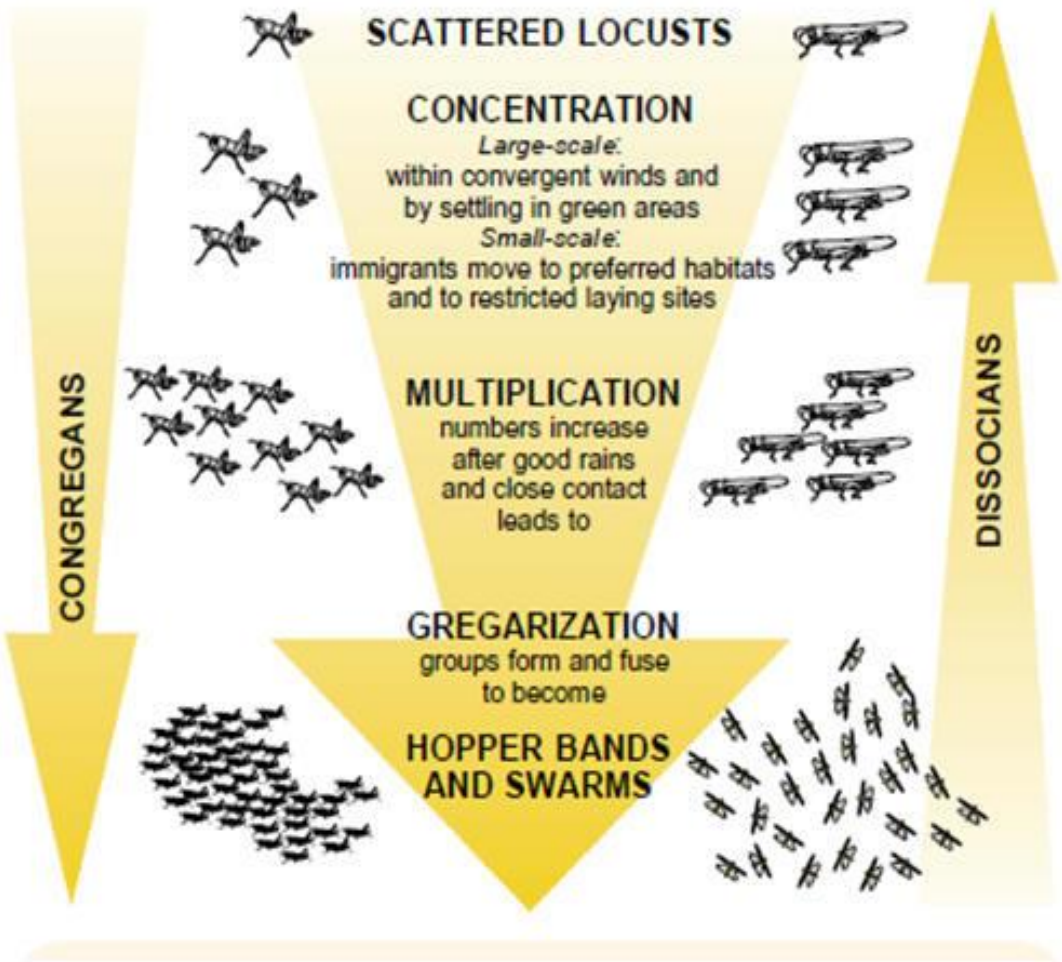
Adult: The V Instar adult moults into adult stage. This change is called 'fledging' and the young adult is called 'fledgling' or 'immature adult' means they are sexually immature. The period of sexual maturity varies. In suitable condition the adult may mature in 3 weeks and under cool and /or dry condition it may take 8 months' time. During this stage the adults fly for search of favorable breeding condition and may cover thousands of kilometers.

Young immature adults are pink in color but old ones become dark red or brown in cold condition. On maturation the adults become bright yellow. Males mature before females. Oviposition commences within two days of copulation.



Locust Phases:

Locust is generally found in two phases (i) Solitary, when it is so called inactive and individual locust live scattered and (ii) Gregarious, when it is very active, the individuals tend to remain together, breed rapidly and form swarms which leave the breeding grounds and invade far distant tracts and even cross many countries. In addition to difference in behavior, the two phases can generally be distinguished by colour and some anatomical and morphological features. The two phases run into each other, as there are some individuals which are intermediate in habits and physique and are therefore considered to be in transient phase.



A few differences between solitary and gregarious phase are as under:

Characteristics	**Solitary phase**	**Gregarious phase**
Behavior	-Do not form groups or swarms -Roost, bask, feed and move as individuals -Hoppers move short distance, adults fly as individuals at night	-Form persistent and cohesive groups, bands and swarm -Roost, bask, feed and move together -Very mobile, fly as swarms by day. Hoppers move in band.
Colour	-Hoppers uniformly green in early instars but may be brown in last two instars. -Adult pale grayish brown, buffer peach coloured. Males change to pale yellow on sexual maturation. -Female show no colour change on maturation at low density.	-Hoppers have black pattern on yellow or orange background -Adults rosy pink on fledging, darkens with age to grayish or brownish red then to yellow on sexual maturation. Males are brighter.
Morphometrics	F/C Male 3.75 and above Female 3.85 and above E/F Male 2.025 or below Female 2.075 or below	F/C Male 3.15 or below Female same as above E/F Male 2.225 and above Female 2.272 and above
Note: C = Width of head, E = Length of forewing, F = Length of hind femur, measuring Unit in milimetre		

Seasonal Breeding:

In all, there are three breeding seasons for locusts (i) **Winter breeding** [November to December], (ii) **Spring breeding** [January to June] and (iii) **Summer breeding** [July to October]. India has only one locust breeding season and that is Summer breeding. The neighboring country Pakistan has both spring and summer breeding.

Present Scenario on locust:

The scheme Locust Control and Research is being implemented through an Organisation known as Locust Warning Organisation (LWO) established during 1939 and later merged with directorate of PPQ&S in 1946. The Locust Warning Organisation (LWO) monitors locust development and its activities over an area of 2.00 lakh sq km of the Scheduled Desert Area (SDA) mainly in the states of Rajasthan and Gujarat and partly in Haryana.

The Scheme is being executed through ten Locust Circle Offices (LCOs) located at Bikaner, Jaisalmer, Barmer, Jalore, Phalodi, Nagaur, Suratgarh, Churu in Rajasthan and Palanpur & Bhuj in Gujarat, Locust Warning Organisation (LWO) Field Headquarters at Jodhpur and Locust Division at Central Headquarter Faridabad (Haryana). Besides, there is one Field Station for Investigation on Locust (FSIL) situated at Bikaner. To strengthen the locust monitoring and forecasting and as per the recommendations made during 28th Session of the FAO Commission for Controlling the Desert Locust in South-West Asia (SWAC), an advanced device named eLocust3 and software RAMSES V4 has been made functional in LWO from January, 2016 with the cooperation of FAO. LWO has wireless network for exchanging the information on locust survey and control between various field offices and Hqrs. Faridabad. Satisfactory, locust control potential is being maintained in the form of pesticides, plant protection equipments, wireless sets, GPS, eLocust3 and trained manpower.

Locust Monitoring/ Control:

Monitoring of Locust population:

Assessment survey: This type of survey is undertaken in the field to monitor (1) the presence of locust and (2) ecological conditions and also undertaken to determine whether locust populations has crossed economic threshold level [adults more than 10,000 ps km. and 5-6 hoppers per bush] that may require control.

The surveys are undertaken in sandy areas with green vegetation and about two weeks after rain has fallen. These surveys are done regularly during whole of the year. The frequency of the survey is doubled from May to

November (rainy season) as compared to the frequency of surveys from December to April. The surveys are undertaken from sunrise to midday and for a few hours in the evening before sunset in the temperature range of 20° - 38° C.

Survey Methodology:

Foot transect (FAO Method)

The locust surveyor walk about 300 meters into the wind and observes locust, vegetation, soil moisture etc. and feeds the information in e-locust2 and send the report to the headquarter.

Vehicle transect (FAO Method)

In this method the surveyor is in the vehicle and the vehicle is driven upwind for about one kilometer in the low gear and the locust adults are counted that fly up in front of the vehicle. The information on locust and ecological conditions are fed in e-locust2 unit and sent to headquarter.

Survey during upsurges, outbreaks, plagues:

Search survey

This involves searching the hopper bands and swarms by following up a report from local people/ nomads/ BSF or any other agency. In this case ecological conditions available at the spot where hopper bands or swarms are found are fed into elocust2 unit and sent to Field Hqrs. This usually require hopper or swarm control. This also involves survey of the spot in the following years for checking any further locust infestation

Plant Protection Equipment

Presently ULV sprayers are in use. Hand held Micro-ULVA, Vehicle mounted ULVA Mast and Vehicle mounted Micronair aerial sprayer.

Micro-ULVA

This is a hand-held, battery-operated spinning disc sprayer. It has one toothed disc which can cope with flow-rates between approximately 20 and 100 ml/min. The actual flow-rate can be changed by changing the restrictor; four different sized restrictors are supplied with the Micro-ULVA. Pesticide is

contained in a bottle which feeds the disc by gravity. The sprayer has a twin neck 1 ltr bottle with a separate fuller cap so the bottle need not be removed to refill. The sprayer can be fitted with an additional 5 ltr backpack which refills the bottle through a closed piping system. The Micro-ULVA is cheap, simple, easy to maintain and has a narrow drop spectrum. This is useful where vehicle has no access.

ULVA Mast

This is a vehicle-mounted sprayer fitted with a stacked disc atomizer. Its toothed discs produce a narrow drop spectrum at flow-rates between 0.1 and 2.0/ min. The stack of discs is driven by a rubber belt from an electric motor. The speed of revolution of this stack can be changed by a belt and pulley system. Faster disc speeds produce smaller drops. 12 volt supply from the vehicle battery gives the atomizer disc a speed of 8,500 - 10,000 rpm with the fastest pulley and 5,500 rpm with the medium speed pulley (the lowest pulley setting should not be used for locust control).

Pesticide is pumped from the tank through an adjustable valve to the atomizer. The newly developed centrifugal pump can be used with all active ingredients and all formulations since no components which might be affected come into contact with the pesticide. There is a 10 ltr auxiliary flushing tank with parallel plumbing. This can be filled with pesticide for trials or to treat small areas.

Micronair AU8115M

The Micronair AU8115M is a self-contained vehicle mounted Controlled Droplet Application (CDA) sprayer designed for a wide range of migrant pests. The sprayer utilises Micronair rotary cage spray technology to produce spray droplets of a precise and consistent size. The Micronair rotary atomiser is driven by a powerful air stream generated from a blower mounted at the base of the unit. During operation, the air stream carries the spray droplets away from the vehicle and operators. This gives an effective release height of up to 15 meters and enables a swath of over 100 meters to be achieved when using a drift spraying technique with a wind speed of 2.5 meters / second or more.

Micronair AU5000 aerial sprayer

Micronair spinning cage atomizers produce a drop spectrum lying between the wide spectrum of conventional nozzles and the narrow one produced by discs .The spectrum is adequate for ULV locust spraying. These atomizers can cope with high flow-rate so that one on a vehicle or two units mounted on an aircraft is sufficient for normal ULV application volumes.

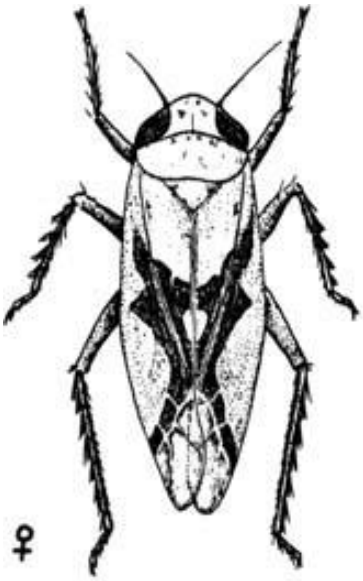
The cage is turned either by the air stream acting on the blades of a propeller or by a motor. Liquid is pumped from the pesticide tank to the atomizer core from which it is forced out under pressure. The pesticide is shattered by the rotation of baffles and by the perforated housing cylinder. The liquid is then thrown out onto the cage itself and is thrown off from there by the rotation of the cage; where there is air shear at the gauze surface this causes further shattering. Different gauge gauzes are available which produce slightly different drop size ranges.

Integrated Management of Locust

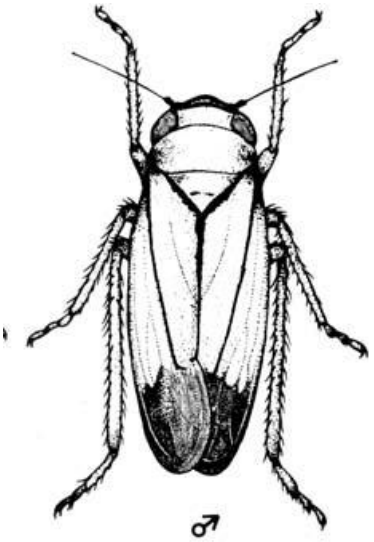
- Dig out the egg laying places – destroy
- Dig out a trench around the breeding ground
- Dig out trenches of 45 cm deep & 30 cm wide
- Provide metal sheet barriers to 4 cm height – across the front of marching nymphs
- Burn the nymphs hiding on bushes during the night- flame thrower
- Poison baits : Sodium arsenite or sodium flurosilicate or paris
- green + wheat or rice bran – attract and kill the nymphs
- Carbaryl 10 D at 25 Kg / ha
- Beat the adults to death – throny sticks or brooms
- Flame throwers to burn the adults –sluggish due to cold
- Aerial spraying of insecticides on the locusts
- Predatory birds: Crow, Common Myna and Starlings
- Bio control agents: *Nosema locustae* – unable to reproduce and get killed
- Bacteria :*Bacillus thuringiensis*– control the locust effectively
- Spray malathion 50 EC @ 1000 ml / ha
- Neem seed powder 0.1 % - protect crop from locust attack - about 21days
- India, Pakistan and Iran exchange the information – locust situation.

Ex.No. 1

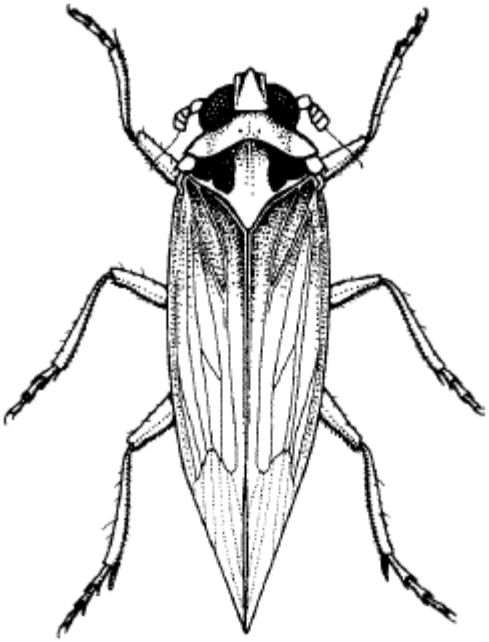
Zig-zag Winged Rice Leafhopper



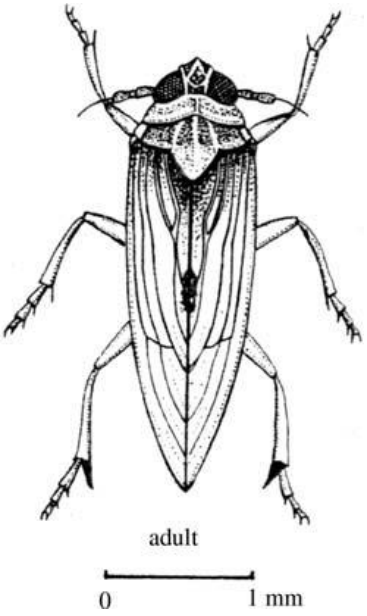
Green Rice Leafhoppers



Rice White-backed Planthopper

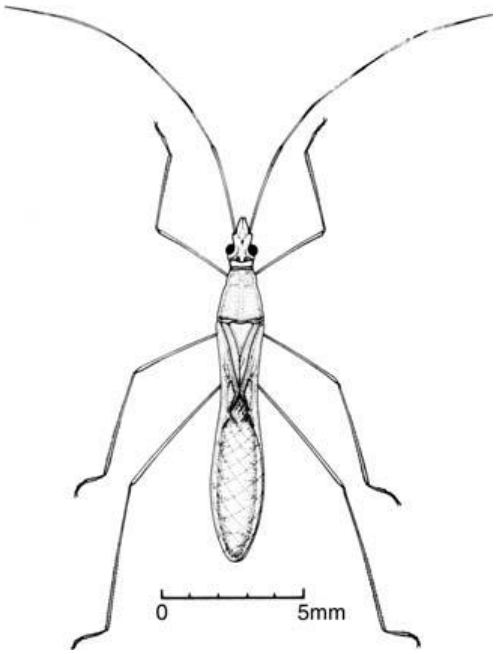


Brown Rice Planthopper (BPH)

