Lab Manual
on
Pests of Horticultural Crops and their Management and Beneficial Insects

Course Code: ASEN3204
Credits: 3(2+1)

By
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Centurion UNIVERSITY
Shaping Lives...
Empowering Communities...

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Ex. No: 1 **Date:**

Identification of Typical Symptoms of Damage by various Phytophagous Insects

Insects inflict injury to plant either directly or indirectly to secure food. Almost all portions of plant *viz.*, roots, stem, bark, leaves, buds, flowers and fruits are attacked. The study of signs/ symptoms exhibited by different parts of the plant due to the damage caused by the insect pests are known as symptomatology. Based on the nature and symptoms of damage, insects can be classified into different groups as mentioned below:

1. **Stem Borers**
   Larvae enter into the stem/ tillers and feed on internal contents. As a result, damaged part is cut off from the main plant and affected part wilts, dries up and exhibits symptoms like dead heart/ white ear/ bunchy top.
   e.g. Stem Borers of Paddy, Millets, Sugarcane and Brinjal
2. **Shoot Borers**
   Larvae attack tender shoots and bore inside during the vegetative stage of crop growth and cause wilting, drooping of terminal plant part which later dries up.
   e.g. Shoot Borers of Brinjal, Bhendi, Cotton, Castor, Shoot Fly of Sorghum and Black Gram Stem Fly.
3. **Defoliators/ Skeletonizers**
   Larvae feed on the leaves completely leaving only midrib/ veins or scrape the chlorophyll content of leaves or cause numerous holes.
   e.g. Castor Semilooper, Red Headed Hairy Caterpillar, Bihar Hairy Caterpillar, Snake Gourd Semilooper, Ash Weevils, Tobacco Caterpillar, Brinjal Epilachna Beetle
4. **Leaf Miners**
   Larvae mine leaves/ leaflets between the epidermal layers and feed on greenish matter, resulting in the appearance of translucent white patches/ zig-zag galleries on leaves.
   e.g. Leaf Miners of Citrus, Cashew and Rice Hispa.
5. **Leaf Webbers**
   Larvae web leaves/ leaflets by means of silken threads and feed on the chlorophyll content by remaining within the web. Often faecal pellets/ frass are found within the web.
   e.g. Leaf Webbers on Gingelly, Ground Nut, Sapota, Mango and Cashew Shoot Webber.
6. **Leaf Folders**
   Larvae fold leaves from tip to base/ longitudinally/ margin to margin there by giving appearance of a fold/ roll.
   e.g. Rice Leaf Folder, Cotton Leaf Folder

7. Gall Makers

Larvae feeding inside the stem/ tiller/ leaf/ flower bud, stimulates excessive growth of cells at the affected portion and distorts normal growth. It results in malformation of plant parts, exhibiting gall formation.

e.g. Paddy Gall Midge, Tobacco Stem Borer, Cotton Stem Weevil, Mango Inflorescence Midge, Chilli Midge

8. Pod/ Capsule Borers/ Boll Worms

During the reproductive stage of crop, larva enter into the pods, capsules and feed on the seeds/ lint exhibiting symptoms like webbed condition of pods/ bolls or web few pods/ capsules with frass and excreta or holes of different sizes and shapes/ damaged tissues (Chilli)/ lint (Cotton).

e.g. Spotted Pod Borer, Capsule Borers of Castor and Gingelly, Red Gram Pod Fly, Tobacco Caterpillar, Gram Caterpillar, Pink Boll Worm

9. Fruit Borers

Larvae enter into the tender fruits and feed on fresh matter/ pulp and plug the larval burrow with excreta. e.g. Fruit Borer of Brinjal/ Bhendi/ Tomato, Mango Stone Weevil, Cashew, Apple and Nut Borer.

10. Bark Borers

Larvae remain in a small tunnel at the axils of branches, under the bark, constructing galleries of frassy web on the stem and near bark/ angles of branches and move about, conceal inside the silken gallery and feed on the bark by scraping.

e.g. Bark Eating Caterpillars of Citrus, Mango, Guava, Casuarinas

11. Tree Borers

Larvae bore deep into the tree trunk, make the tunnels in zig-zag manner and feed on inner tissues, arresting translocation of sap to top portions of tree, there by the trees exhibit symptoms like yellowing, withering of leaves, drying of twigs or complete drying of tree. Sometimes, gummy material oozes from the affected portion on the tree trunk. e.g. Tree Borers of Mango, Cashew, Coconut Red Palm Weevil

12. Root Feeders

Larvae feed on root/ root nodules or nymphs and adults suck sap form the roots resulting in stunted growth/ poor tillering/ drying of plants in isolated patches.

e.g. White Grubs, Termites, Rice Root Weevil and Ragi Root Aphid.

13. From Fruits

Holes, plugged with excreta/ forming necrotic patches/ rotting on fruit. e.g. Fruit Flies, Fruit Sucking Moths.

14. Seed Feeders (Stored Grain Pests)

Larvae feed on stored seeds either as internal/ external feeders/ by webbing the food particles.

e.g. Rice Weevil, Red Rust Flour Beetle, Rice Moth

15. Sap Feeders

1. **From Grain:** Nymphs and adults suck juice from developing ovaries/ milky grains resulting in the formation of shrivelled/ chaffy grains
   e.g**.,** Rice Gundhi Bug, Sorghum Earhead Bug, Sorghum Midge
2. **From Tender Plant Parts:** Nymphs and adults suck sap from the base of the plant/ leaves/ tender terminal plant parts/ flowers, thereby affect the vigour and growth of the plants. Different insects exhibit different symptoms. In case of severe infestation, sooty mould develops on the plant parts covered with honey dew excreted by insects while feeding.

Table 1.1 Characteristic symptoms of damage caused by different pests

Sl. No.	Symptoms	Example
1	Hopper burn, complete drying of leaves and plants in patches, giving scorched appearance	Paddy Brown Planthopper, White Backed Plant Hopper, Paddy Leafhopper
2	Curling of leaf margins/ mottling/ Necrotic patches	Cotton Leafhopper
3	Upward curling of leaves	Chilli Thrips
4	Downward curling of leaves/ elongation of petioles of older leaves/ reduction in leaf size and clustering at tip of branch/ brittleness	Chilli White Mites
5	Leaf drying from top to bottom	Onion Thrips
6	White/ yellow blotches on upper surface of leaves	Mites on Castor/ Coconut/ Bhendi.
7	Reduced vigour/ sooty mould/ square/ flower drop	Whiteflies on Cotton
8	Yellowing/ crinkling of leaves	Thrips on Ground Nut, Pulses
9	Reduced vigour/ stunted growth/ yellowing/ sooty mould	Aphids

Q. Draw any 8 important horticultural pests with their characteristic symptoms of damage with proper labels.

Ex. No: 2 **Date:**

Identification of Insect Pests of Vegetables and Their Damage Symptoms

Table 2.1Marks of identification, nature and symptoms of damage caused by insect pests of vegetable crops

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
BRINJAL			
1. EPILACHNA BEETLE: *Henosepilachna viginctioctopunctata* Fabricius, Coccinellidae: Coleoptera	**Adult:** An yellow hemispherical beetle with 12-28 black spots on elytra. Head partly concealed by pronotum. **Grub:** Body yellowish broad anteriorly and narrow posteriorly and covered with spiny structures all over.	Both grubs and adults scrape the leaves in characteristic manner and feed (ladder like scrapings). They confine their feeding activity mostly to the lower side of leaves.	
2. SHOOT AND FRUIT BORER: *Leucinodes orbonalis* Guenee, Pyralidae: Lepidoptera	**Adult:** White moth with pink brown markings on wings and blackish brown head and thorax. **Caterpillar:** Pinkish with sparingly disturbed hairs arising on warts all over the body.	If infestation occurs during vegetative phase, caterpillars enter into the petiole, midribs and young shots. As a result, the infested shoot wilts and droops. During fruiting stage, caterpillars enter into fruits make holes and feed inside. Initially, the entry hole is so small that it is not visible. Later, fruits bear large circular holes plugged with excreta.	