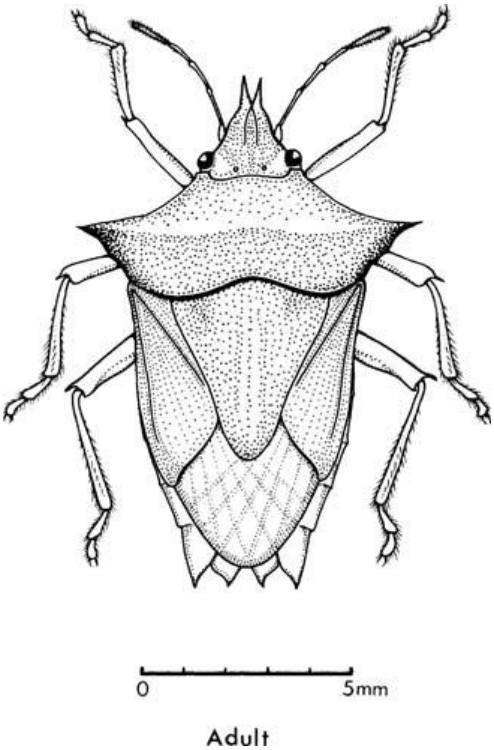


Ex.No. 1

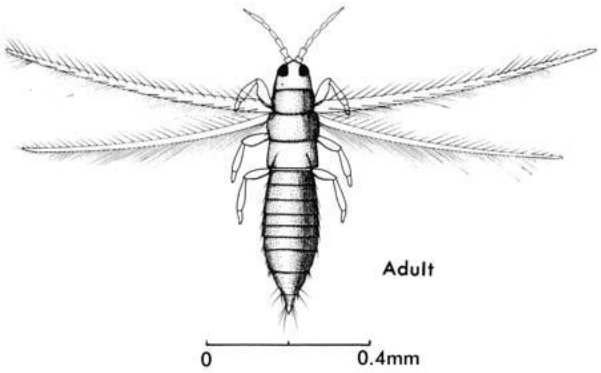
Rice Seed Bug



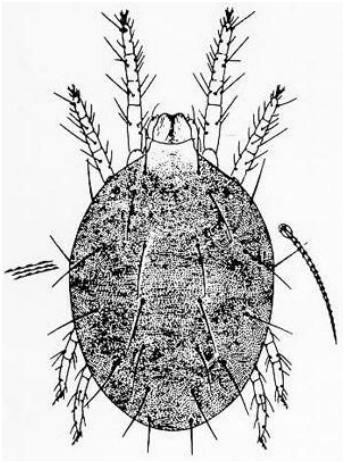
Rice Stink Bug



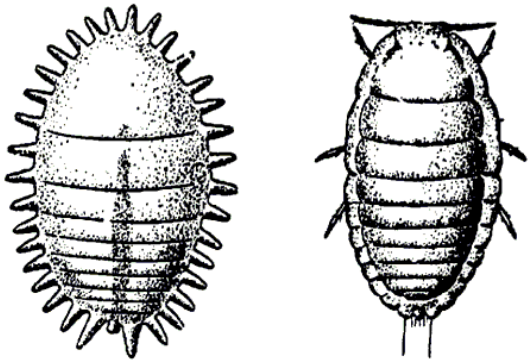
Rice Thrips



Rice leaf mite

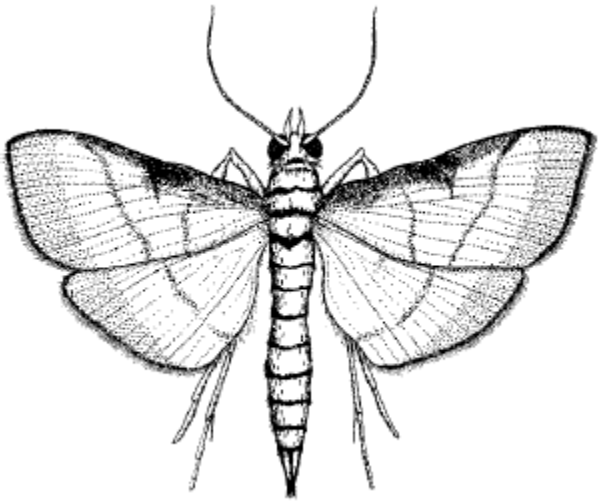


Rice
Mealy bug

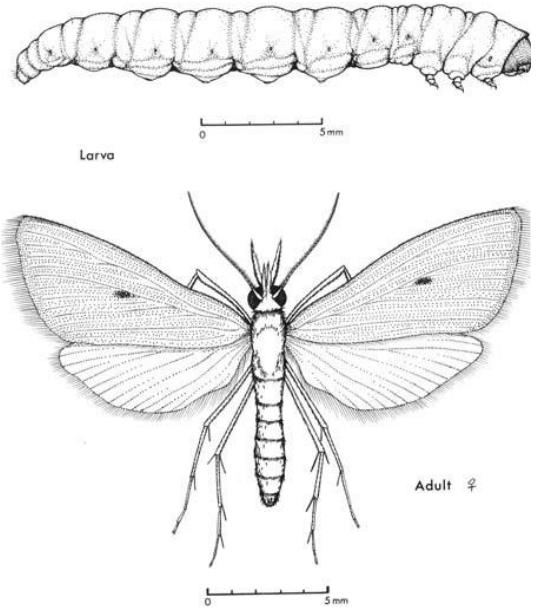


Ex.No. 2

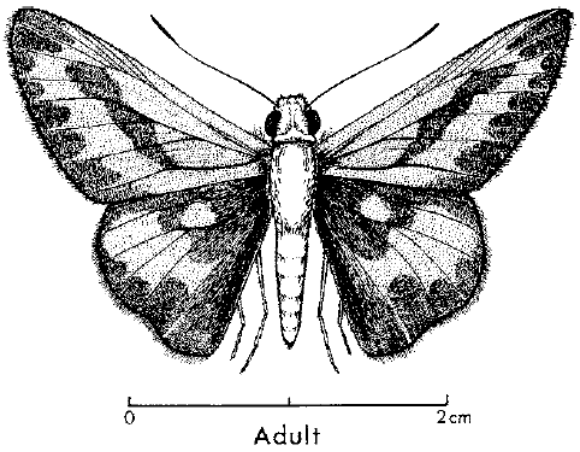
Rice Leaf Folder



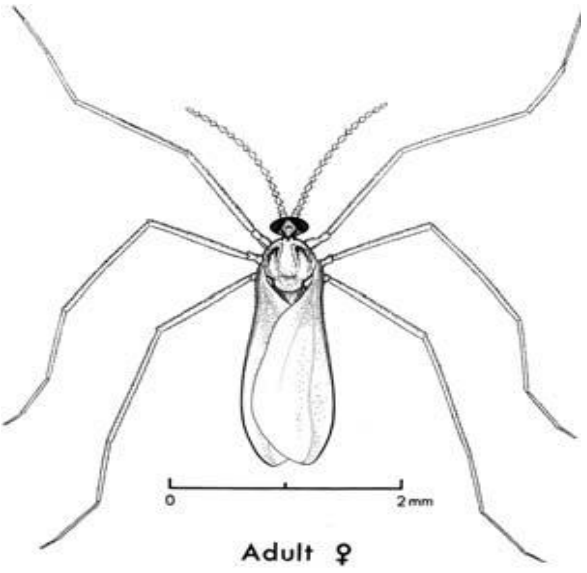
Yellow Paddy Stem Borer



Rice Skipper



Rice Stem Gall Midges



Rice case worm

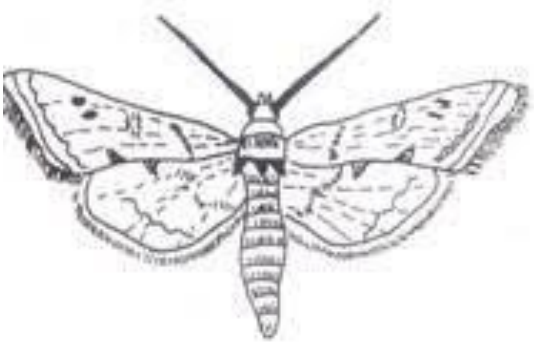
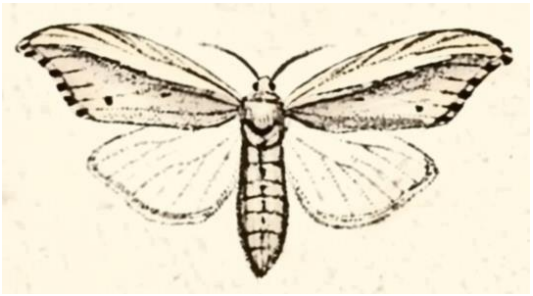


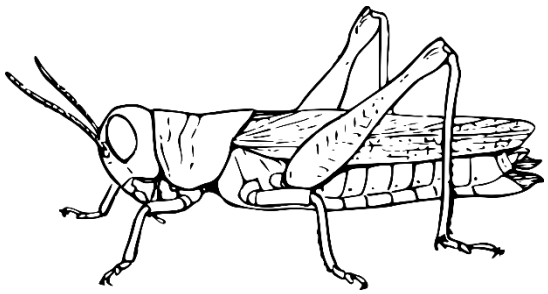
Fig. 50. *Nymphula depunctalis* (Adult)

Ex.No. 2

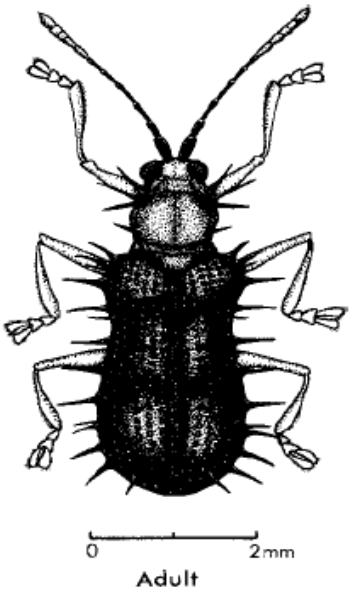
Rice Yellow hairy caterpillar



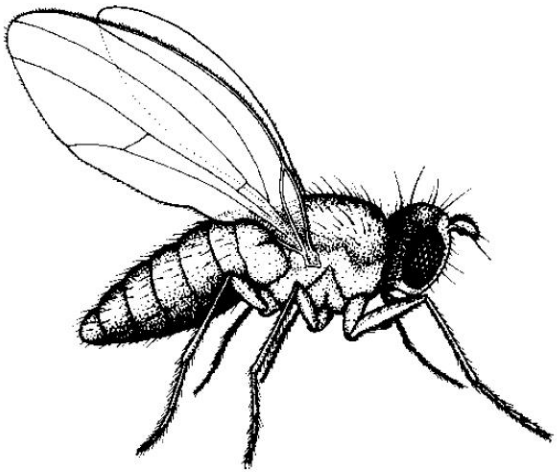
Rice Grasshoppers



Paddy Hispa

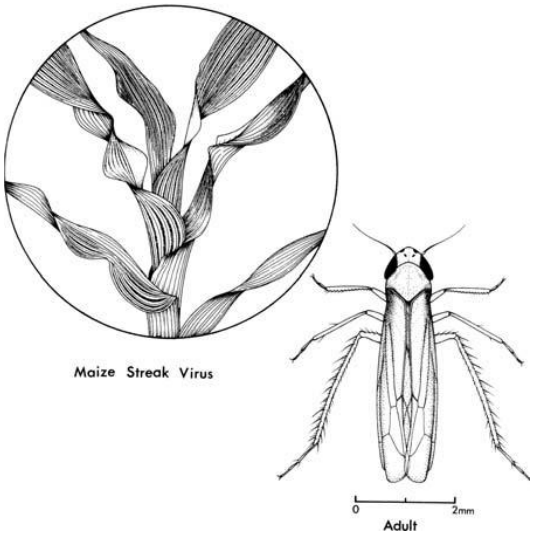


Rice Whorl Maggot

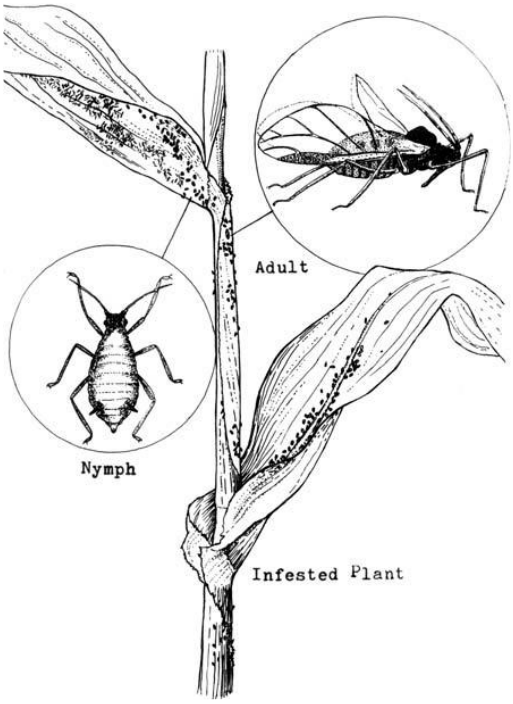


Ex.No. 3

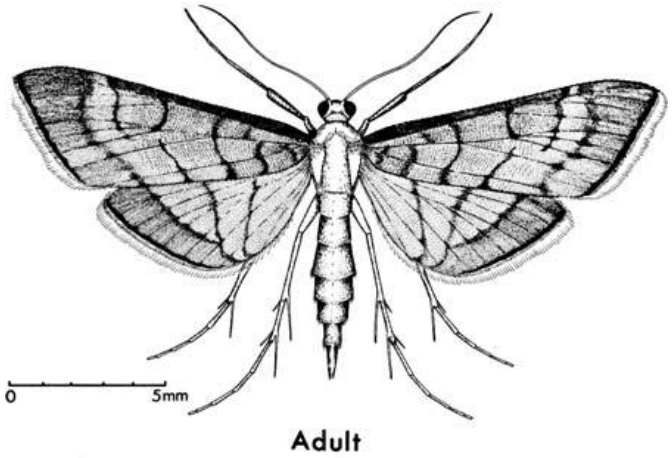
Maize Leafhopper



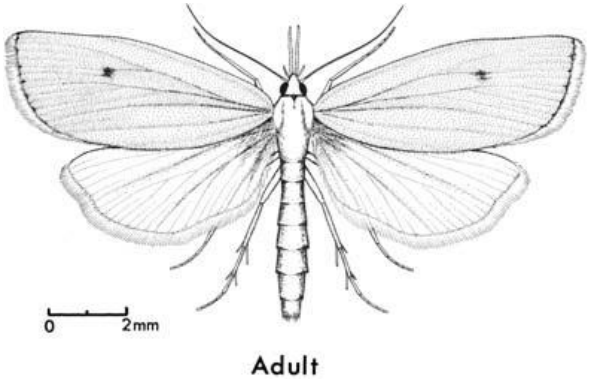
Maize Aphid



Maize Webworm

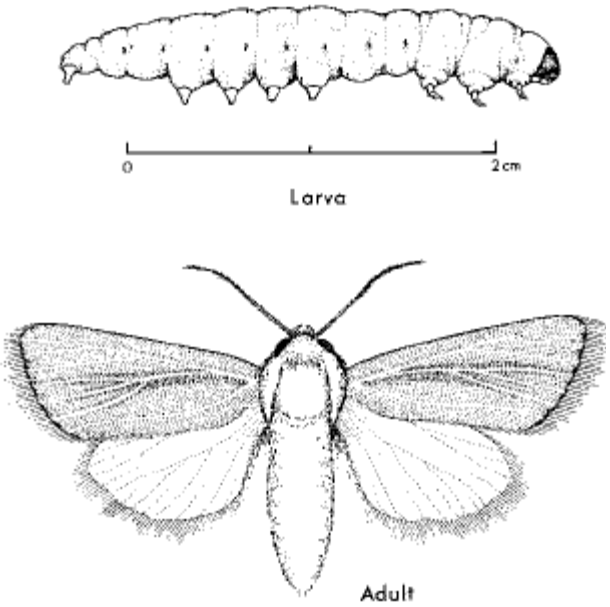


Maize Spotted Stalk Borer

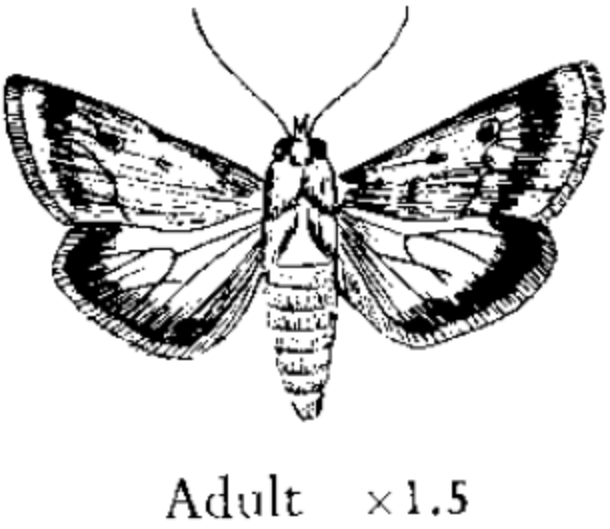


Ex.No. 3

Maize Pink Stem Borer

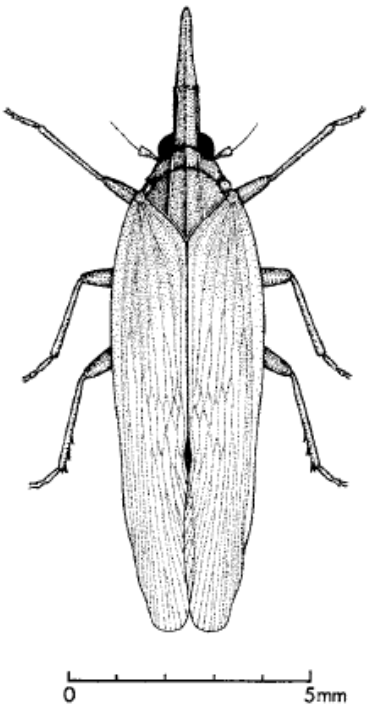


Corn worm



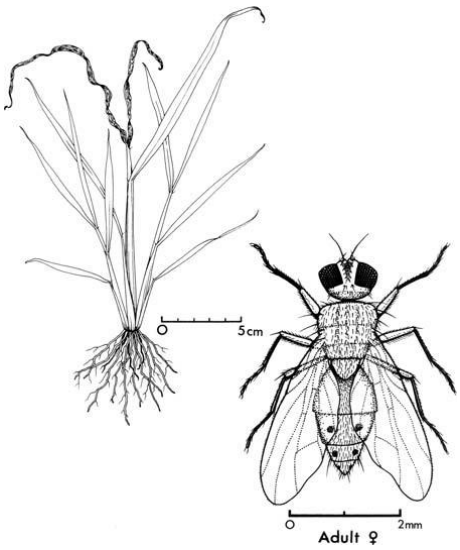
Maize Fall army worm

Maize Leafhopper

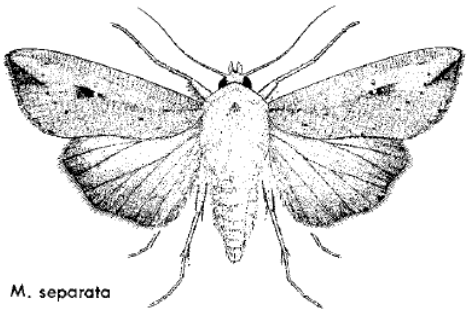


Ex.No. 3

Maize Stem Fly

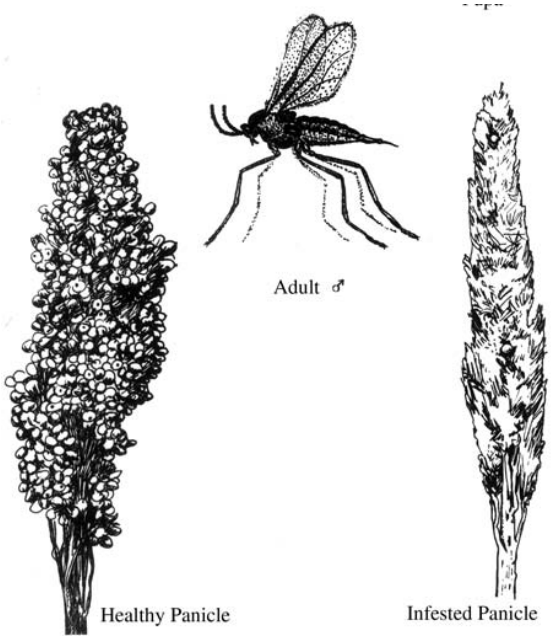


Maize Oriental Armyworm/ Cut worm

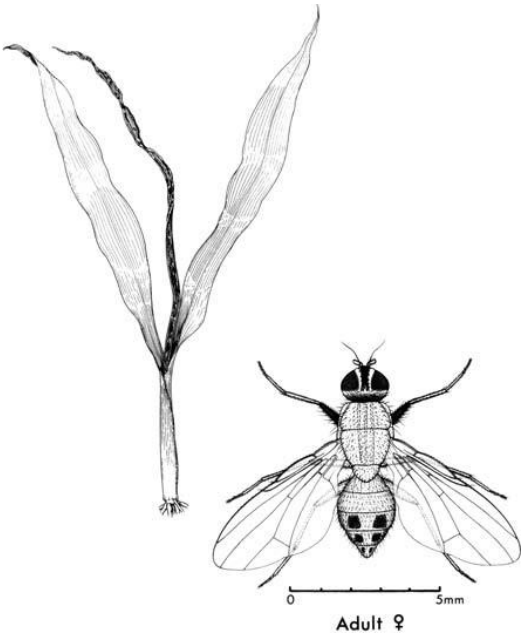


Ex.No. 3

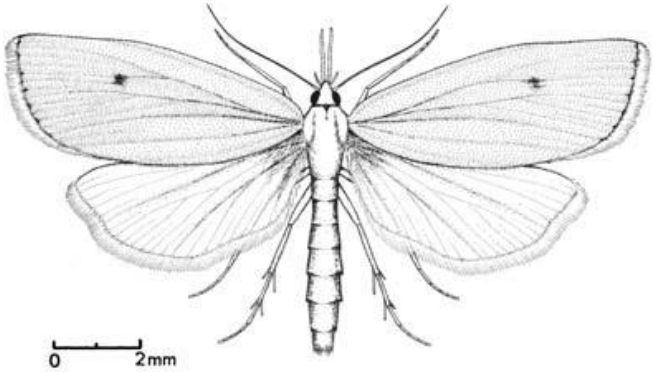
Sorghum Midge



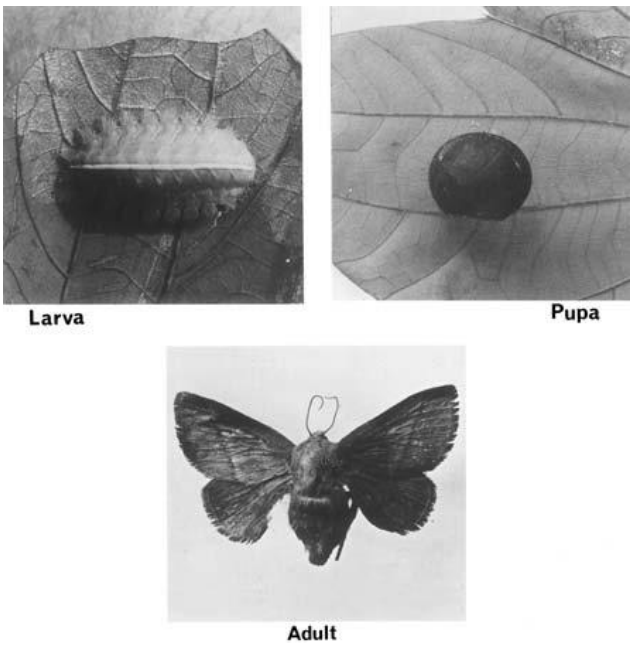
Sorghum Shoot Fly



Sorghum Stem Borer

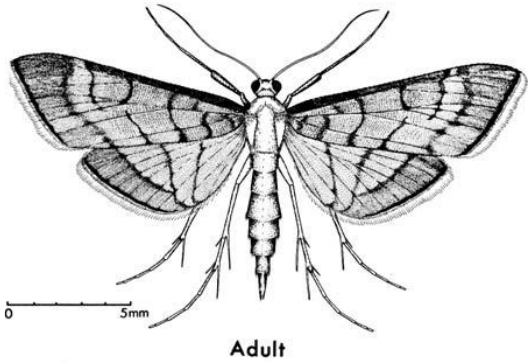


Sorghum Slug Caterpillar



Ex.No. 3

Sorghum Webworm/
Leaf roller

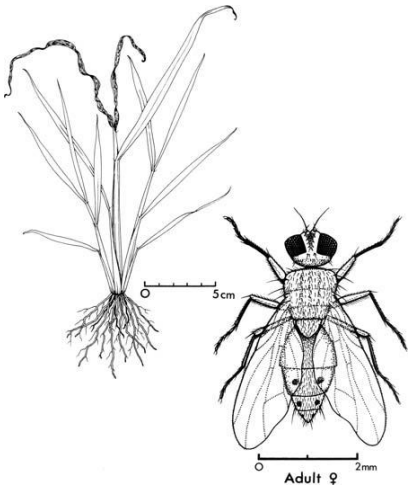


Adult

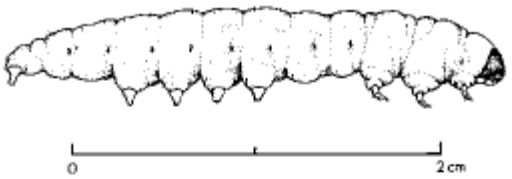
Sorghum Webworm/
Leaf roller

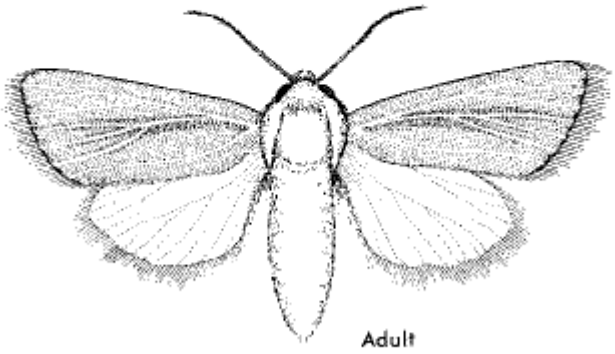
Ex.No. 4

Wheat shoot fly

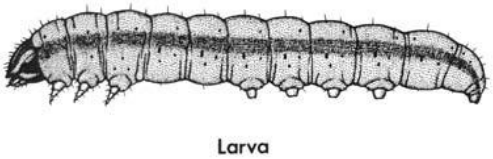


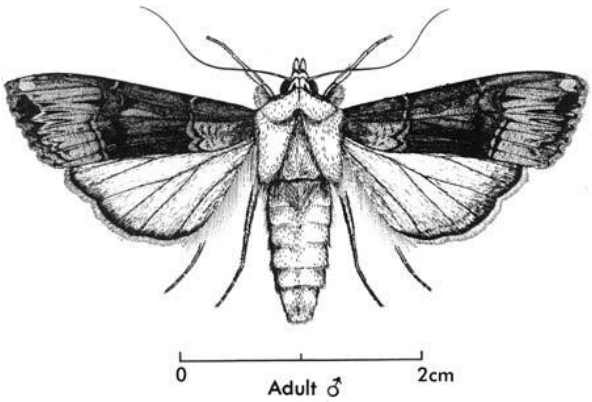
Wheat Pink Stem Borer



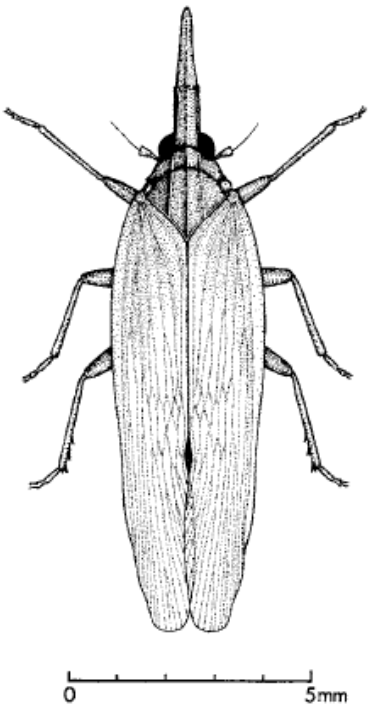


Wheat Cutworm



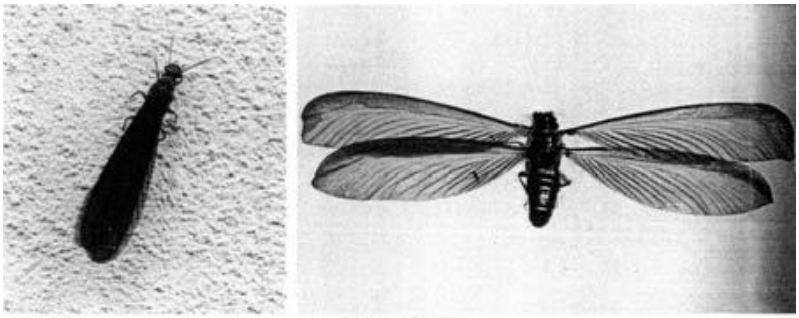


Wheat Leafhopper



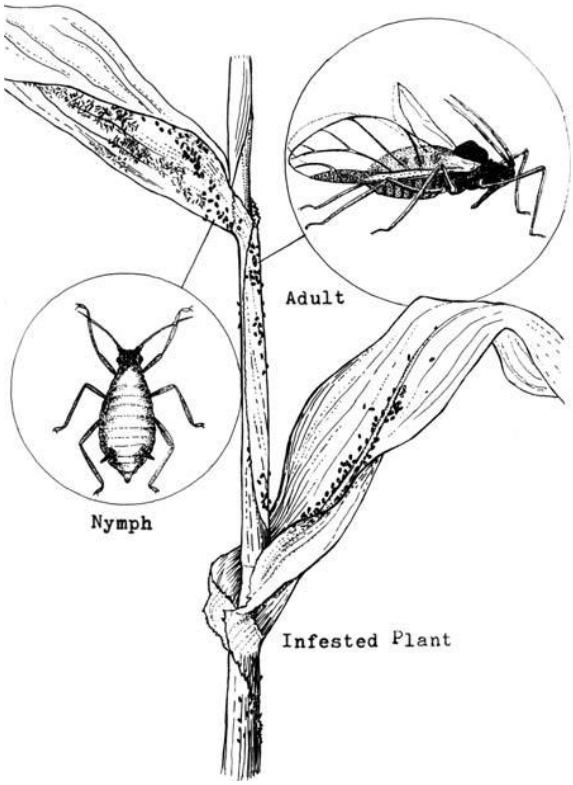
Ex.No. 4

Wheat Termites



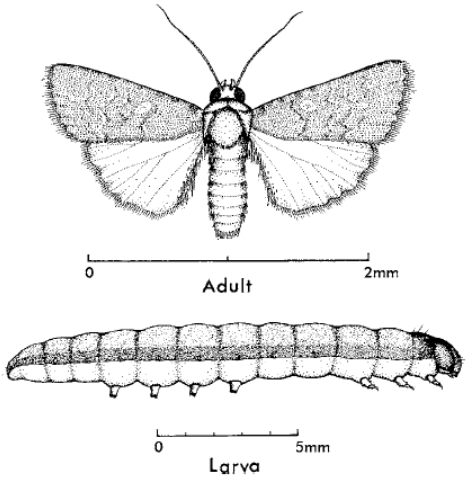
adult winged forms

Wheat Aphids

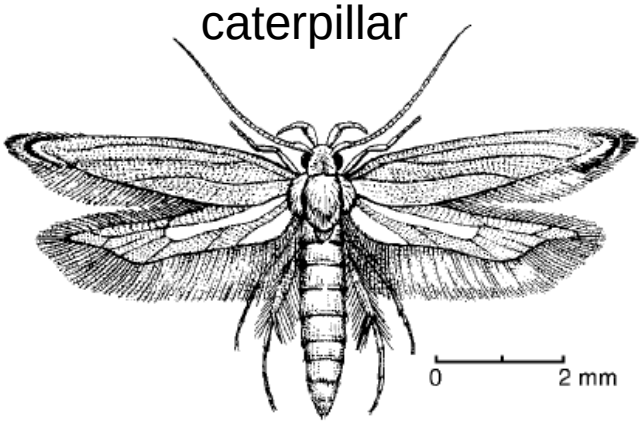