1	2	3	4
3. BRINJAL STEM BORER: *Euzophera perticella* Rag. Pyralidae: Lepidoptera	**Adult:** Medium sized with greyish brown forewings having transverse lines in the middle and white hind wings. **Caterpillar:** Creamy white in colour.	Caterpillar enters into stem near the axil of leaf/ branch at ground level of the plant. Excreta can be seen coming out of the entry hole. An infested plant wilts and dries up.	
4. MEALY BUG: *Centrococcus insolitus* (G.), Pseudococcidae: Hemiptera	**Adult:** Brownish/pinkish and oval in shape. Body covered with white waxy filamentous material.	Colonies of nymphs and adults suck sap from lower side of leaves, tender shoots and fruit stalks. Infestation results in yellowing and drying of plants. Infested leaves look as if white washed.	
5. BRINJAL MITE: *Tetranychus telarius* L., Tetranychidae: Acarina		Feed on lower surface of leaves by remaining underneath a web in case of red spider mites. Infested leaves curl down become hard and crisp and ultimately shed.	
BHENDI			
1. SHOOT AND FRUIT BORER: *Earias vittella* Fabricius, *E. insulana* Boisduval, Noctuidae: Lepidoptera	**Adult:** Fore wings of *E. vittella* are pale white with a broad greenish transverse band in the middle while those of *E. insulana* are completely green. **Caterpillar:** Brownish white with a dark head and prothoracic shield. Body surface is irregularly spotted and shiny.	Insect first appears on the crop about 6 weeks after sowing and initially damages the tender shoots by boring into them, which results in drooping of shoots. In the later stages, larvae bore into the flower buds and fruits. Larval feeding results in severe shedding of early formed flower buds.	

1	2	3	4
2. LEAFHOPPER: *Amrasca biguttula biguttula* (Ishida), Cicadellidae: Hemiptera	**Adult:** Wedge shaped with two black spots on vertex and a black spot on each forewing. **Nymph:** Greenish varying from less than a millimetre to about 3 mm.	Both nymphs and adults suck sap from leaf tissues. During the process of de-sapping, they inject a toxin into plant tissue, resulting in hopper burn. Infestation results in general mottling accompanied by curling	
CRUCIFERS			
3. DIAMOND BACK MOTH: *Plutella xylostella* Linnaeus, Plutellidae: Lepidoptera	**Adult:** Small grayish brown with narrow forewings having pale white marking at anal region which form a diamond like patch, when folded. **Caterpillar:** Small greenish with short hairs on body which tapers towards both the ends.	Caterpillars feed on the lower side of leaves and bite holes on leaves. Affected leaves present a withered appearance. In severe case, leaves are skeletonized.	
4. CABBAGE BORER: *Helulla undalis* Fabricius, Pyralidae: Lepidoptera	**Adult:** Small pale brown with grey wavy lines and central elliptical marking on forewings. **Caterpillar:** Brownish with a black head and four longitudinal lines on the body.	Caterpillars web the leaves and bore into stem, stalk or leaf veins. They bore into the cabbage head also and make it unfit for consumption.	
5. CABBAGE LEAF WEBBER: *Crocidolomia pavonana* Zeller, Pyralidae: Lepidoptera	**Adult:** Small with light brownish forewings. **Caterpillar:** Bears red head with brown longitudinal stripes and rows of tubercles on the body.	Caterpillars web the foliage and skeletonize the leaves. Feed on flower heads in case of cabbage and cauliflower. Also feeds on flowers and pods in case of mustard.	

1	2	3	4
CUCURBITS			
1. FRUITFLY: *Bactrocera cucurbitae* Coquillet, *B. dorsalis* Hendel, Tephritidae: Diptera	**Adult:** Reddish brown fly with brown markings on wings. **Maggot:** Apodous, acephalous, dirty white, thicker at one end and tapering at the anterior end.	Maggots attack the fruits at immature stage and feed on the soft pulp of the fruits. It results in premature fruit drop. A resinous globule appears on the fruit at the place of oviposition.	
2. PUMPKIN BEETLE: *Raphidopalpa foveicollis* Lucas, *Aulacophora cincta* Fabricius, *A. intermedia* Jacob, Galerucidae: Coleoptera	**Adult:** *R. fovecollis* adults with reddish brown elytra. *A. cincta* adults have grey elytra with black border. *A. intermedia* adults have blue black elytra. **Caterpillar:** Creamy white with dark oval shield at back.	Adult beetles bite holes on the cotyledon leaves and flowers. Grubs damage the plants by boring into the roots and underground stems and sometimes fruits touching the soil.	
3. SNAKE GOURD SEMILOOPER: *Anadevidia peponis* Fabricius, Noctuidae: Lepidoptera	**Adult:** Dark brown with shiny brown fore-wings. **Caterpillar:** Greenish with white longitudinal line and black tubercles with thin hair arising on them. Last abdominal segment is humped.	Caterpillars defoliate the plants.	
4. SERPENTINE LEAF MINER: *Liriomyza trifoli* (Burgess), Agromyzidae: Diptera	**Adult:** Small black flies. **Maggot:** Leg less, orange yellow.	The maggot soon after emergence mines into the leaf and feed on the mesophyll tissues, resulting in characteristic serpentine white line ending in the shape of snake hood. Infested leaves sun scorch and drop. 50-90% leaves damaged in severe cases.	

1	2	3	4
5. PUPMKIN CATERPILLAR: *Palpita (Diaphania) indica* Saund, Pyralidae: Lepidoptera	**Adult:** Medium sized moth conspicuous with transparent white wings with dark broad marginal patches. **Caterpillar:** Elongate bright green caterpillar with a pair of longitudinal sub-dorsal white streaks.	Caterpillar feeds on leaves.	
AMARANTHUS			
1. AMARANTHUS CATERPILLAR: *Hymenia recurvalis* Fab. Pyralidae: Lepidoptera	**Adult:** Small to medium sized moth, wings are dark with white wavy markings. **Caterpillar:** Green and slender.	The caterpillars fold the leaves, top shoots and defoliate.	
CHILLI			
1. CHILLI THRIPS: *Scirtothrips dorsalis* Hood, Thripidae: Thysanoptera	**Adult:** A minute, delicate light yellow insect. Wings fringed with hairs. **Nymph:** Very minute and wingless.	Both nymphs and adults lacerate the leaf tissue and suck the oozing sap. Infested leaves start curling upwards, crumbling and drop down. Sometimes, even flowers and buds are infested. In severe infestation, the plant withers and finally dries up.	
2. CHILLI MITES: *Polyphagotarsonemus latus* Bank, *Tarsonemus transulcens* L. Tarsonemidae: Acarina	Mites are tiny, white, and transparent and found mostly under the lower side of leaves.	Both nymphs and adults suck sap particularly form terminal/axillary tender shoots a devitalize the plant. Infested leaves curl downwards along the margins. Petioles of older leaves are elongated.	

		Younger leaves get reduced in size and form a cluster at the tip of the branch. Affected leaves turn dark green and become brittle.	
3. CHILLI APHID: *Aphis gossypii* G. *Myzus persicae* S., Aphididae: Hemiptera	*A. gossypii*: Brownish green in colour. *M. persicae*: White/ light yellow in colour.	Both nymphs and adults suck sap by remaining on lower surface of leaves and reduce vitality of the plant. In case of severe attack, leaves curl down, fade gradually and finally dry up. Black sooty mould develops on honey dew excreted by the aphids, which falls on leaves.	
4. CHILLI POD BORER: *Spodoptera litura* Fab., *Helicoverpa armigera* Hub., *Utethesia lotrix* Lin., *S. exigua,* Noctuidae: Lepidoptera		*S. litura, H. armigera* feed on the pericarp and also seeds of fruits. *U. lotrix* feeds on pericarp only.	

Q. Draw two important pests of Brinjal, Bhendi, Crucifers, Cucurbits, Amaranthus and Chilli with their symptoms of damage

Ex. No: 3 **Date:**

Identification of Insect Pests of Coconut, Turmeric, Betelvine, Onion, Ginger and Tobacco and Their Damage Symptoms

Table 3.1Marks of identification, nature and symptoms of damage caused by insect pests of Coconut, Turmeric, Betelvine, Onion, Ginger and Tobacco

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
COCONUT			
1. COCONUTBLACK HEADED CATERPILLAR: *Opisina arenosella* Meyr., Cryptophasidae: Lepidoptera	**Adult:** Medium in sized with pale greyish wings. Few black spots present on forewings. **Caterpillar:** Greenish brown with dark brown head and prothorax and a reddish mesothorax. It posses five reddish brown wavy lines; one on the dorsal side and two on each of lateral sides.	Caterpillar constructs a silken gall on the lower side of leaflet and feeds by scraping the green matter within the gallery. In severe cases orchard gives a burnt appearance even from a distance. Later, bits of the leaf are added to the silken gallery and the length of gallery increases with the increase in the feeding activity.	
2. RHINOCEROUS BEETLE: *Oryctes rhinoceros* Linnaeus, Scarabaeidae: Coleoptera	**Adult:** Stout, black or reddish black beetle with a long horn projecting dorsally from the head. **Grub:** Creamy white and 'C' shaped.	Adult beetle feeds on the un opened central whorl of leaves in the crown of the plant. When the affected whorl opens up leaves show characteristic 'v' shaped clippings or holes in the leaflets. Frequent infestation results in stunted growth of trees and death of growing point in young plantations. This damage paves way for further fungal and bacterial infection.	

3. RED PALM WEEVIL: *Rhynchophorous ferrugineus* Fab., Curculionidae: Coleoptera	**Adult:** Reddish brown weevil with six dark spots on thorax. Head is prolonged into a long snout. **Grub:** Light yellowish with a reddish brown head and is apodous.	Newly hatched grubs bore into the trunk and crown and feed on the internal tissues and make tunnels. In the early stage of infestation, few small holes can be seen in the crown/ soft trunk from which pieces of chewed fibre protrude and brownish viscous liquid oozes. In many cases, the drying up of the young leaves or splitting of the petioles near the area of attack can be observed, the central shoot shows signs of wilting and the crown topples. Large mass of grubs, pupae and adults can be seen inside the trunk near the affected portion. Note the pupa is found within the fibrous cocoon.	

1	2	3	4
TURMERIC			
1. TURMERIC RHIZOME FLY: *Mimegralla coerulifrons* Mac., Micropezidae: Diptera	**Adult:** Dipterous fly. **Maggot:** Apodous, taper anteriorly.	Maggots mine into the mid-rib of leaves and enter into the rhizome through the petiole. It results in the rotting of rhizomes and dead hearts.	
BETEL VINE			
1. BETEL VINE BUG: *Disphinctus politus* W., Miridae: Hemiptera	The bug is slender, active, reddish brown with dark head and antennae, measures about half an inch.	Both nymphs and adults suck sap from tender leaves which develop black spots near the punctures.	
ONION			
1. ONION THRIPS: *Thrips tabaci* Linn., Thripidae: Thysanoptera	**Adult**: A minute, delicate light yellow insect. Wings fringed with hairs. **Nymph:** Very minute and wingless.	Both nymphs and adults remain at leaf bases and whorls of onion and suck sap. The Infestation causes pale white blotches on leaves. In severe infestation, the leaves dry from top to bottom.	

1	2	3	4
TOBACCO			
1. TOBACCO CATERPILLAR: *Spodoptera litura* Fabricius, Noctuidae: Lepidoptera	**Adult:** Medium sized moth with stout body. Forewings pale grey to dark brown in colour withwavy white markings and hind wings white with smoky margins. **Caterpillar:** Velvety black with yellowish green dorsal stripes and lateral white bands. A dark ring like marking is seen on anterior and posterior region in early stages.	During early instar, caterpillars scrape chlorophyll content of leaf lamina giving it a papery white appearance. During later instars, skeletonizes the leaves leaving only veins and petioles.	
2. WHITEFLY: *Bemisia tabaci* (Gennadius), Aleyrodidae: Hemiptera	**Adult:** Minute insect with yellowish body and whitish wings. **Nymph:** Oval scale like and yellowish in colour.	Both nymphs and adults suck sap from lower side of leaves. It results in reduction of plant vigour which ultimately leads to shedding of flowers. Sooty mould develops on infested leaves due to excretion of hone y dew and it hampers the photosynthetic activity.	

1	2	3	4
3. TOBACCO APHID: *Myzus persicae* S., Aphididae: Hemiptera	**Adult & Nymph:** Greenish/light pink, winged female has a black head and greenish abdomen with one/ two transverse dark bands and four lateral dark spots.	Both nymphs and adults suck sap by remaining on lower surface of leaves and reduce vitality of the plant. In case of severe attack, leaves curl down, fade gradually and finally dry up. Black sooty mould develops on honey dew excreted by the aphids, which falls on leaves. They transmit tobacco ring spot virus and rosettes disease.	
4. TOBACCO STEM BORER: *Scrobipalpa heliopa* L., Gelechidae: Lepidoptera	**Adult:** Dark brown moth. **Caterpillar:** Slender, dark headed and pinkish.	Caterpillar mines into the leaf axil and then into stem. Bored stems become hollow, swollen and forms a gall.	

Q. Draw two important pest of Coconut with their symptoms of damage

Q. Draw one important pest each of Turmeric, Betelvine, Onion and Ginger with symptoms of damage

Ex. No: 4 **Date:**

Identification of Insect Pests of Mango, Cashew and Banana and Their Damage Symptoms

Table 4.1Marks of identification, nature and symptoms of damage caused by insect pests of Mango, Cashew and Banana

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
MANGO			
1. MANGO LEAFHOPPER: *Amritodus atkinsoni* (Lethierry), *Idioscopus clypealis* (Lethierry), *I. niveosparsus* (Lethierry), Cicadellidae: Hemiptera	*A. atkinsoni*: largest light brown with two spots on scutellum. *I. clypealis*: smallest, light brown with spots on scutellum and a dark spot on vertex. *I. niveosparsus*: medium sized, with three spots on scutellum and prominent white band across its light brown wings.	Both nymphs and adults suck sap from leaves, tender shoots and inflorescence. Flower buds, flower *etc*., first become flaccid then wither and die, leading to reduction in fruit set. They produce sticky honey dew which encourages the development of sooty mould and which in turn hinders the photosynthetic activity.	
2. MANGO TREE BORER: *Batocera rufomaculata* Degger, Cerambycidae: Coleoptera	**Adult***:* Brownish grey with two pink spot and a pair of lateral spines on thorax. **Grub**: White, fleshy with dark brown head and strong jaws.	Grubs tunnel through the stem, eating away the nutrition-translocation system and ultimately kill the tree. Depending on the intensity of attack, the affectedtrees show the symptoms like withering of leaves and twigs and drying of entire tree. A white/yellowish exudates dripping down of the stem indicate the occurrence of stem borer, during its early stage of attack.	

1	2	3	4
3. MANGO STONE WEEVIL: *Sternochetus mangiferae* Fabricius, Curculionidae: Coleoptera	**Adult**: A stout, greyish brown weevil. **Grub:** White, thick, fleshy and legless.	Grub soon after hatching, burrows into the mesocarp flesh of tender fruit and reaches the region where the endocarp seed coat is still very soft. Once, the grub crosses this barrier of seed coat, it reaches seed endosperm to complete its life cycle. In the mean time, the fruit develops and heals up the larval tunnel, so that no external symptom is visible. Adult, who emerges from seeds, also feeds on seed. This hastens the maturity of infested fruit.	
4. MANGO LEAF WEBBER: *Orthaga exvinacea* Wlk., Noctuidae: Lepidoptera	**Adult:** Medium sized, dark brown stout moth. **Caterpillar:** Slender pale green, 35 mm long	Caterpillar webs terminal leaves and feed by scraping inside. Leaves are skeletonised. Flower stalks do not emerge properly.	
CASHEW			
1. CASHEW TREE BORER: *Placaederus ferrugineus* Linneaus, Cerabycidae: Coleoptera	**Adult:** Medium sized, dark brown longicorn beetle. **Grub:** Creamy white, robust and fleshy.	Newly hatched grubs feed on the sub-epidermal and soft wood tissues below the bark. Gradually, they bore into the stem and root Bore holes are plugged with chewed fibre an excreta. Gummy, resinous material oozes form the attacked portion. In the later stages, grubs feed on the inner tissue by forming irregular tunnels. When vascular tissues got damaged, leaves turn yellow and twig and branches dry leading to the death of tree.	