Ex.No. 4

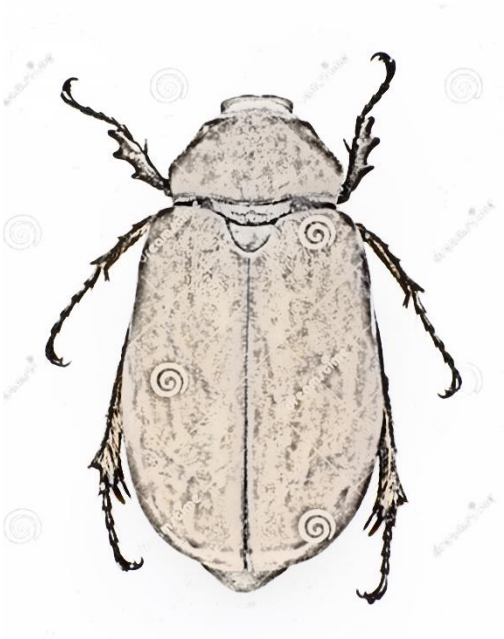
Ragi cutworm



Ragi Earhead caterpillar



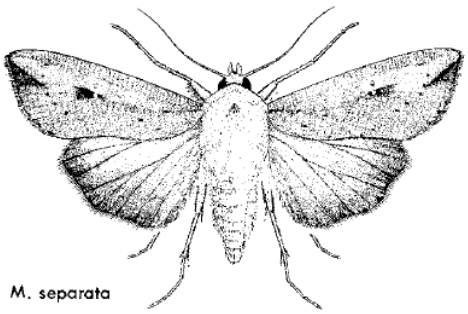
Ragi white grub



Ragi root aphid

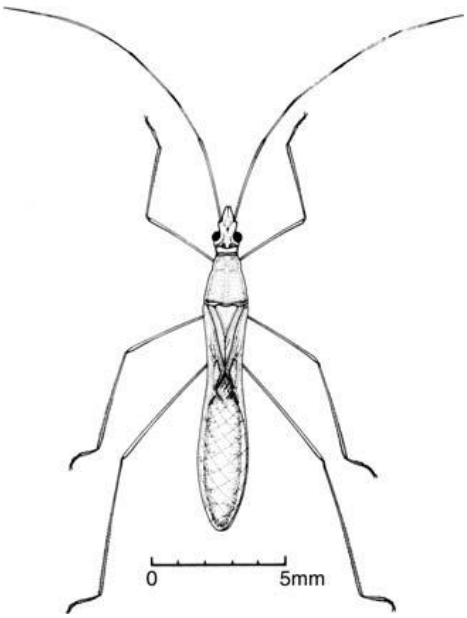
Ex.No. 4

Tenai Cut worm

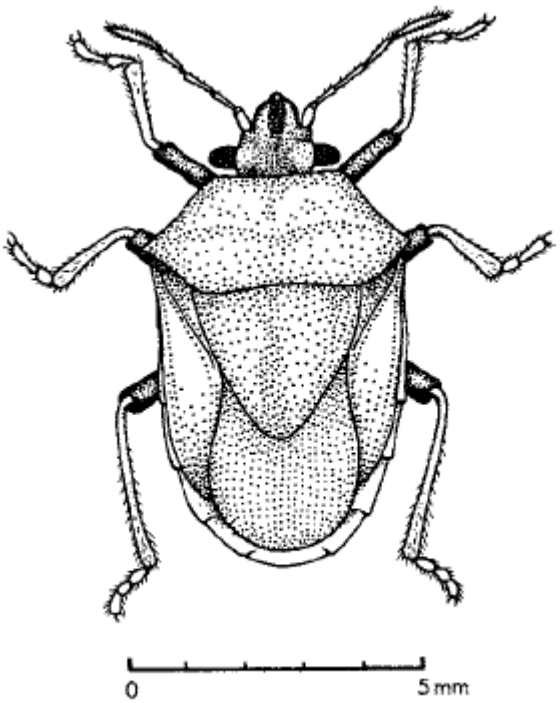


Tenai planthopper

Tenai earhead bug



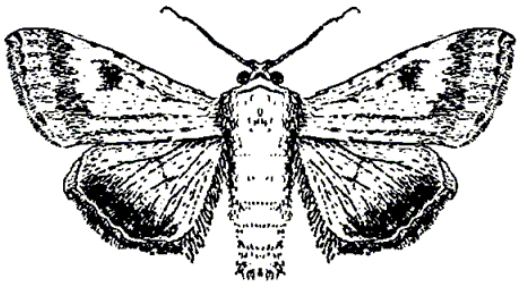
Tenai Black Bug



Adult

Ex. No: 5

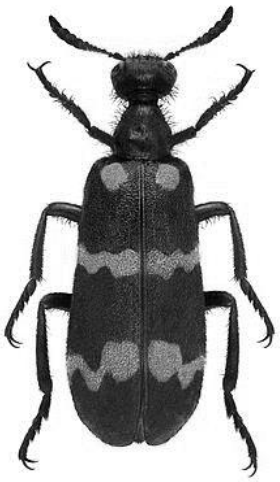
Spotted pod borer



Gram pod borer

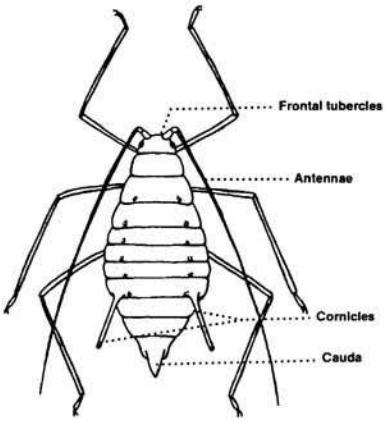
Pulse blue butterfly

Gram pod bug & its symptom

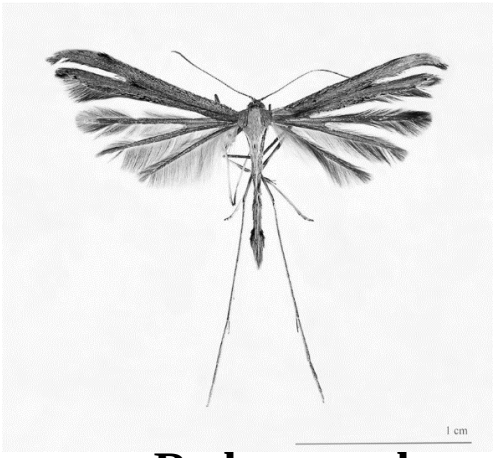


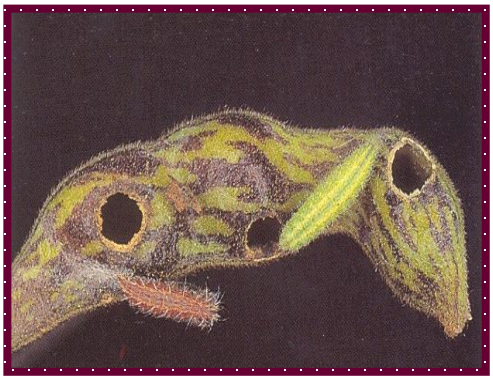
Blister beetle

Ex. No: 5

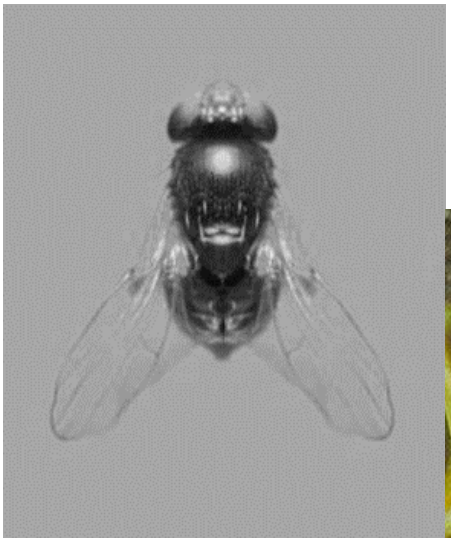


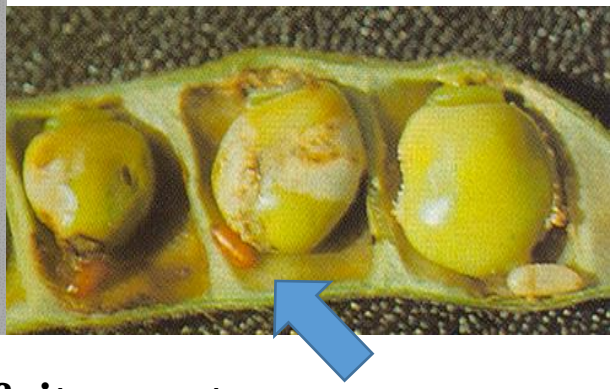
Black bean aphid & its symptom





Red gram plume moth & its symptom

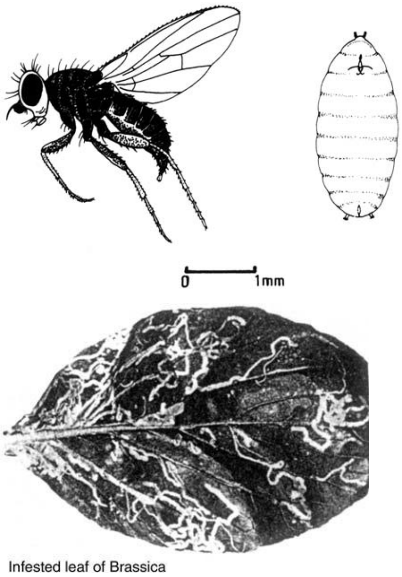




Pod fly & its symptom

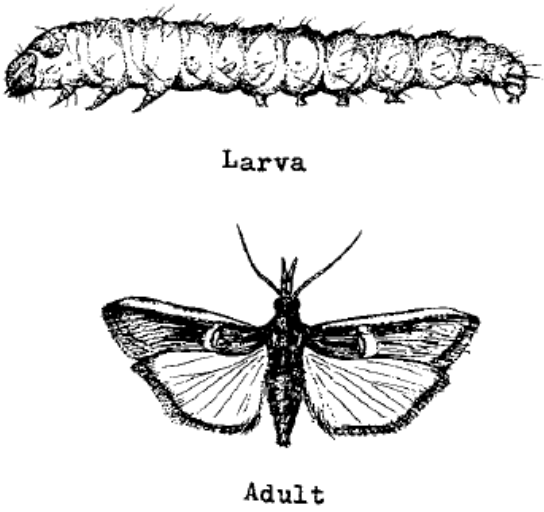
Ex.No. 6

Leaf Miner



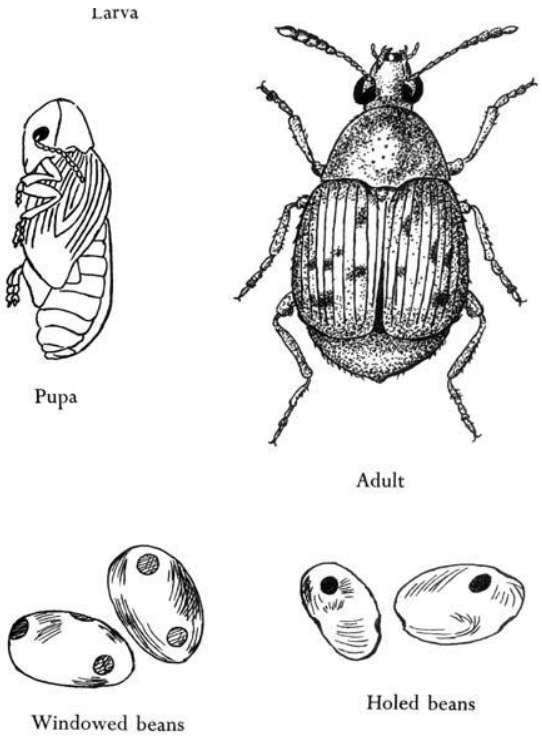
Infested leaf of Brassica

Pea Pod Borer



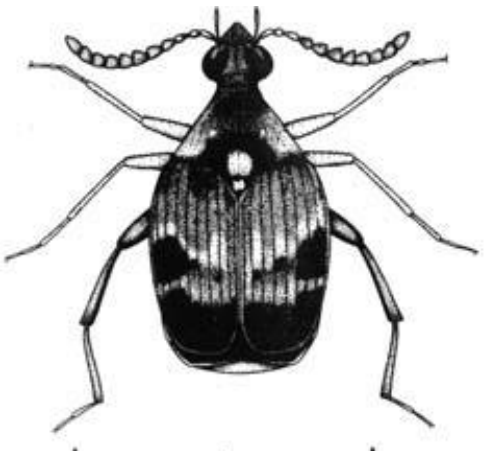
Gram Pod Borer

Bean Bruchid



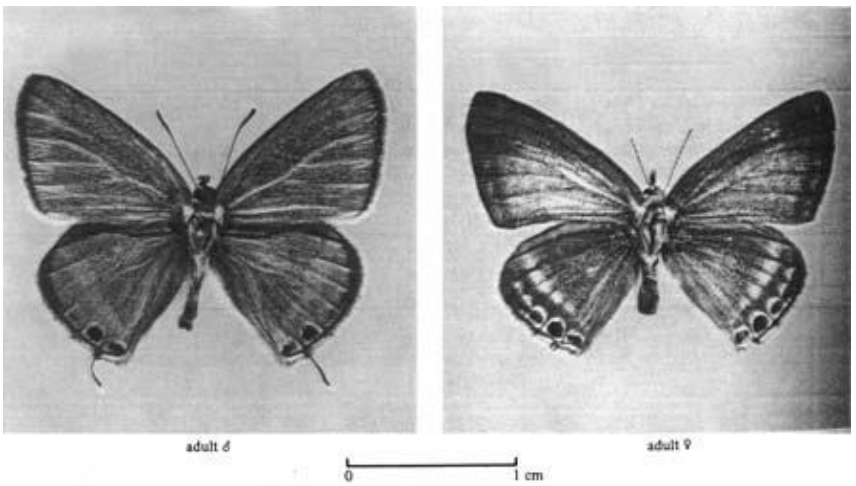
Ex.No. 6

Cowpea Bruchids



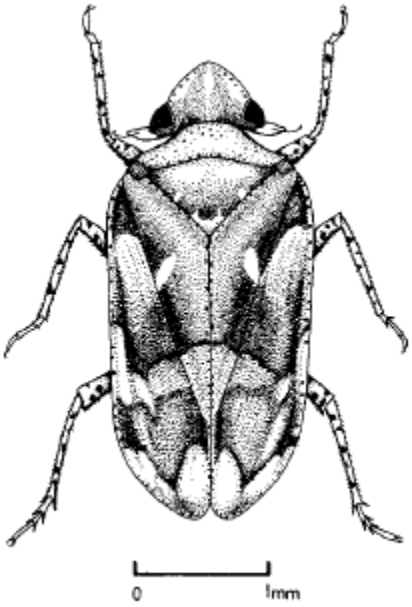
Mung Moth

Blue Butterfly

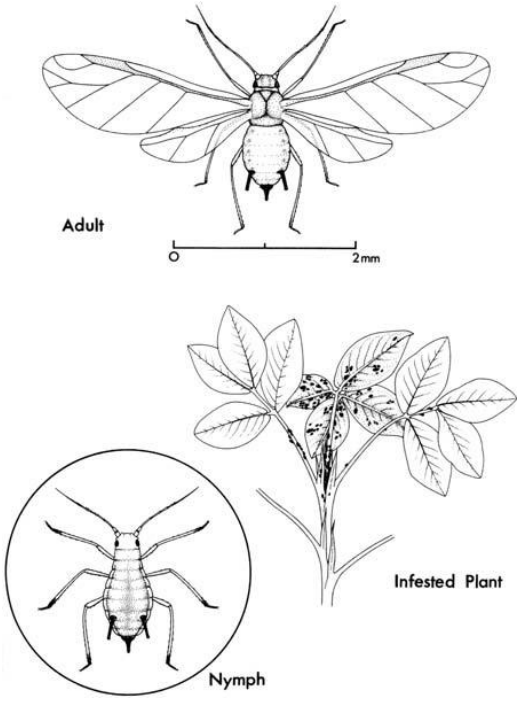


Ex.No. 7

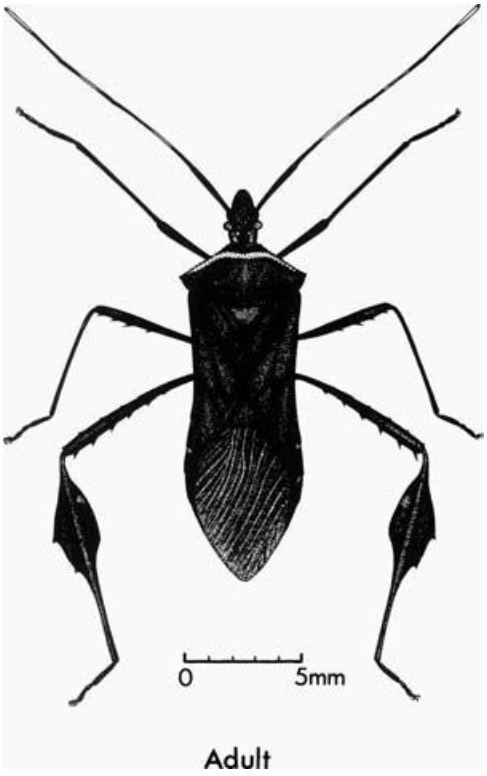
Groundnut Hopper



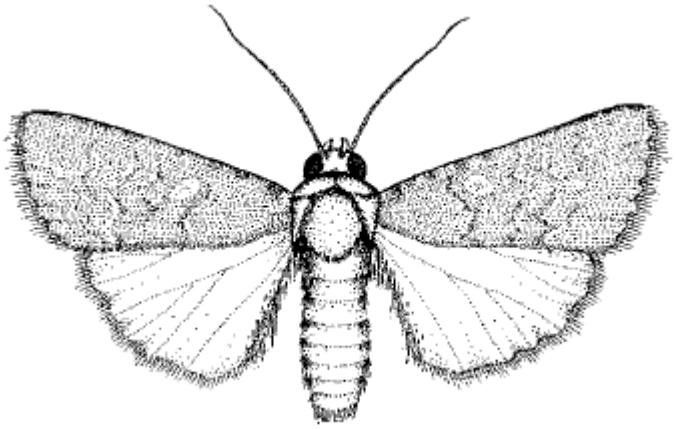
Groundnut Aphid



Groundnut Leaf-footed Plant Bug

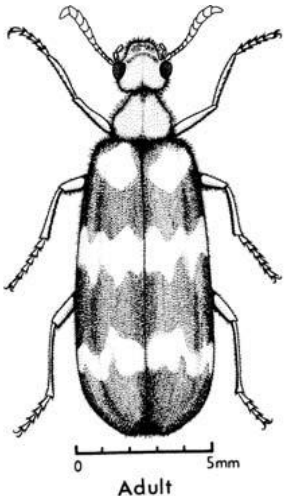


Armyworm

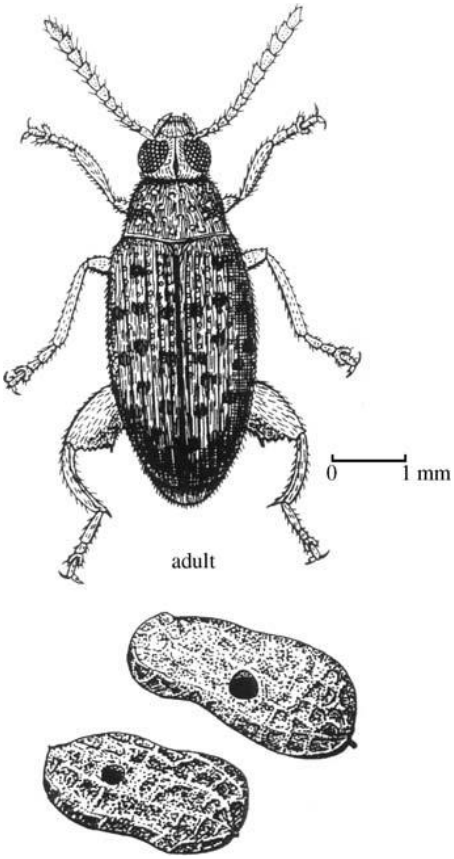


Ex.No. 7

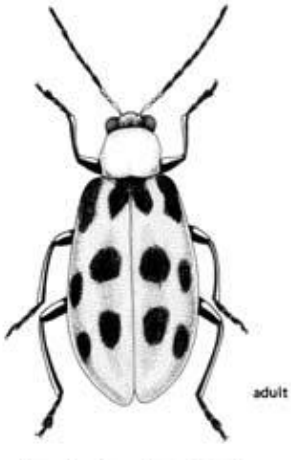
Blister Beetles



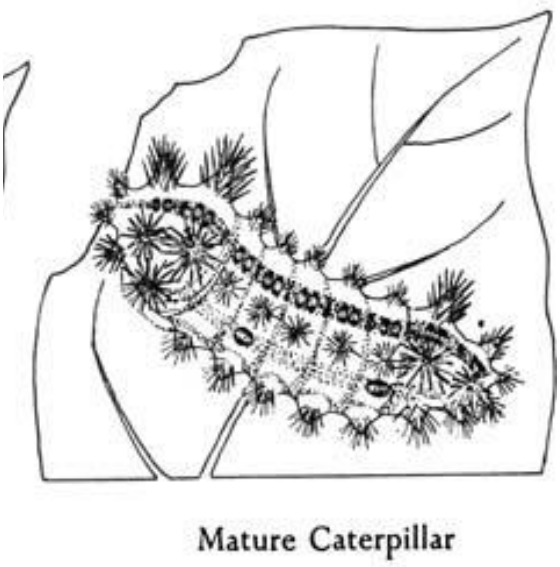
Groundnut Borer;



Spotted Beetle.

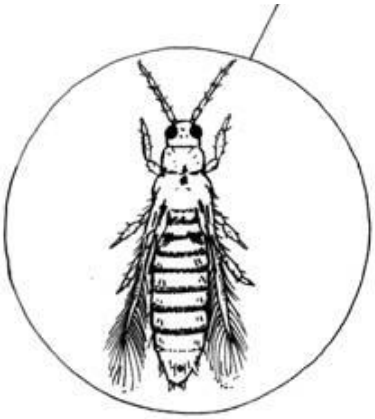


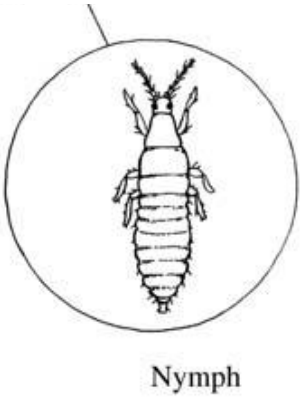
Stinging Caterpillar



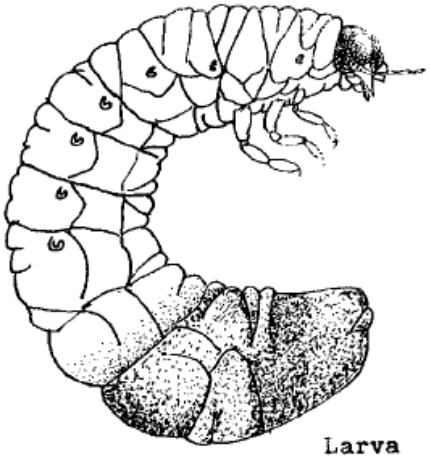
Ex.No. 7

Flower Thrips

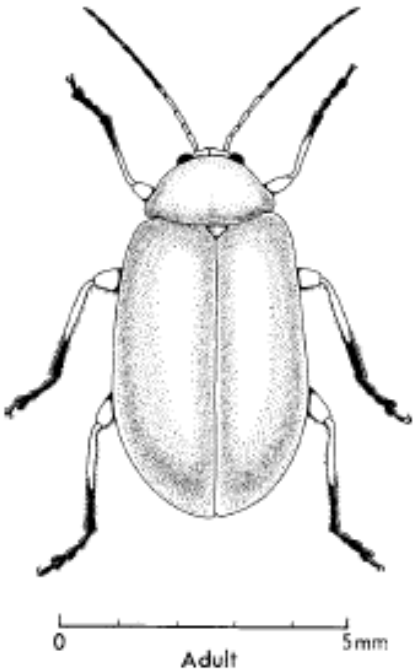




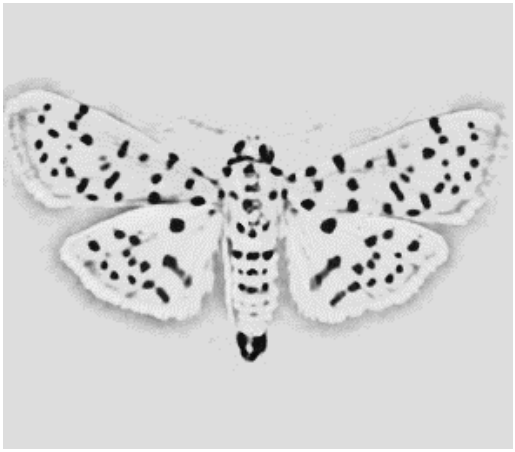
Chafer Grubs



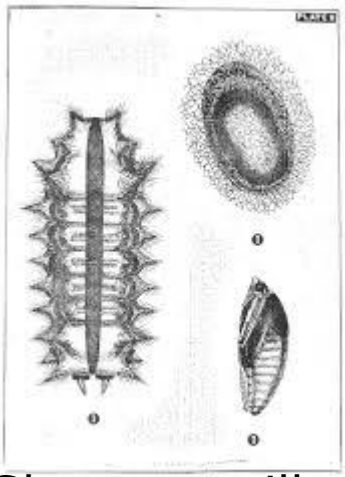
Brown Leaf Beetle



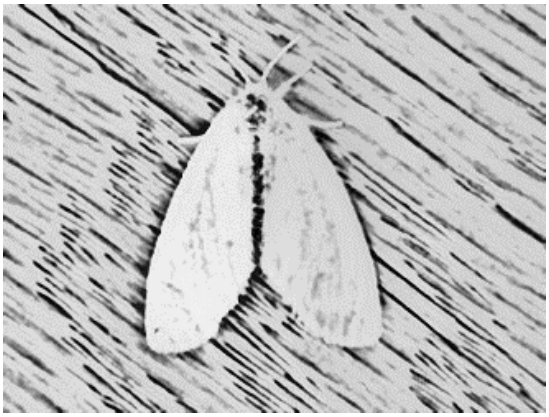
Ex. No: 8



Capsule & Shoot borer

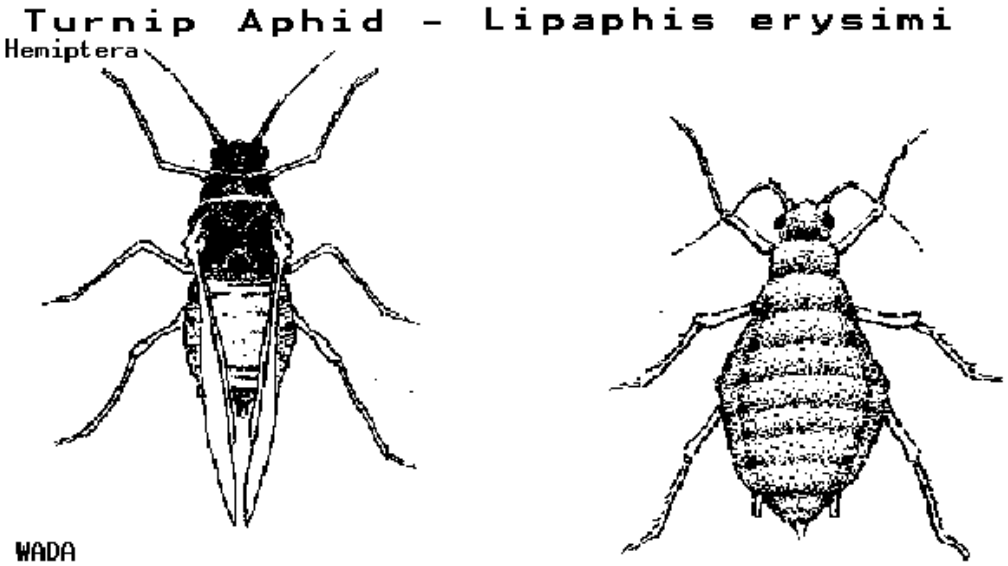


Slug caterpillar

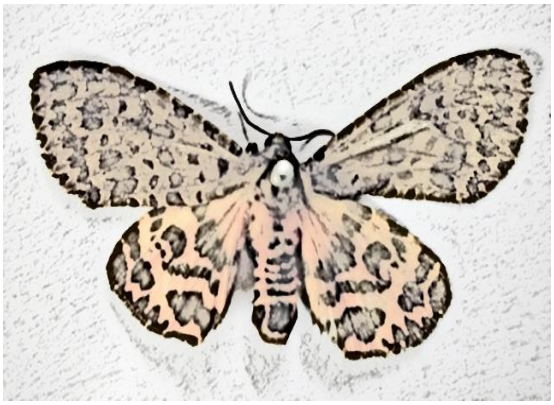


Hairy caterpillar

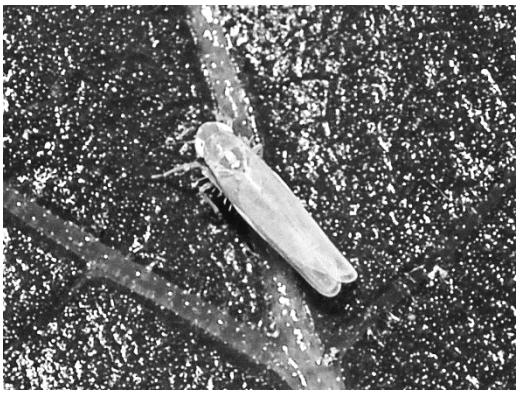
Castor butterfly



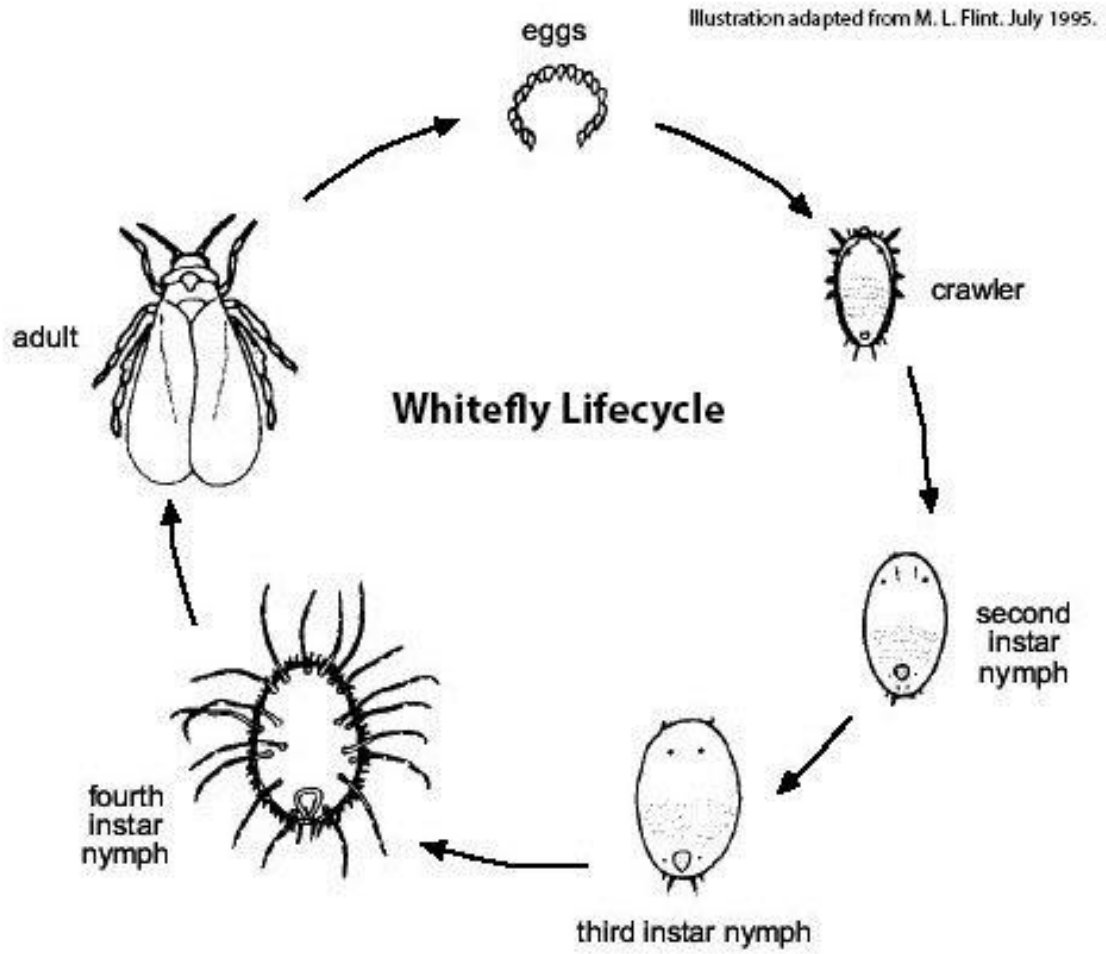
Ex. No: 8



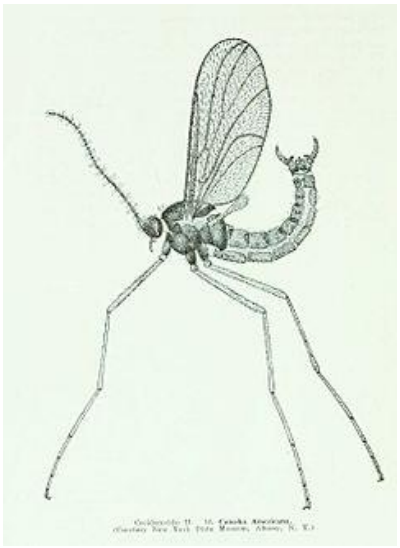
Wooly bear



Leaf hopper attack
on underside of the leave



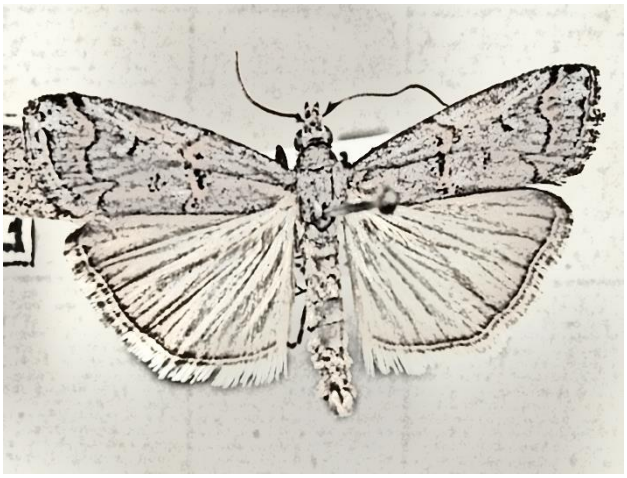
Ex. No: 8



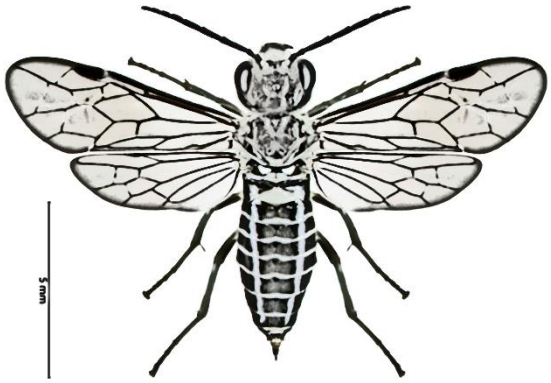
Castor gall fly

Sailor butterfly

Head / Capsule borer

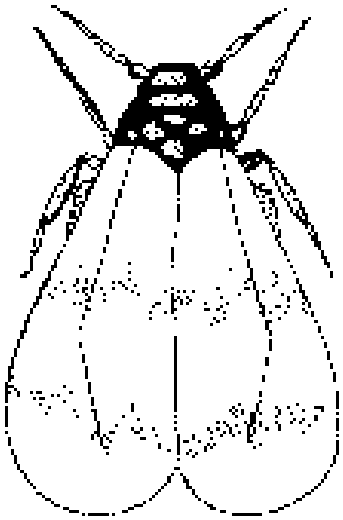


Jatropha Leaf webber



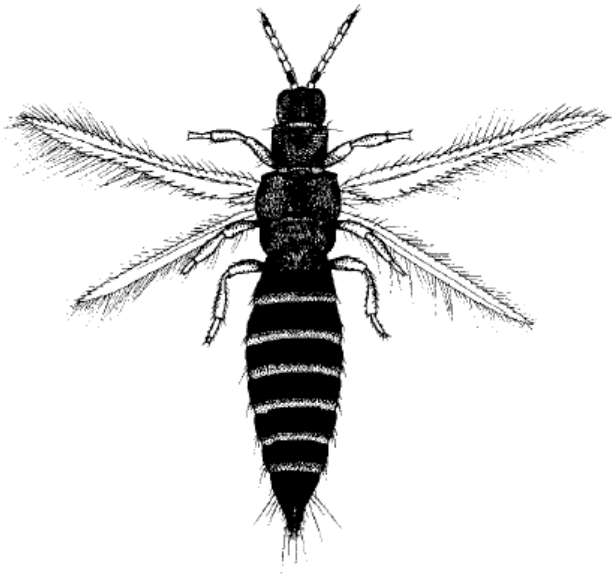
Mustard Sawfly

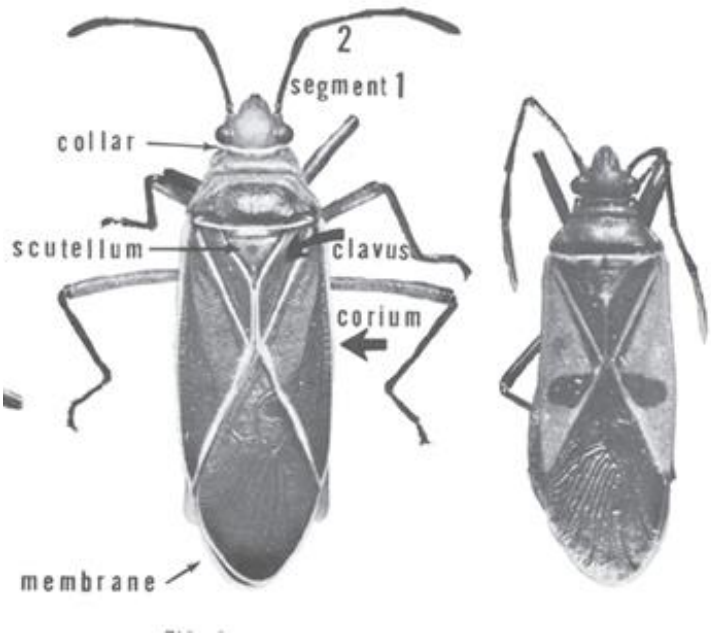
Ex. No: 9



Cotton whitefly

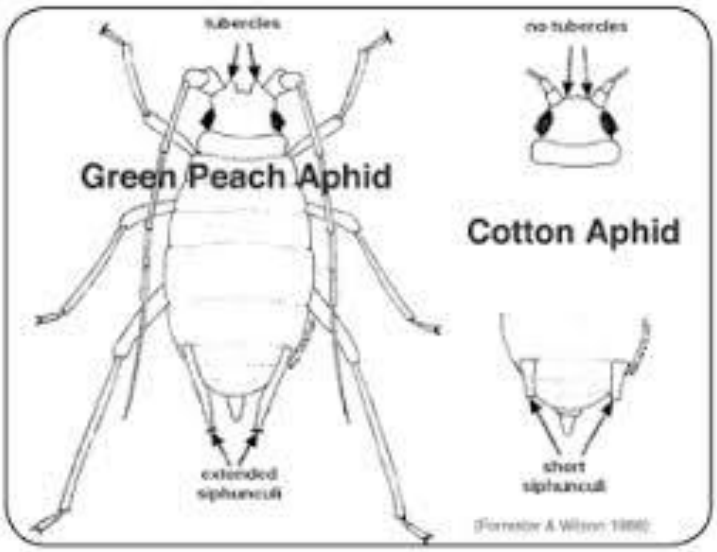
Cotton Thrips





Red cotton bug

Ex. No: 9