1	2	3	4
2. CASHEW SHOOT AND BLOSSOM WEBBER: *Lamida moncusalis* Walker, Pyralidae: Lepidoptera	**Adult:** Medium sized dark brown moth. **Caterpillar:** Newly hatched pale white caterpillar turns to reddish brown, when full grown and bears lateral longitudinal bands and pinkish dorsal lines.	Caterpillar webs the leaves and feeds. It webs the inflorescence also, at the time of blossoming. Apples and nuts are also damaged. They feed by scraping the upper green layer of apples and nuts when they are tender. It results in cracking of tissues and retardation in nut development.	
3. CASHEW LEAF MINER: *Acrocercops syngramma* M., Gracillaridae: Lepidoptera	**Adult:** Minute moth silvery grey in colour. **Caterpillar:** Yellowish and turns reddish brown.	Caterpillars mine into leaves and roll the fresh leaves. The thin epidermal layers of tender leaf swell up in the mined areas and appear as whitish blistered patches. In older leaves, big holes are formed due to drying and crumbling of mined areas.	
BANANA			
1. BANANA RHIZOME WEEVIL: *Cosmopolites sordidus,* Curculionidae: Coleoptera	**Adult:** Medium, dark brown, ridged, drawn out mouthparts. ½" long elytra do not cover the abdomen completely. **Caterpillar:** Dwarf, stout with red head and powerful mandibles.	Grubs tunnel through pseudostem and rhizome making circular hole, which increase in size with the growth of grubs. Tunnels up to 2-3' in stem with 6-10 grubs/stem. Plants break down at tunnelled portion. Less number of fruits and suckers. Circular holes with black rotten tissue of rhizome, plugged with excreta.	

Q. Draw two important pests of mango, cashew and banana with their symptoms of damage

Ex. No: 5 **Date:**

Identification of Insect Pests of Citrus and Sapota and Their Damage Symptoms

Table 5.1Marks of identification, nature and symptoms of damage caused by insect pests of Citrus and Sapota

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
CITRUS			
1. CITURS BUTTERFLY: *Papilio demoleus* Linnaeus, Papilionidae: Lepidoptera	**Adult:** Big, beautiful butterfly with yellow and black markings on fore wings. Hind wings have a brick red oval patch near the anal margin and tail like extension behind. **Caterpillar:** Dark brown with irregular white markings on their body, when young, changes to deep green colour, when fully grown.	Caterpillars feed voraciously on leaves, leaving behind midribs only. In general, they start feeding from the margin inwards, reaching the midrib.	
2.CITRUS FRUIT SUCKING MOTH: *Eudocima maternal* Linnaeus, *E. fullonica* Linnaeus, *E. ancilla* Linnaeus, Noctuidae: Lepidoptera	**Adult:** *E. maternal:* Brown forewings with a white stripe and hind wings with a circular black spot in the middle. *E. fullonica*: Brown black fore-wings and yellowish hind wings with kidney shaped black spot. *E. ancilla*: Cylindrical, stout, semilooper with dark brown velvety colour. **Caterpillar:** Cylindrical, stout, semilooper with dark brown velvety colour.	Adult moths pierce their proboscis into the fruits and suck the juice. This results not only in fruit drop, but also exposes the fruits to bacterial/ fungal infection due to which fruits rot/ severely suffer in quality.	

1	2	3	4
3. CITRUS LEAF MINER: *Phyllocnistis citerlla* Staint, Gracillaridae: Lepidoptera	**Adult:** Silvery white with brown striped forewings having a prominent black spot near the tip. Both pairs of wings fringed with hairs. **Caterpillar:** Yellowish green slender with brownish mandibles.	Caterpillar mines in between the epidermal layers of the leaf in a zig-zag manner. As a result, the leaf gets deformed, irregularly curled up in shape, unhealthy in look, defective in its function and finally it dries and falls off. Sometimes, larvae mine the outer layer of the skin of young green twigs.	
4.RUSTMITE: *Phyllcoptruta oleivora* Ahmead, Eriophyidae: Acarina	**Adult:** Minute, yellowish, wedge shaped, worm like. **Larva:** Minute light yellow, resembles adult except in size.	The mite punctures the epidermal cells of leaves and tender fruits. After about a month leaves and fruits develop dusty appearance ultimately turning pink/ black/ rusty spots. At this stage the affected fruits are conspicuous and growers call it as "**Mangu**" in Andhra Pradesh.	
5. BARKBORER: *Indarbela tetraonis* Moore, Metarbelidae: Lepidoptera	**Adult:** Medium sized well built pale brown moth with wavy grey markings on the wings. **Caterpillar:** Dirty pale brown with dark head and measures about an inch an half in length.	The caterpillars make zig-zag tunnel on the stem, branches and feed on the tissues preferably at fork region. They make galleries with silken web made up of fine chips of wood and excretory pellets. Caterpillars move in the galleries at night and spread to other parts. Such galleries/ribbons are seen hanging particularly at branches. Attack is more on older trees in neglected orchards.	

1	2	3	4
SAPOTA			
1. SAPOTA LEAF WEBBER: *Nephopteryx eugraphella* Rag., Pyralidae: Lepidoptera	**Adult:** Small grey moths. **Caterpillar:** Pinkish brown with closely set longitudinal lines on dorsum.	The caterpillar webs the leaves and also feeds on flower buds and fruits.	

Q. Draw one important pest each of Citrus and Sapota with symptoms of damage

Ex. No: 6 **Date:**

Identification of Insect Pests of Grapevine, Pomegranate and Guava and Their Damage Symptoms

Table 6.1Marks of identification, nature and symptoms of damage caused by insect pests of Grapevine, Pomegranate and Guava

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
GRAPEVINE			
1. GRAPEVINE FLEA BEETLE: *Scelodonta strigicolis,* Chrysomelidae: Coleoptera	**Adult:** Small, coppery brown with three prominent circular patches on each elytra-8mm long. **Grub:** Dirty white 8 mm long, found in soil.	Adults are destructive to the new flush after pruning. Adults feed on sprouting buds. Adults also feed on mature leaves. Grubs feed on cortical layers of roots (not causing much loss). Completely feed sprouting buds. Rectangular shot holes on leaves.	
2. GRAPEVINE THRIPS: *Rhipiphorothrips cruentatus,* Thripidae: Thysanoptera	**Adult:** One mm long with fringed wings. **Nymph:** Reddish brown, carrying a black drop of shiny excretory droplet.	Nymphs and adults lacerate tissues of tender foliage, flower stalk, tender fruits. Pale patches to shining spots/ dots on leaves and scab on berries.	
3. GRAPEVINE MEALY BUG: *Maconellicoccus hirsutus,* Pseudococcidae: Hemiptera	**Female:** Light pinkish with functional mouth parts, wingless, sessile. **Male:** With one pair of wings and degenerate mouth parts.	Crawler move to succulent parts like leaves, buds, and petioles, bunches and settle and become sedentary and cause desapping. Malformation of shoots and leaves. Sooty mould on honey dew and movement of black ants can be seen.	

1	2	3	4
GUAVA			
1. GUAVA MEALY BUG: *Ferrisia virgata,* Pseudococcidae: Hemiptera.	**Female:** Big, apterous with long prominent filaments at posterior end covered with waxy filaments.	Pest infests pedicels, stalks under surface of leaves, shoots and fruits. Sooty mould develops on infested parts. Twisting and malformed twigs, leaves and fruit drop.	
2. TEA MOSQUITO BUG: *Helopeltis antonii,* Miridae: Hempitera.	**Adult:** Reddish with 'T' shaped raised/ knobbed process present mid-dorsally on the thorax.	Nymphs and adults tap fruit surface causing scab on fruit surface. On twigs black linear scars. On leaves, reddish streaks.	
POMOGRANATE			
1. POMOGRANATE BUTTERFLY: *Deudorix isocrates* (Fab.), Lycaenidae: Lepidoptera.	**Adult:** Medium sized butterfly with tail like extension at the lower margins of hind wings. **Caterpillar:** Full grown caterpillar dirty brown, short and stout built covered with a few short hairs and measures about ¾" in length.	The caterpillar bores into the fruit. No entry hole can be made out. The fruit appear healthy, but the caterpillar inside eat the seeds. Severely infested fruits show holes often plugged by the anal segment of the caterpillar or its excreta.	