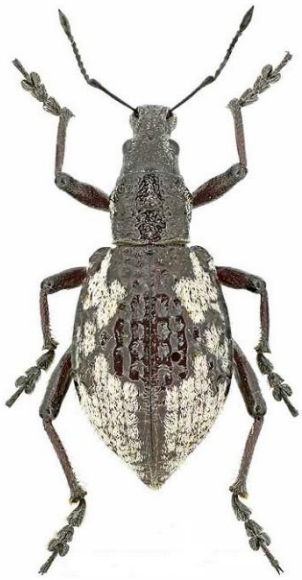
Symptom in underside of leaves

Cotton aphid

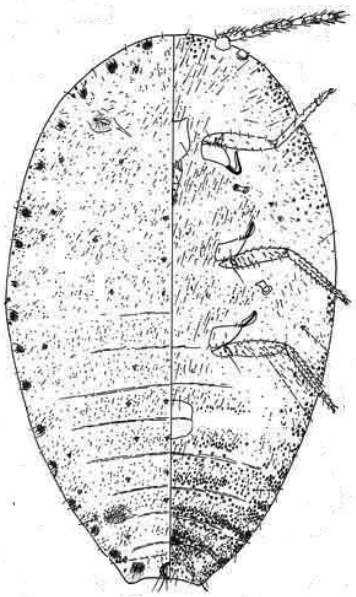
Cotton
Leafhopper / Jassid

Symptom of Cotton
Spiralling whitefly

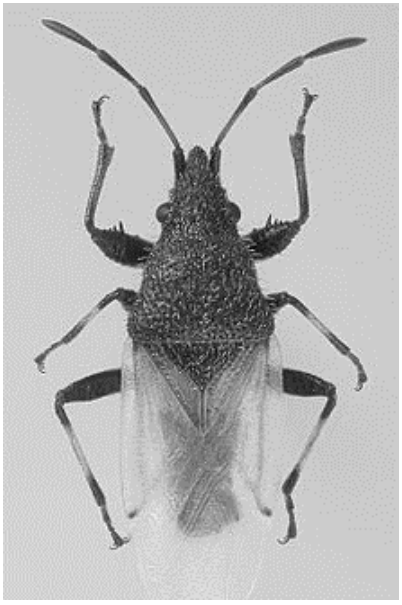
Ex. No: 9



Stem weevil



Black scale



Dusky cotton bug

Ex. No: 10

Pink Bollworm

Moth

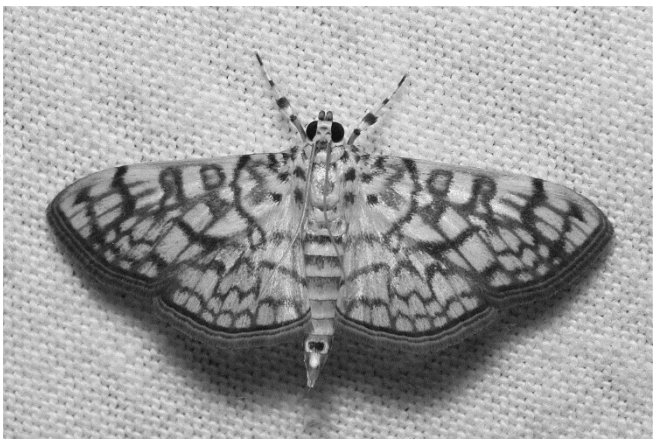
Caterpillar

Spiny Bollworms

E. insulana
(Male)

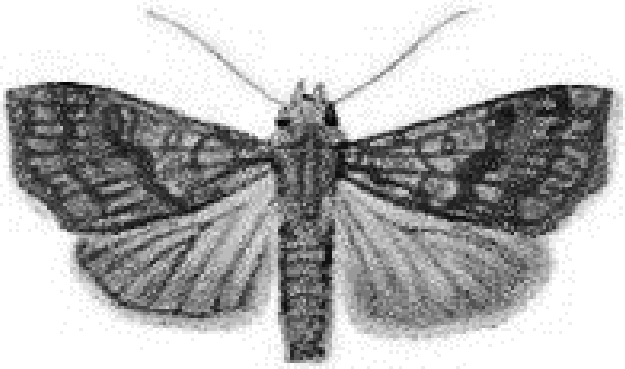
Caterpillar

Tobacco Cutworm

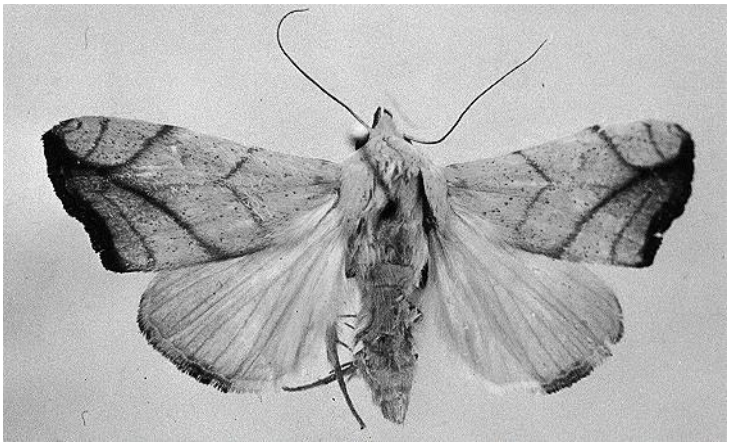


Leaf roller

Ex. No: 10



Anomis flava



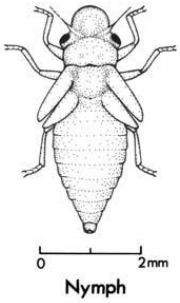
Xanthodes graelsi

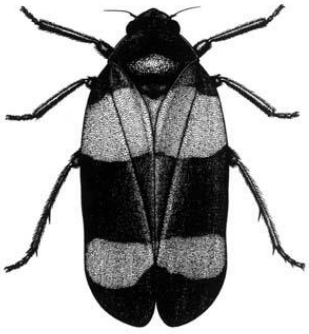
Tarache nitidula

Semilooper complex in cotton

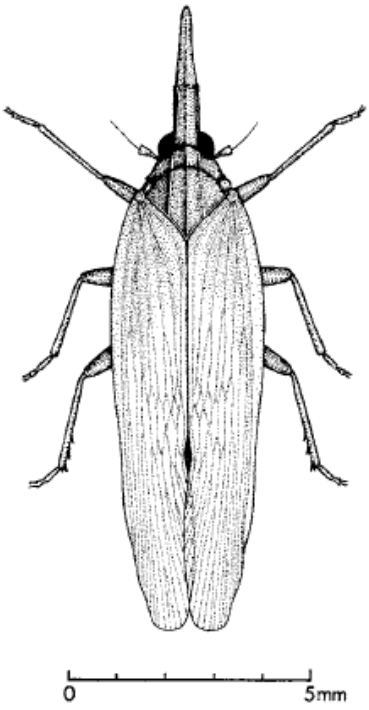
Ex.No. 11

Sugarcane Spittlebugs

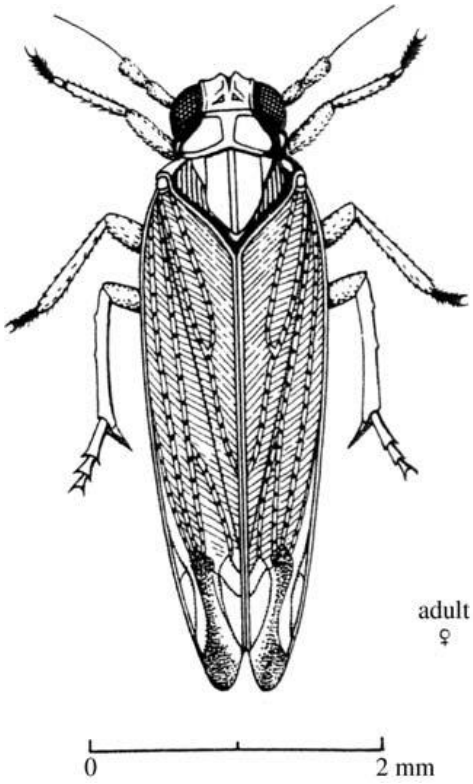




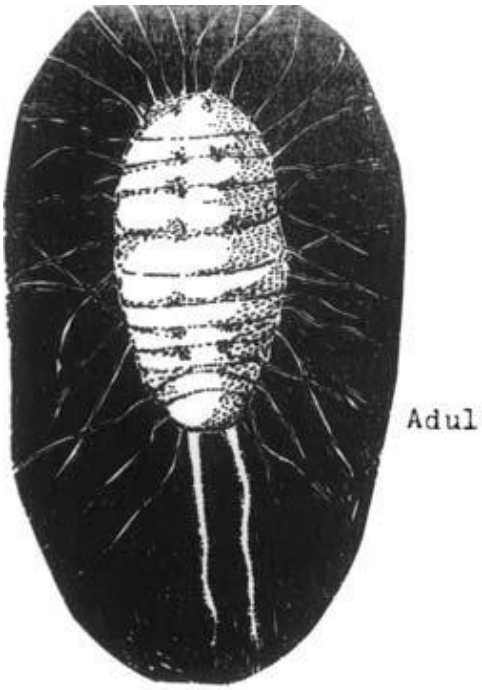
Sugarcane Leafhopper



Sugarcane Planthopper

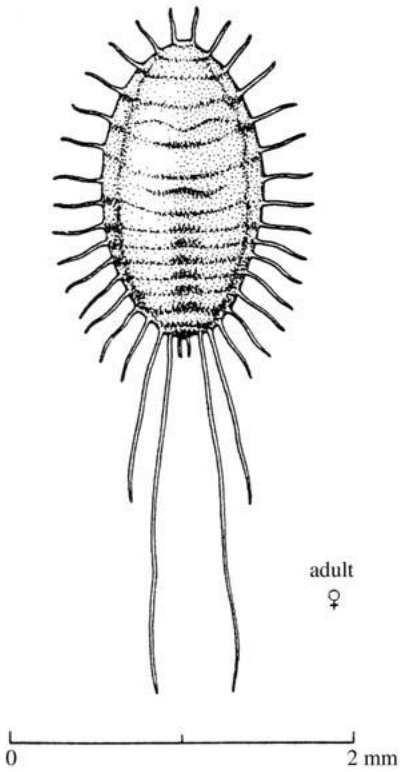


Sugarcane Striped Mealybug

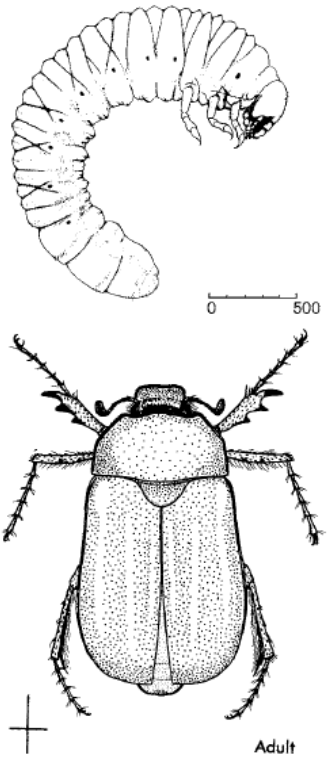


Ex.No. 11

Sugarcane Long-tailed Mealybug

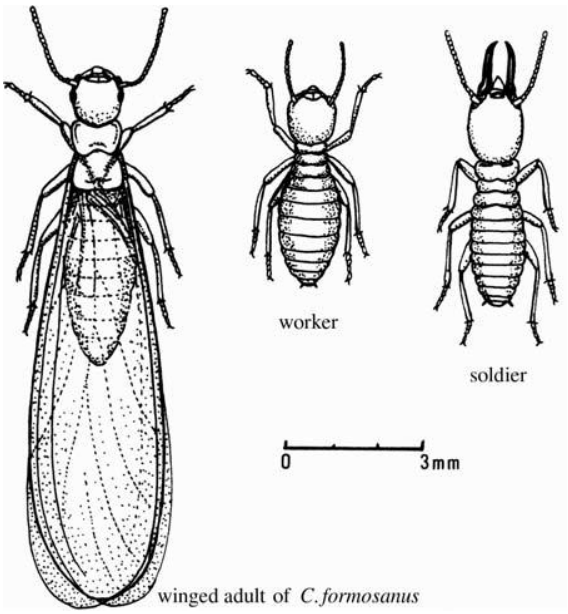


Sugarcane Whitegrub

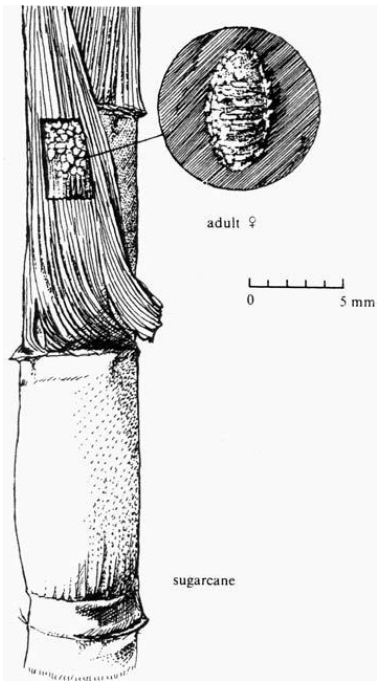


Termites

Coptotermes spp.



Pink Sugarcane Mealybug

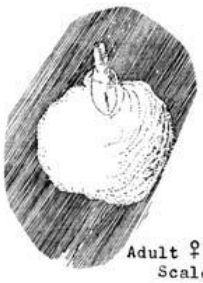


Ex.No. 11

Sugarcane Scale


Infested Cane

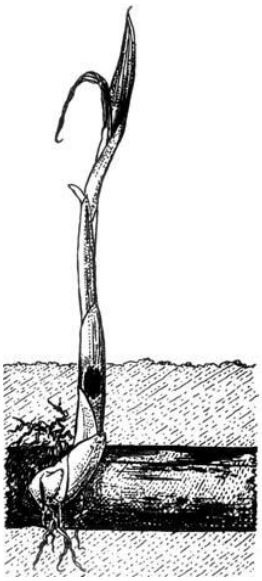

Adult ♀ without Scale


Adult ♀ with Scale

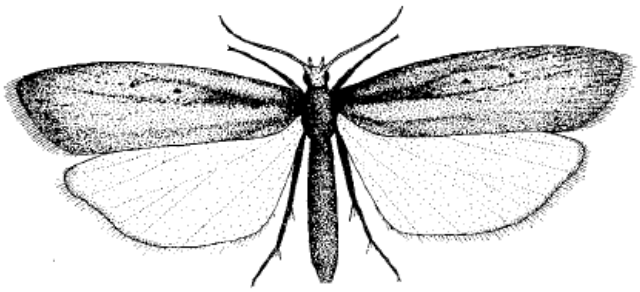
Sugarcane Beetle


Eggs on Soil

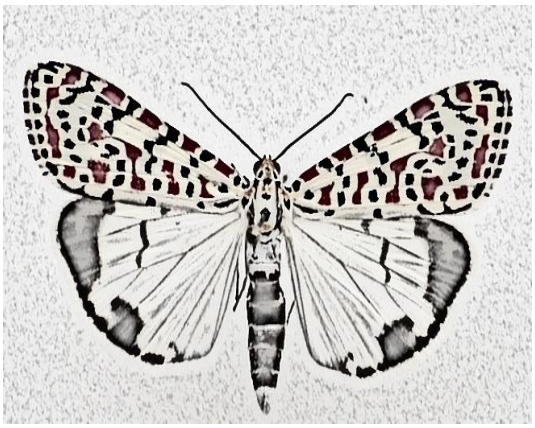

Adult


Damaged Plant

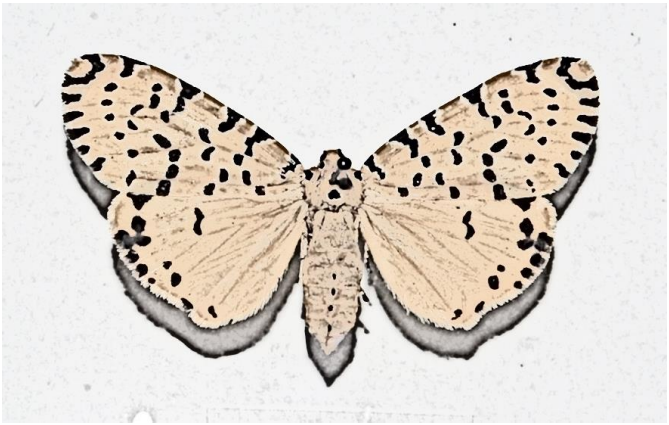
Sugarcane Stalk Borer



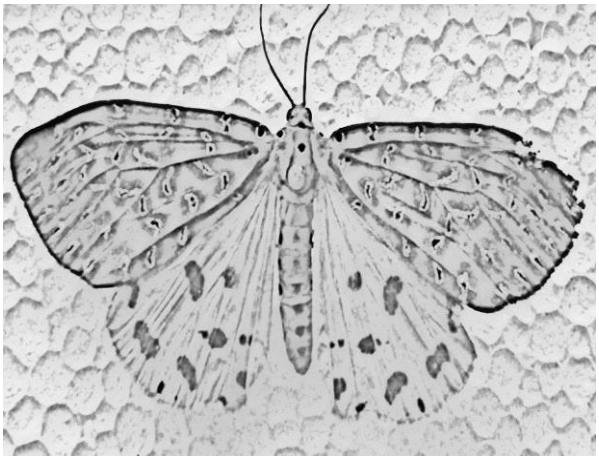
Ex. No: 12



Utethesia pulchella



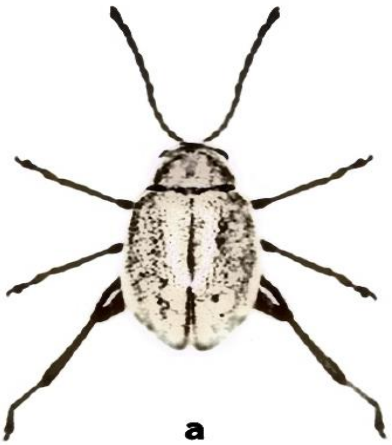
Argina cribraria



Argina syringa,

Hairy caterpillar complex

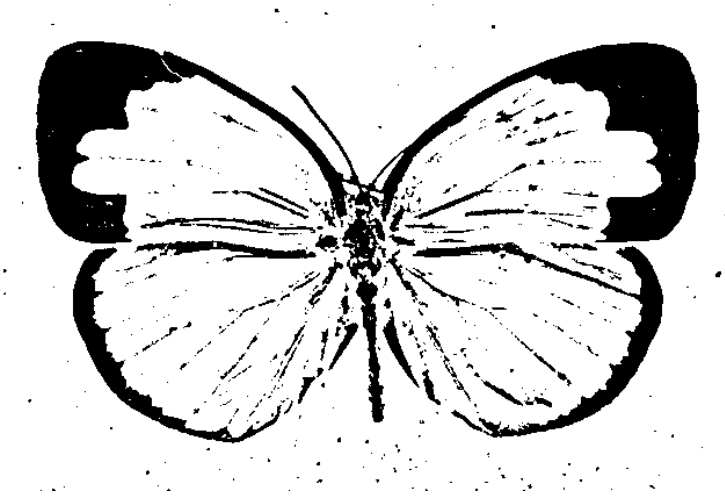
Ex. No: 12



Flea beetle

Sesbania stem borer

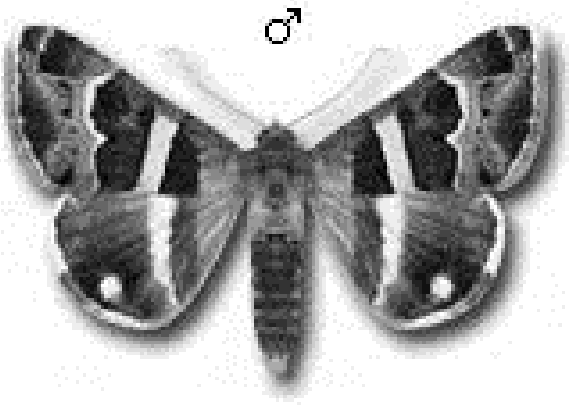
Green semilooper



Pierid butterflies

Ex. No: 12

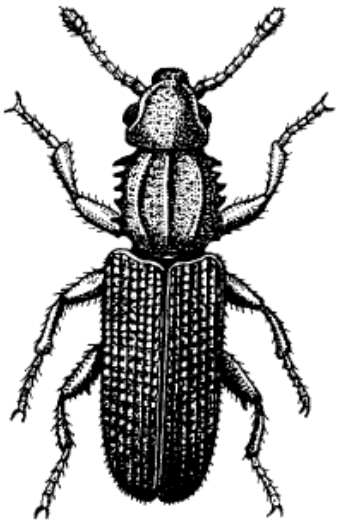
Mottled emigrant



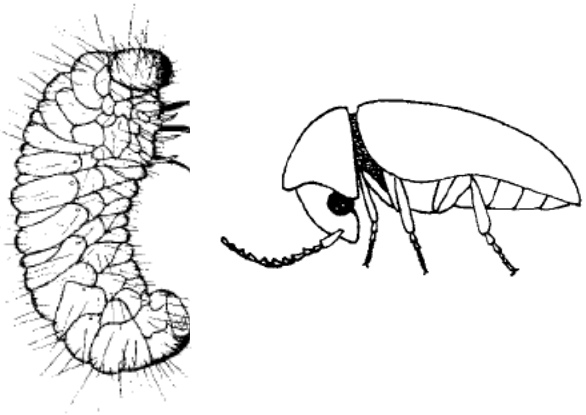
Semilooper

Ex.No. 13

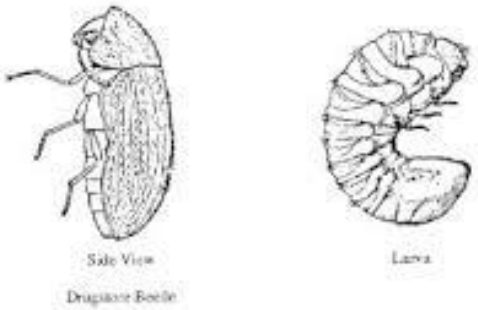
Saw-toothed Grain Beetle;