Q. Draw one important pest each of grapevine, pomegranate and guava with symptoms of damage

Ex. No: 7 **Date:**

Identification of Insect Pests of Flower and Ornamental Plants and Their Damage Symptoms

Table 7.1Marks of identification, nature and symptoms of damage caused by insect pests of Flowers and Ornamental plants

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
PESTS OF ROSE			
1. THRIPS *Rhipiphorothrips cruentatus* Thripidae: Thysanoptera	**Adult** Dark brown, black in colour **Nymph:** Reddish in colour	Infest grain both in store and field. Both grubs and adults damage the grain by feeding inside the kernels. Adults cut a circular hole on the grain.	
2. SCALE *Lindingaspis rossi, Aonidiella aurantii* Diaspididae: Hemiptera	Red scales completely cover the stem.	Both nymphs and adults suck sap causing drying and death of plants.	
3. ROSELEAF **CATERPILLARS** *Euproctis fraterna, Porthesia scintillans*: Lymantriidae *Latoia lepida*: Limacodidae *Achaea janata*: Noctuidae Lepidoptera .	**Adult** **1.** Yellow moth with pale transverse lines on the forewings **2.** Yellow moth with spots on the edges of wings **3.** Green moth with brown markings at the base of the wings **4.** Grayish moth with wavy lines on fore wings and white patches on hind wing **Caterpillar:** **1.** Reddish brown with red head surrounded by white hairs and long tufts of hairs all over the body and a long pre anal tuft.	Caterpillars defoliate the leaves	

	2. Yellow coloured with brown head, yellow stripe with a central red line on the body **3.** Slug like flat ventrally greenish body ,scoli tipped red or black		
4. ROSE CHAFER BEETLE *Oxycetonia versicolor* Cetoniidae: Coleoptera .	**Adult:** Beetles are red coloured with black markings.	Adults feed on leaves, flowers during night causing irregular feeding mark on buds and flowers.	
PESTS OF JASMINE			
1. JASMINE STINK BUG *Antestiopsis cruciata* Pentatomidae: Hemiptera	**Adult:** Dark brown shield shaped bug with orange and white markings o wings **Nymph:** Dark brownish black and round	Nymphs and adults suck sap from flowers, tender plant portions causing heavy damage to flowers and yellowing and drying of leaves. Sometimes, they feed in large numbers on tender shoots and buds preventing flower formation	
2. JASMINE BUD WORM *Hendecasis duplifascialis* Pyralidae: Lepidoptera	**Adult:** Small white moth with black palp and three lines on the abdomen an the hind legs **Caterpillar:** Dark green with black head	Greenish caterpillar attacks two or three buds and buds are webbed together by silken threads. Petals are eaten away by larva resulting in buds with bore holes, webbings soiled with excreta. Pupation is in soil.	
3. JASMINE GALL/ FELT MITE *Aceria jasmini* Eriophyidae: Acarina.		It produces white felt like hairy outgrowth on the leaf surface, tender stems and buds leading to stunted growth and suppression of flower development	

PESTS OF CHRYSANTHEMUM			
1	**2**	**3**	**4**
1.CHRYSANTHEMUM BLACK APHIDS *Macrosiphoniella sanborni* Aphididae: Hemiptera	**Adult:** Slender, dark brown flat beetle with a row of six teeth like structures on either side of thorax. **Grub:** Slender pale cream with two dark patches on each segment.	Nymphs and adults infest tender shoots sucking sap and causing yellowing and drying of tender shoots, devitalisation and stunted growth.	

Q. Draw one important pest each of Rose, Jasmine and Chrysanthemum with symptoms of damage

Ex. No: 8 Date:

Study of Different Species of Honey Bees and Bee Hives

Apiculture: The science and art of rearing honey bees.
Apiary: A bee yard where colonies, hives and other equipment are assembled in one location for bee keeping.

'Apis' means bee. The scientific names of different species of honeybees begin with the generic name *Apis*. Apiculture or bee-keeping is the art of caring for, and manipulating colonies of honeybee in large quantity, over and above their own requirement.

Importance of bee keeping/apiculture:
1. Bee keeping does not require a)
Own land
b) Labour
c) Full time attention
d) Heavy continuous investment, except initial establishment cost.
2. Does not compete with other agricultural operations/activities.
3. Provides additional income through a) Honey-a hygienic food, tonic and medicine,
b) Bee products – wax, propolis, royal jelly, pollen and bee venom, c) Sale of colonies.
4. Provides employment to village artisans for fabricating equipment.
5. Provides wealth and valuable food from material (i.e., pollen and nectar) at presentgoing waste.
6. Improves crop yields and
7. Helps to maintain natural plant diversity through cross pollination.

Limitations:
Lack of
a) Awareness about importance of bee keeping
b) Knowledge about bee management c)
Skill in bee management
d) Patience to gain experience in bee keeping e)
Man power to popularize bee keeping
f) Expectation of immediate returns g)
Fear of bee stings
h) Non availability of equipment and bees at door steps i)
Increased cost of timber
j) Psychology of bee keepers to discourage the others to enter the profession.

Species of honey bee:
Honey bees:

- Well known, popular and economically beneficial insects
- Social insects like ants, termites and some wasps
- Vegetarians unlike ants and wasps
- Derive protein from pollen, carbohydrate from honey which they make from nectar
- Live together in colonies, cooperate in foraging tasks and take care of young ones

The position of honey bees in the animal kingdom is mentioned below:

Phylum: Arthropoda
Class : Hexapoda/Insecta
Order : Hymenoptera
Family: Apidae
Genus : Apis
Species:

a) *A. dorsata*
b) *A. florea*
c) *A. indica*
d) *A. mellifera*

Table 8.1 Important Honey bee species

Sl. No.	Character	Rock bee/ giant bee *A.dorsalis*	Little bee/ dwarf bee *A. florea*	Indian bee *A. cernana indica*	European/ Italian bee *A. mellifera*
1.	Wild/ domesticated	Wild in nature	Wild in nature	Domesticate d species	Domesticated species
2.	Size	Largestof all species	Smallest of all the species	Intermediate	Bigger than *A.cerana* but smaller than *A.dorsata*
3.	Distribution	Present all over India in plains an inhilly areas upto 1600 m above sea level	Found in plains of India upto 300 m above sea level	Present all over India in plains and hilly areas upto2500m above sea level	Imported species. Got acclimatized to different climatic conditions all over India
4.	Worker	Light brown 16-18 mm in size	Deep black with white strips on the posterior part of the bright orange abdomen	Thorax dark coloured with brown hair. Abdomen brown with dark bands	Blackwith yellowish hairs.
5.	Queen	Darker and much larger than workers and drones	Bigger and abdomen is golden brown	Thorax dark and sparsely hairy. Abdomen and legs coppery brown. Abdomen is big, distended and without black bands.	Brownish body longer than worker and drone
6.	Drones	Black and as big as workers	Black with smoky brown hair on the abdomen	Stout and slightly bigger than workers	Amber/ yellow body with yellowish hair
7.	Temperament	Ferocious	Very mild, but they do sting when irritated	Gentle	Moderately mild
8.	Nesting/comb construction	Constructs single, big comb in open where they get some diffused light (1-2 m from side to side and 0.5 to 1.25 m from top to bottom	Constructs single, small comb (15 cm long and 30 cm height) in open where they get some diffused light	Constructs several parallel combs (13-18) i.e., parallel to the direction of the entrance in plains and at right angles to the entrance at high altitude	Constructs a series of parallel combs inside some enclosures.

9.	Place of nesting	Suspends its comb to large tree branches/ building projections/water reservoirs/ceilings etc protecting it from direct sun rays and rain	Constructs the comb in the files of cotton sticks/bushes/ house chimneys/ house arches and other such places	In nature constructs combs inside some enclosures such as hollows in the walls/rocks/tree trunks/ inverted baskets etc.	In nature, construct comb in the hollows of walls/rocks/tree trunks/inverted baskets etc
10.	Honey gathering per year/colony	Heavy gathers 37 kg	Poor gathers 0.5 to 1.0 kg	Fair gather 3-5 kg in plains, but yields are as high as 20-25 kg in Kashmir	15-20 kg. A strong colony can gather upto 50 kg if abundant bee flora is available

Morphology of honey bee:

Honey bees share the general characters of class Insecta. But the organ systems are variously modified to lead a specific life i.e., food habits, social life etc.

Body:

- Covered with a hard external skeleton to protect the internal organs.
- Divided into three regions i.e., head, thorax and abdomen.

Head:

Bears

a) A pair of geniculate antennae. Flagellum (third segment) having chemo and mechanoreceptors.
b) A pair of large compound eyes on lateral sides and three simple eyes (Ocelli). Bee can distinguish colour, but are red blind.
Ocelli: Perceive only the degree of light and do not form an image on the retina.
c) A pair of mandibles: Mandibles differ in the three castes.
d) Mouth parts: These are modified for sucking and lapping in worker. The proboscis (tongue) is formed by median labium and two lateral maxillae and is used for ingesting liquids.
e) Thorax: Consists of three segments and joined to the abdomen by a narrow propodeum. Besides locomotion, legs modified to perform other function i.e., prothoracic legs for antenna cleaning, meta thoracic legs for pollen and propolis collection, meso-thoracic legs for wax picking.
f) Abdomen: bears a sting, wax and scent glands and genital organs and viscera internally.
g) Sting: In worker, the ovipositor (egg laying apparatus) is modified into a sting
h) Wax glands: Situated in the sternites of 4^{th} to 7^{th} abdominal segments. Become active in worker bees at the age of 14-18 days. Wax is secreted in liquid form which solidified into thin flakes
i) Scent glands: Present in the thin membrane connecting the last two abdominal terga. Bee bends her abdomen and exposes the membrane to produce the scent. The odour produced from the cells is derived from scented waste products of metabolism.

Biology:

Honey bees undergo metamorphosis. Through four developmental stages i.e., egg, larva, pupa and adult.

Eggs:

Queen lays both fertilized and unfertilized eggs which are similar in size and shape. Fertilized eggs develop into females (worker and queen) and unfertilized eggs develop into drone bees. Eggs are laid singly and attached vertically to the bottom of cell wall. Eggs hatch on 3rd day.

Larv:

After hatching, all the larvae fed with royal jelly (bee milk produced by worker bees) for 3 days. Thereafter, the worker and drone larvae are fed with nectar and pollen. A queen larva is fed continuously with royal jelly up to 8th day, when the queen cells are further packed with royal jelly and are sealed. The capped royal larva (queen) continues to feed until it pupates. Initially, the larvae are loop shaped, but towards cell capping, they get stretched in the cell with head facing upwards. After passing through four moults, larvae enter into the prepupal and final pupal stage.

Pupa:

Before entering into pupal stage, the larva spins a thin silken cocoon around itself and undergoes gradual, but drastic changes. At this stage, head, thorax and abdomen are clearly distinguishable. The compound eyes and various appendages are also clearly visible.

Adult:

When pupal development is completed, the insect metamorphoses into adult and finally adult bee emerges by gnawing its way out of the sealed cell. The development stages of all the three castes of honey bees are similar, but the time taken for development, sexual maturity and also longevity of different castes are variable as shown in table.

Bee Hives:

A beehive is an enclosed structure in which some honey bee sps live & raise their young. Primitive Beekeeping was revolutionized through discovery of Bee space by Rev. L.L. Langstroth and successful use of movable frames which in turn led to designing of modern beehive.

• The “Modern” bee hive is based on understanding of “Bee Space” 1/4”- 3/8”.

• Bee space (passage way) is the space required between any two frames for bees to move about between the combs & too small to build combs & too large to deposit propolis.

• Bee space for *Apis mellifera* is 5/16 “& for *Apis cerana* is 1/ 4”

Different types of bee hives:

1. Pot hive
2. Hook hive
3. Madusagar hive
4. House hive
5. Nucleus hive Jeolikote’s hive
6. Dadant’s hive (Single walled & Double walled)
7. British standard hive
8. Langstroth’s hive (*A.mellifera*)
9. Newton’s hive (*A.cerana*)

• Natural beehives (referred to as "nests") are naturally occurring structures occupied by honey bee colonies,

• The beehive's internal structure is a densely packed matrix of hexagonal cell made of beeswax, called a honeycomb. Bees use cells to store food (honey and pollen),& to house "brood" (eggs, larvae,& pupae).

- **Natural bees' nests:**

Honey bees in subgenus Apis use caves, rock cavities & hollow trees as natural nesting sites. Members of other subgenera have exposed aerial combs.
Nests - composed of multiple honeycombs, parallel to each other, with a relatively uniform bee space, usually with a single entrance.

- **Artificial bee hives:**

• Traditional beehives
• Modern beehives
• Skeps are made of baskets with single entry points at the bottom for the bees & no structure inside. It is not feasible to inspect bees inside, & harvesting means destroying entire hive by killing / driving away bees.
Bee Gums – Hives of this type are located exactly on hollowed body part of gum trees. Sticks are attached to honey combs for easier pulling out by the time of harvesting.

Langstroth Hive:

• Frames - thin rectangular structures (wood/ plastic) & with a wax / plastic foundation to draw out the comb - hold beeswax honeycomb formed by bees.
• Ten frames side-to-side/hive & leave right amount of bee space between each frame & between end frames & hive.
• Frames - reinforced with wire, making it possible to extract honey in centrifuges to spin honey out of comb.
• Empty frames & comb - returned to hive for use in next season.
• Bees require - require 1 kg of beeswax to make 8 kg of honey
Comb reuse - significantly increase honey production.

National hive:

• Widely used hive in the UK. A square hive, with grooves to serve as hand grips.
• Frames - smaller than standard Langstroth hive& have longer hand grips (or "lugs").

WBC hive:

• Invented by & named after William Broughton Carr
• A double-walled hive with an external housing that splays out towards the bottom of each frame covering a standard box shape hive inside.
• Offers extra level of insulation for bees by its double-walled design.
• Inconvenient to remove external layer before hive can be examined

QUESTIONS

1. What does “Apis”, a latin word mean literally?

2. Write three advantages of bee-keeping.

3. Name the two species of honeybee that can be domesticated.

4. Name the three castes in a honey bee colony

Ex. No: 9 Date:

Study of Equipment for Handling Honeybees

The successful use of movable frames and the discovery of bee space revolutionized the primitive way of keeping bees and paved the way for designing of modern bee hive. In1851, Rev. L. L. Langstroth improved the earlier type of hive based on his discovery of "Bee Space". Bee space (Passage way) is the space required between any two frames for the bees to move about between the combs and is too small to build combs and too large to deposit propolis. Bee space for *Apies mellifera* is 5/16 inches and *Apis cerana indica* is ¼ inches. Langstroth hive and Newton's hive are generally used for beekeeping with *A. mellifera* and *A. cerana indica* respectively.

Beehive:

- It is a tool/equipment used in a scientific method of bee keeping.
- It consists of a bottom board, brood chamber, brood frame, super chamber, super frame, inner cover and top cover.

Table 9.1 Bee Keeping Equipment

Beehive stand	This is made of RCC or wood or iron with provision for water cups to prevent ants from entering beehive. Bee hive is kept on the beehive stand.
Smoker	This is made of a tin or copper container attached with a leather bellow. This is used to smoke bees to subdue them while handling.
Hive tool	It is made of a thick iron plate to clean the hive, to handle the frames and to remove propolis etc.
Bee veil	This is made of mosquito net type material for being worn to protect the face from being stung by bees while handling.
Gloves	These are used to protect hands from bee sting while handling.
Honey extractor	This is made out of tinned copper, brass or zinc drum with basket cages to hold frames and wheel to rotate them in order to extract honey by centrifugal force generated in it.
Queen gate	This is made out of zinc sheet with perforations to prevent queen from
Queen excluder	This is made out of zinc sheet with perforations and is placed between broad chamber and super chamber to prevent the movement of queen bee
Drone excluder	This is used to prevent the re-entry of drones into the hive after the bees
Drone trap	It is useful for fixing in front of the hive entrance when workers and drones come out for play flight. Workers can easily go out through the groove at the bottom, but drones are trapped. Drones, thus trapped can be removed and killed, when they are no longer required in the hive.

Comb foundation sheet	This is made of pure wax. It is used to aid the bees to construct straight parallel combs.
Dummy division board	This is useful to reduce the inner area of the broad chamber so that the bees can be confined to a limited space when bee population in the hive is low.
Swarm trap	It is a rectangular box open at one of the broader sides and wire gauge fixed to about 2/3 of its height on the other side and the remaining 1/3 portion with a queen excluder sheet made of zinc in a slanting position. During swarming season, when bees construct queen cells, the box is kept on the alighting board with open side close to the hive and tightly secured. One or two frames with comb
Bee brush	It is used to brush off bees from honey comb before it is taken away for extraction.
Feeders	These are used to feed sugar syrup to bees. The division board feeder is commonly used. It is a wooden trough of regular frame dimensions of the hive to hang in the hive just like any other frame with a wooden strip to serve as a float
Queen cages	Several types of queen cages are available for caging the queens
Queen cell protector	A queen cell which may have to be introduced from a queen-right to a queen less colony is protected with a queen cell protector until its acceptance by the bees

Bee pasturage:

Honey bees have close link with flora because they live solely on nectar and pollen. To maximize the honey production, bee keeper should have a thorough knowledge of floral cycle, on set of major honey flow and dearth periods.