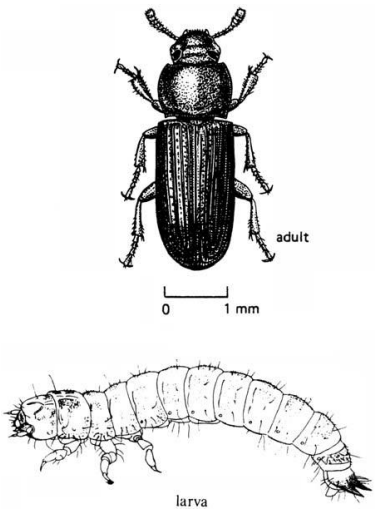
Cigarette Beetle



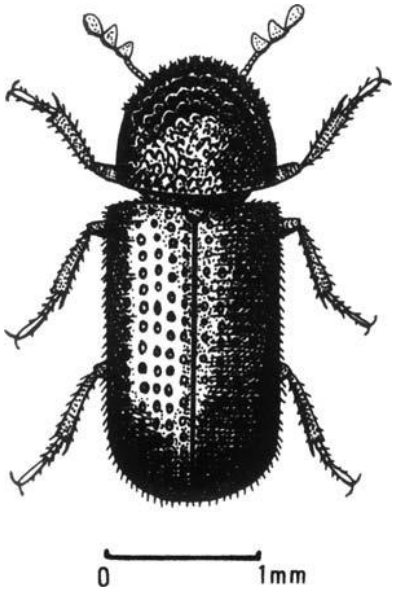
Drug store Beetle



Red flour beetles

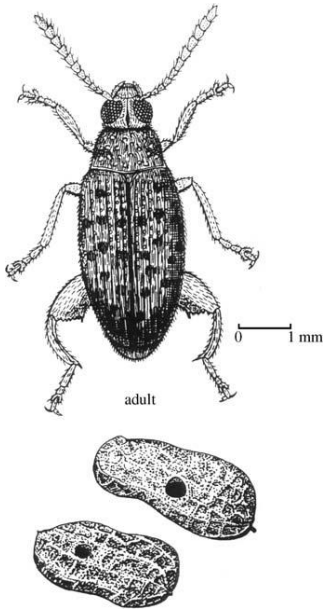


Lesser Grain Borer

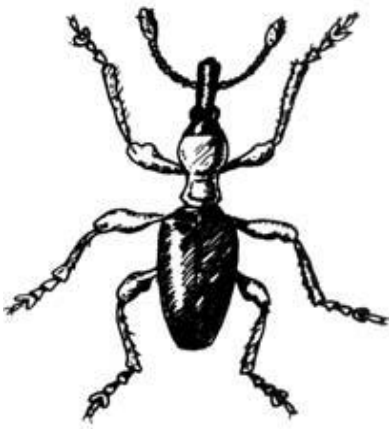


Ex.No. 13

Groundnut / Tamarind beetle



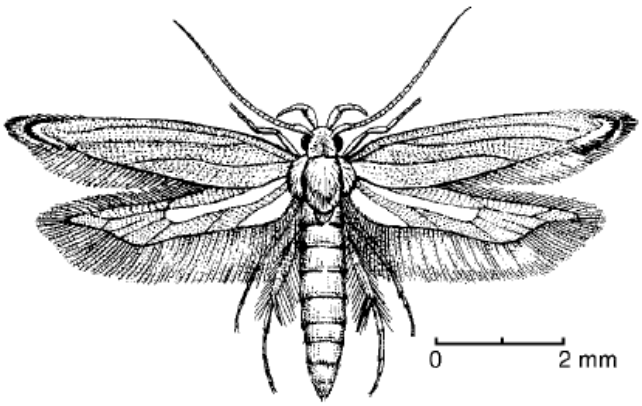
Sweet Potato Weevil



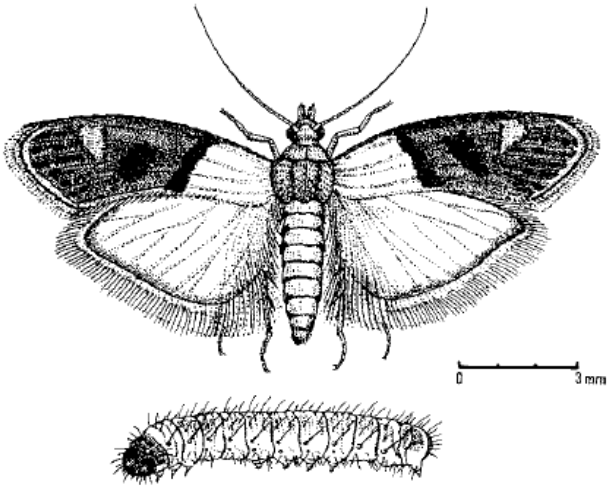
C. formicarius

Potato Tuber Moth

Angoumois Grain Moth

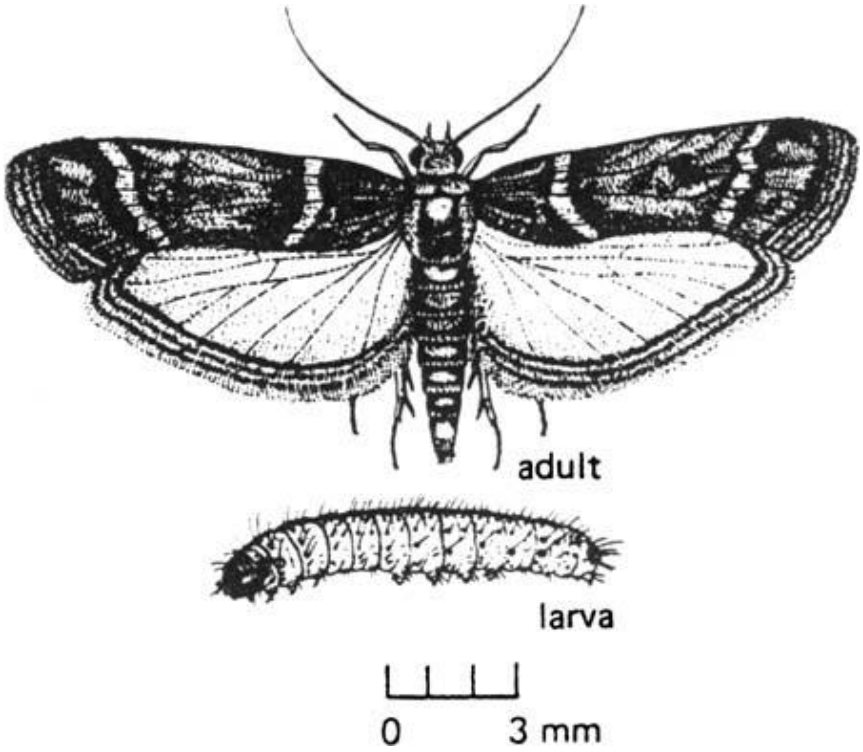


Indian Meal Moth

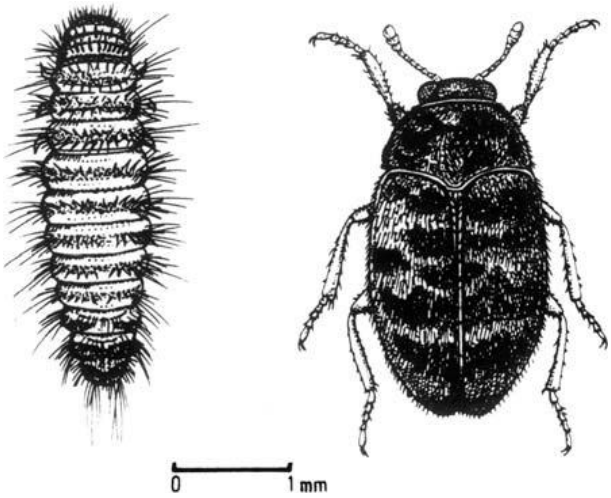


Ex.No. 13

Warehouse Moth

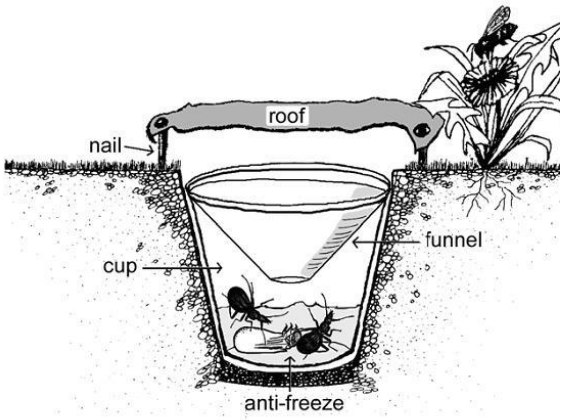


Khapra Beetle

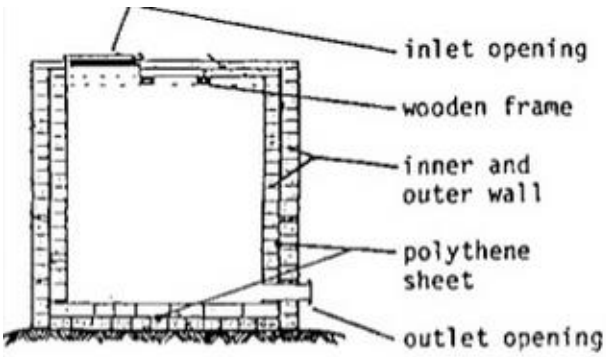


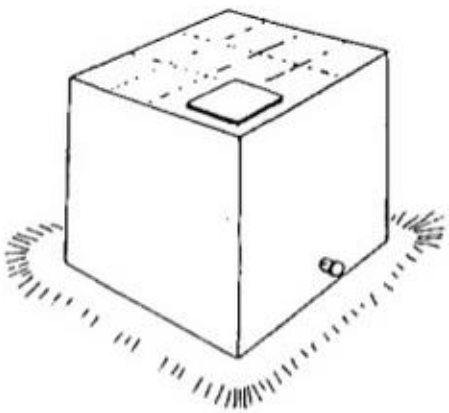
Ex. No: 14

TNAU insect probe trap



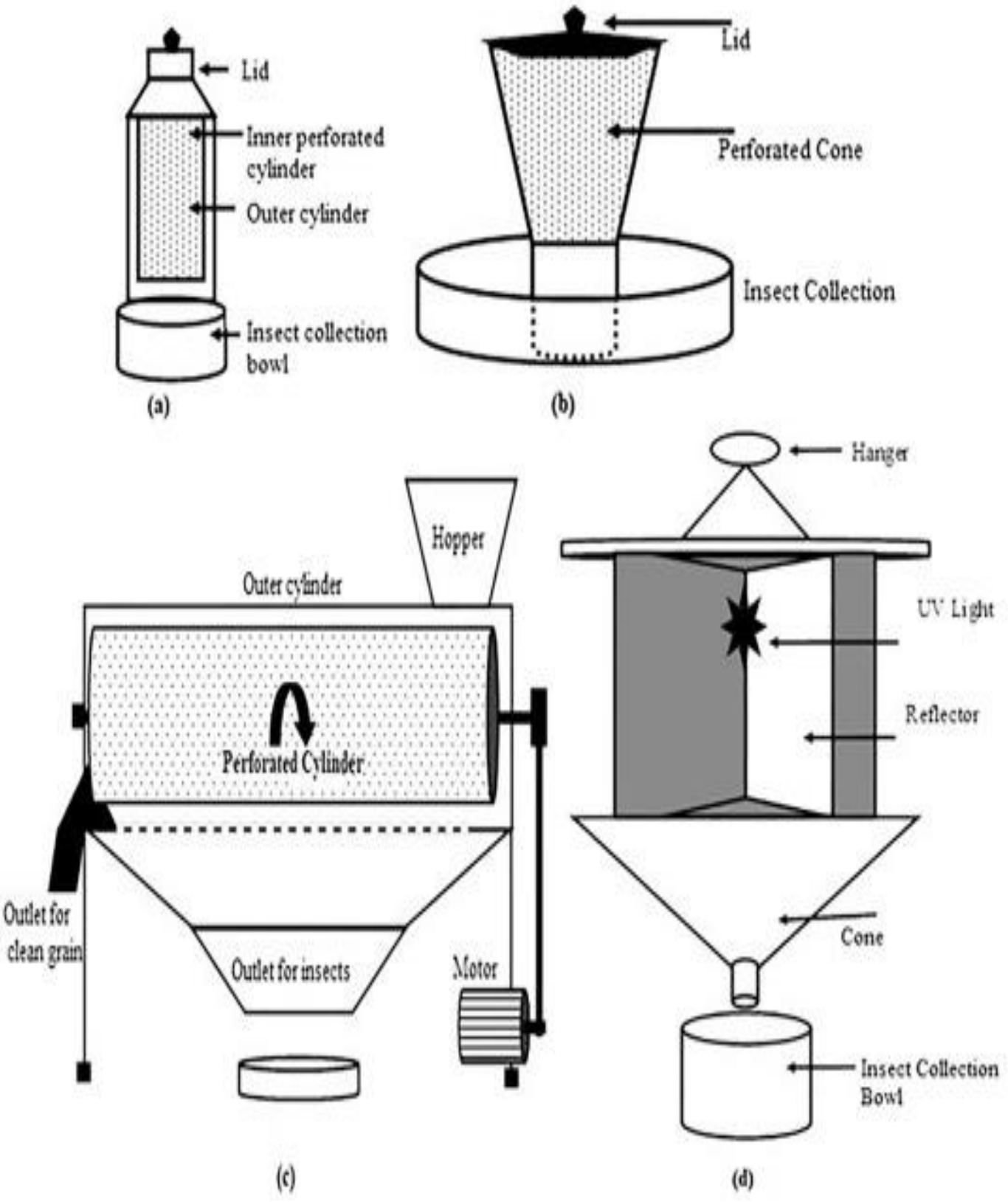
TNAU pitfall trap





Pusa bin

Ex. No: 14



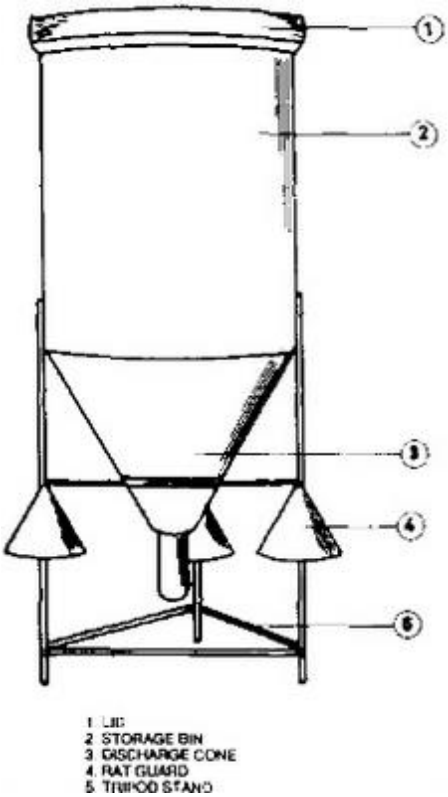
a. Automatic insect removal bin

b. TNAU indicator device

c. TNAU insect egg remover

d. TNAU- UV light trap

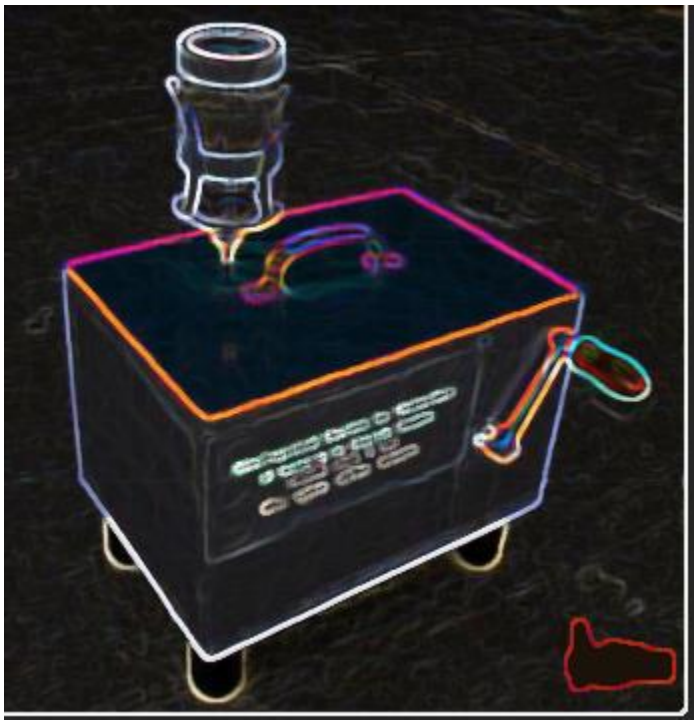
Ex. No: 14



PKV akola bin

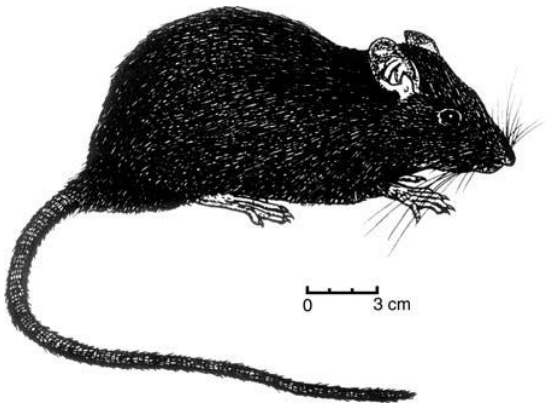
TNAU stack probe trap

Entoleter

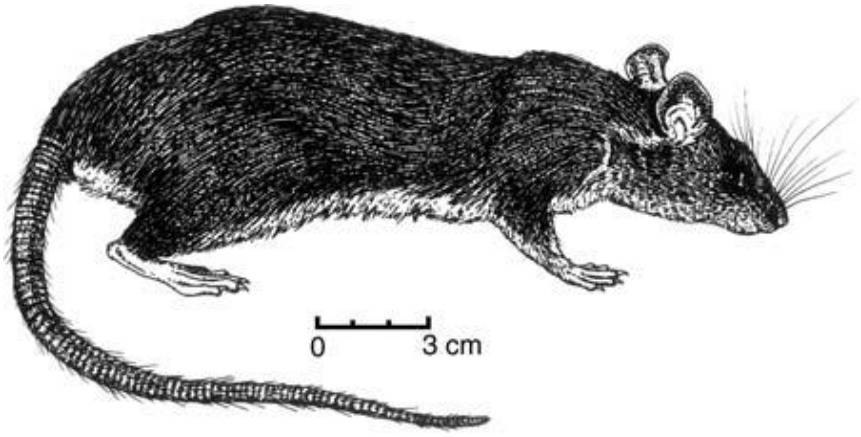


CIPHET mechanical device

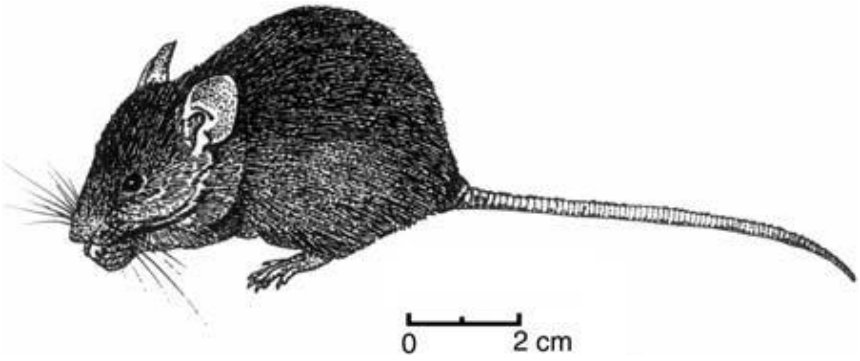
Ex.No. 15



Rattus rattus

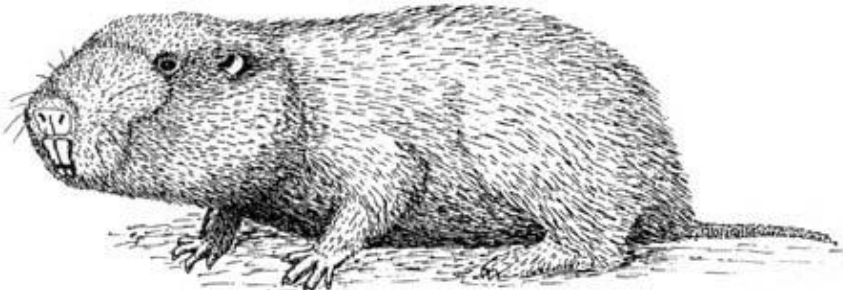


Rattus norvegicus

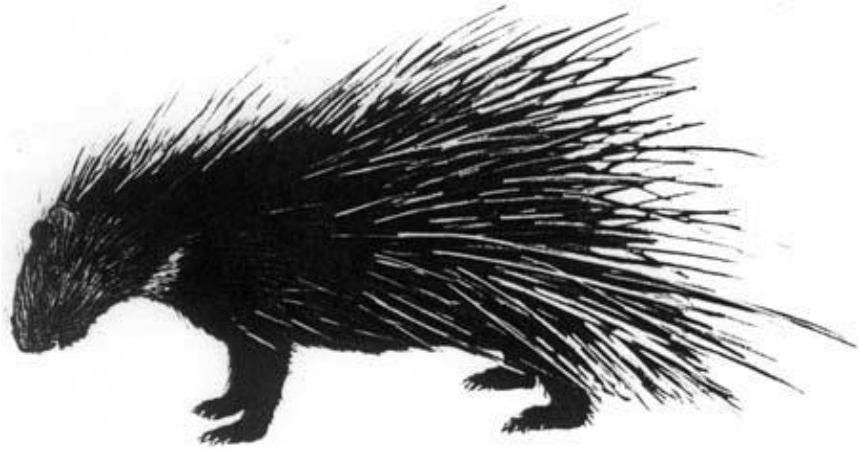


Mus musculus

Ex.No. 15



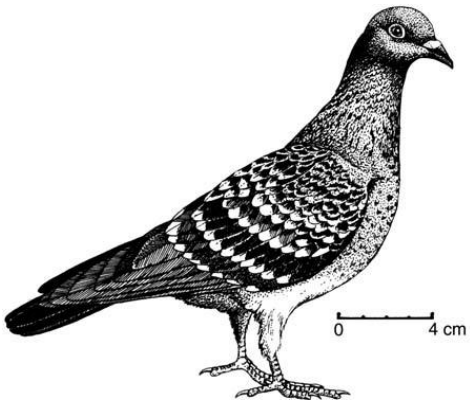
Common Mole Rat



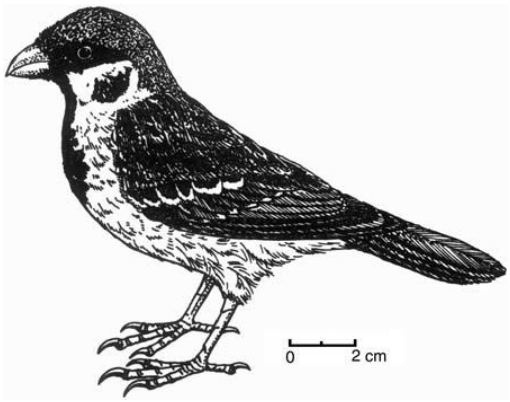
Porcupines

Ex.No. 15

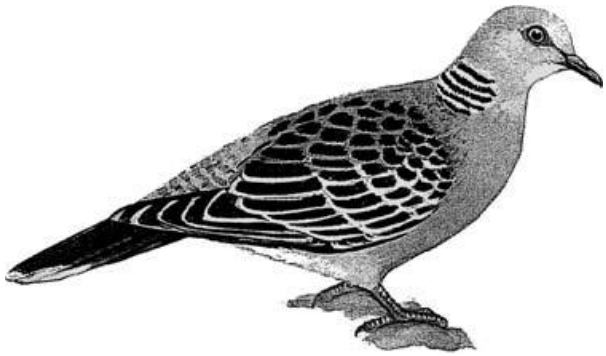
Pigeons



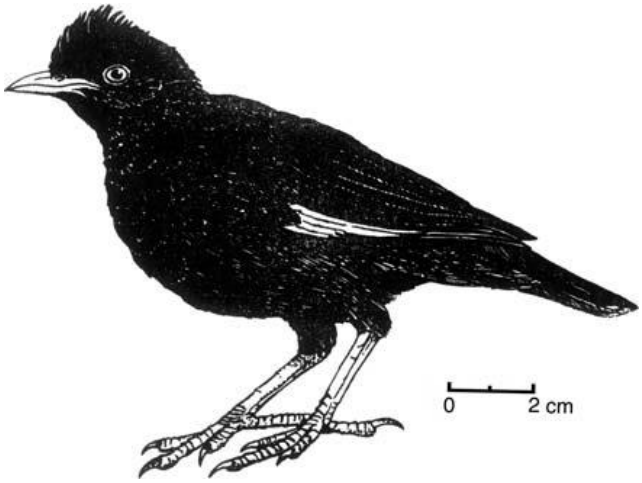
Sparrows



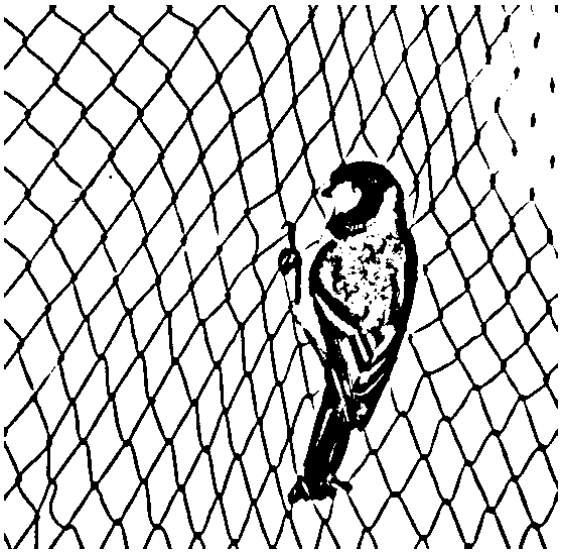
Doves



Common Mynah



Ex.No. 15



Bird perches

Acetylene gun