1. **The plants which are visited by bees only for nectar are:**
   Tamarind (*Tamarindus indicus*) (rich source), Neem (*Azadirachta indica*), Soap nut (*Sapindum* spp.), *Eucalyptus* spp., Pungam (*Pongamia glabra*), *Morinda tinctoria, Prosopis spicigera, Quisqualis indica, Legasca mollis, Tribulus terrestris, Glyricidia maculata.*
2. **Plants which supply pollen to the bees are:**
   Sorghum (rich source), maize, roses, bajra, finger millet, pomegranate, sweet potato, tobacco, castor, tea etc.

3. **Plants which supply both nectar and pollen are:**

Banana, citrus, apple, pear, plum, peach, guava, mango, coconut, sesamum, safflower, mustard, cruciferous and cucurbitaceous vegetables, bhendi, onion, Lucern, clover, hollyhock, aster, *Cassia fistula,* cotton (very rich source).

Honey extraction and processing:

When the honey flow begins to slow down, the frames with honey should be removed for extraction. To remove honey comb, the colony is smoked, the desired combs taken out and bees brushed off with a soft brush or leaves. These combs are placed in tight hive bodies, carried to the extraction room. A room with wire gauged bee tight doors is necessary for honey extraction. Frames should be uncapped with a hot knife. The uncapped frames should be placed in extractor and rotated slowly and then at a faster speed. Then the frames are reversed and extraction is again worked. Finally, honey collected in the container is strained and packed in tins or bottles. After the extraction, the place should be swabbed with water and the appliances cleaned. The empty wet combs should be returned to the hives for bees for cleaning and reuse.

QUESTION

1. **Draw any four honey bee rearing equipment**

Ex. No: 10 Date:

Study of Insect Pests and Diseases of Bees

A) Greater wax moth, *Galleria melonella*

Adult is brownish grey, 10-18 mm length. The colour and size of adults vary according to food eaten during larval period. Dark brown combs containing pollen give rise to darker and bigger adults. The fore wing of male has a semi lunar notch, while that of females are smooth. Female lays 300-400 eggs in clusters in 4-10 days. Eggs hatch in 3-5 days. Caterpillars are highly active and consume gnawed pieces of comb. They soon spin silken tunnels in the comb or tubular galleries on bottom board to protect them. Life cycle is completed in 6 weeks to 6 months. Caterpillars eat away the combs by making tunnels in midrib of combs. The presence of small pieces of minute particles of wax outside the holes is the first indication of entry of larva into comb. Later, faint webbings are perceptible over some cells of comb. In case of severe infestation, brood rearing is stopped and the bees desert their nest.

Management:

a) Maintain the colonies strong to resist wax moth.
b) Keep the hives without cracks and crevices.
c) Reduce hive entrance size for effective guarding by bees.
d) Keep the bottom board neat and clean without debris.
e) Hold the comb against sun rays to observe the larvae.
f) Extra combs stored should be fumigated with sulphur.

B) Black ant, *Componotus compressus* Fab.

They carry adult bees as well as broad.

C) Bee hunter wasps, *Palaras orientalis* Kohl, *Philanthus ramakrishnae* T.

They wait near hive entrance and collect 20 bees in a day. Apart from loss of workers, the whole colony is frightened and disturbed.

Diseases:

1. **Broad diseases:**

Honey bee brood suffers from a variety of diseases. Adult bees are not affected by brood diseases, but they can spread the causal organism. Brood diseases are more serious than adult diseases.

Bacterial diseases:

a) American foul brood (*Bacillus larvae*)
b) European foul broad (*Mellissococus pluton*)

Viral diseases:

a) Thaic sac brood b) Sac brood

Fungal diseases:

a) Chalk brood (*Ascophera apis*)
b) Stone brood (*Asperigillus flavus*)

Table 10.1 Symptoms of brood diseases:

	American foul brood	European foul brood
General appearance of brood comb	Brood irregular, intermingling of capped, open and punctured cells. Much dead brood in capped cells with punctured capping and cells uncapped by bees.	Brood irregular. Dead brood mostly in open cells
Time of death	Late larval/early pupal stage	Coiled larvae in unsealed cell and rarely late larval
Cell capping	Cappings sunken and usually have holes	Some cappings perforated
Consistency of dead Brood	At first watery/Slightly viscid becoming ropy, finally brittle	At first soft and watery, afterwards pasty, rarely visual and ropy
Odour of dead brood	Putrid faint	Strong and sour
Brood affected	Worker, rarely drone or queen	Worker, drone and queen
Control	Tetramycin 0.25-0.40 g in 5 lit sugar syrup fed to infected colonies. Repeat after 7-10 days	Tetramycin 0.25-0.40 g in 5 lit sugar syrup fed to infected colonies. Repeat after 7-10 days.

Thai sac brood disease:

The virus multiples in adults which transmits to larvae. Infected brood die in prepupal, but in unsealed stage. Dead larvae straighten out and lie on their backs, with tip of head capsule turned upwards. Dead larvae or Prepupae dry up in brood cells forming loose scales. Affected larvae are yellow/greyish, later darkening to blackish, the change in colour first starts from mouth parts and head. No definite preventive/curative measures available.

- Keep the colonies strong
- Avoid exchange of hive parts and
- Restrict the bee movement

Sac brood virus:

Infected larvae fail to pupate and lie stretched on their back with head turned upwards. Larvae become sac like due to filling of fluid between new integument and unshed skin. Colour of larvae turns pale yellow and finally become dark brown, the darkening starts from head.

2. Adult bee diseases

a. Protozoan diseases – *Nosema apis*

Infected bees become dysenteric with distended and swollen abdomens. They have disjointed wings and found crawling in front of the hive. Disease is severe during spring and wintering with more colony strength with sufficient brood food stores and open

sunny sites helps in overcoming the disease incidence.

b. Acarine disease-

i. ***Acarapsis woodi:*** Endoparasitic mite of adult bees. It infests the trachea of first thoracic spiracle where they suck haemolymph.

Symptoms:

I. Presence of bee crawlers at hive entrance
II. Bees are unable to fly and wings are disjointed in K winged condition
III. Infested bees are short lived

ii. ***Varroa jacobsi:***

Female mite enters the cell of 5 – 5.5 day old larvae before sealing and lays 2-5 eggs on walls of the cell. Feeds on haemolymph of the larva or pupa. Adult female mite lives on adult workers and drones under abdominal sclerites. They feed by making holes in the intersegmental membrane. Dead mites can be seen on bottom board in the debris. In queen rearing and mating yards, *Varroa* infestation causes shortage of drones for mating.

iii. ***Tropilaelaps clareae***

It is an ectoparasitic mite. Infested colonies have irregular brood pattern, dead and malformed larvae and pupae in brood combs. Malformed adults with missing or poorly formed wings and shrunken abdomen can be observed crawling around the hive.

It can be controlled by dusting with sulphur @ 1 g/comb.

Ex. No: 11 Date:

Study of Different Species of Silkworm

Sericulture or silk production

It is the breeding and management of silk worms for the commercial production of silk. Sericulture is an important industry in Japan, China, India, Italy, France and Spain.

Table 11.1 Different species of silkworm

Sl. No.	Common Name	Scientific Name	Host
1.	Mulberry silkworm	*Bombyx mori*	Mulberry
2.	Eri silkworm	*Philosamia ricini*	Castor
3.	Muga silkworm	*Antheraea assama*	Som, Soalo
4.	Tasar sillworm	*Antheraea mylitta*	Arjun, Sal

Source of silk – The silkworm

The silkworm is the larva or the caterpillar of the moth *Bombyx mori* (popularly called the silk moth) the total life history of the moth from egg to adult take 50 days. The different stages are as follows:

a. Egg : 10 days
b. Larva (4 stages) : 30 days
c. Pupa (Cocoon) : 10 days

(i) Adult

The adult silk moth is a creamy white moth that has a flat body and a wing expanse of about 5 cms. It takes no food and seldom attempts to fly. It lives for only 2 to 3 days. After mating, the female moth lays 300-500 eggs on leaves of the mulberry tree.

(ii) Eggs

The eggs are round and yellowish-white, and they become grey as hatching time approaches.

iii) Larvae

The newly hatched larva is about 3 mm long and somewhat black in colour. The larvae grow in size and shed their skin (moult) four times. Each growing stage of the caterpillar consumes lot of mulberry leaves. The last stage full grown larva is about 7 cm long. It has a hump behind the head and a spine-like horn at the tail end. When full grown, the mature larva stops feeding, climbs on a twig and spins a cocoon.

(iv) Pupa

The full grown larva pupates inside the cocoon. In about 10 days time it transforms into a winged adult. The adult moth makes an opening in the cocoon and escapes through it.

The cocoon

The cocoon is formed from a secretion from two large silk glands (actually the salivary glands), which extend along the inside of the body and open through a common duct on the lower lip of the mouthparts. The larva moves the head from side to side very rapidly (about 65 times per minute) throwing out the secretion of the silk glands in the form of a thread. The secretion is a clear viscous fluid, which on exposure to the air gets hardened into the fine silk fibre.

The filament forming a cocoon is contineous and ranges in length from 700-1100 metres. The cocoons from which moths have emerged are called pierced cocoons. These are of low value because continuous thread cannot be obtained. Pieces are removed by instruments and spun into a thread.

Rearing of silkworms

Selected healthy silk moths are allowed to mate for 4 hours. Female moth is then kept in a dark plastic bed. She lays about 400 eggs in 24 hours, the female is taken out and is crushed and examined for any disease, only the certified disease- free eggs are reared for industrial purpose. The eggs are hatched in an incubator.

The hatched larvae are kept in trays inside a rearing house at a temperature of about 20°C-25°C . These are first fed on chopped mulberry leaves. After 4-5 days fresh leaves are provided. As the larvae grow, they are transferred to fresh leaves on clean trays, when fully grown they spin cocoons.

Reeling silk

The cocoons are cooked in hot water and the silk fibre is unwound from the cocoons. This process is called reeling. The silk consists of two proteins the inner core is fibroin and an outer cover of sericin. There are four following steps for the completion of the process of reeling:

For reeling silk the cocoons are gathered about 8 days after spinning had begun.

- The cocoons are first treated by steam or dry heat to kill the insect inside. This is necessary to prevent the destruction of the continuous fibre by the emergence of the moth.
- Next, the cocoons are soaked in hot water (95° -97°C) for 10-15 minutes to soften the gum that binds the silk threads together. This process is called cooking.
- The “cooked” cocoons are kept in hot water and the loose ends of the thread are caught by hand.
- Threads from several cocoons are wound together on wheels (“charakhas”) to form the reels of raw silk.

Only about one-half of the silk of each cocoon is reelable, the remainder is used as a silk waste and formed into spun silk.

Raw silk thus obtained is processed through several treatments to give it the final shape.

Main properties of silk

1. It is lustrous, soft and strong.
2. It is made of two proteins: the inner core is fibroin and an outer cover is sericin
3. It is hard wearing.
4. It can be dyed into several colours

Silk moth *Bombyx mori* is at present fully domesticated. It no longer exists in a wild state and it cannot survive without the human care.

Silk Producing States of India

Major Indian States producing mulberry silk are: Karnataka, West Bengal, Jammu and Kashmir

Non-mulberry "silks"

1. Tasar silk is produced by certain species of another moth *Antherea royeli*. Their larvae are reared on Arjun trees, chiefly in Bihar, Madhya Pradesh and West Bengal.
2. Muga silk is obtained from *Antherea assama* whose larvae are reared on " Som" trees in Brahmaputra Valley.
3. Eri silk is produced by the moth *Philosamia ricini* whose larvae feed on castor leaves. It is produced in Assam.

Ex. No: 12 Date:

Silkworm Rearing House and Equipment

Rearing house and equipment

It is desirable to have a separate rearing house. Space requirement is minimum in shelf or stand rearing and maximum in floor rearing during old age rearing. Stand rearing is common in tropical countries. For a capacity of 200 to 250 dfls the features required can be provided in a 30' x 20' house with the following facilities.

1. Open verandah
2. Leaf room
3. Rearing hall & working space
4. Leaf inlet
5. Litter outlet
6. Two-step roofing
7. Exhaust
8. Air inlet
9. Wire mesh protected windows
10. False roof

Rearing Shed

Shed direction	: East to West
Windows direction	: North to South
Cross ventilation	: Keep wire mesh to windows, ventilators & doors to prevent entry of uzyflies.

Equipment for silkworm rearing

1. Rearing stands: These are made of wood or bamboo, portable and are 2.5 m high, 1.5 m long and 1 m wide with 10 shelves with a space of 20 cm between each shelf. The rearing trays are arranged in the shelves.

In whole shoot feeding method, rearing stand width should be 5 -5.5 ft. With One ft above the ground level.and with –2 ft. Distance between rearing stand & wall.

2. Ant wells: These are provided around the legs of stands to stop ants crawling on to the trays and attacking the worms. These are made of concrete stone base 20 cm^2 and 7.5 cm high with groove of 2.5 cm depth to hold water. The legs of the stands rest in the center of the block.

3. **Rearing trays**: These are used to rear silkworms and are made of bamboo. They are round (1.2 to 1.4 m dia) or rectangular (0.9 to 1.2 m x 0.7 to 0.9 m) with a depth of 7.5 cm.

4. **Rectangular wooden trays or boxes**: These are used for rearing early age larvae, made of light wood, size being 0.9 m x 0.7 m with a depth of 7.5 to 15 cm. About 8 boxes are required for 100 dfls.

5. Paraffin paper: It is a thick craft paper coated with paraffin. It is used for rearing early age worms, on the bottom and as a cover of the rearing bed to prevent withering of chopped leaves and to maintain humidity in the rearing bed.

6. Foam rubber strips: Long foam rubber strips of 2.5 cm wide and 2.5 cm thick dipped in water are used to keep all around silkworm rearing bed during first two instars to maintain humidity.

7. Chop sticks: These are made of bamboo, 17.5 - 20.0 cm long and thin and tapering to one end. A pair of chop sticks are used to pick early age larvae and also for preparing the bed.

8. Feathers: Bird feathers, preferably white ones are used for brushing the delicate newly hatched worms onto the rearing bed.

9. Chopping board: It is made of soft wood and used for cutting the mulberry leaf to suitable sizes and the size is 0.9 m x 0.9 m and 5 cm thick.

10. Chopping knives: These are used for cutting the mulberry leaves and are 0.3 to 0.5 m long with a broad knife blade and wooden handle.

11. Mats: Mats of 1.8 x 1.2 m are used for collecting the leaves when chopping is done on floor to prevent the dust and dirt on the floor getting mixed with the leaves.

12. Leaf chambers: These are maintained in rearing house for storing the harvested mulberry leaf ready for feeding the worms at set intervals.

13. Cleaning nets: These are made of cotton or nylon of different mesh sizes to suit the stage of the larvae. These are used for cleaning the rearing beds and at least two nets are required for each rearing tray.

14. Mountages: These are used as supports for the silkworms to spin cocoons and are made of bamboo, usually 1.8 x 1.2 m. Over a mat base tapes of 5-6 cm wide woven out of bamboo are fixed in the form of spirals with a gap of 5-6 cm in between (Chandrika).

Other equipment includes thermometers, hygrometers, feeding stands, feeding basins, sprayers, leaf baskets etc.

Disinfection and Hygiene:

The rearing house as well as the appliances used in rearing should be disinfected with 2% formalin prior to commencement of every rearing. For effective disinfection, the rearing house should be made air tight as far as possible and with the rearing appliances kept inside, the walls, windows, doors and the appliances should be sprayed with 2% formalin @ 7-8 lt for 100 sq mt and the doors closed immediately. After 24 hours of disinfection the doors and windows should be opened and the rearing house should be completely aerated at least 24 hours before the commencement of brushing.

QUESTION

1. **Draw any five silkworm rearing equipment with proper labels.**

Ex. No: 13 Date:

Mulberry Cultivation and Mulberry Varieties

Mulberry is a fast growing deciduous tree occurring in sub tropical and temperate climate. Mulberry has characteristic long idioblast cells in the upper epidermis of leaves. Inflorescence is a catkin/spike with unisexual flowers. Hence it is a cross pollinated crop. The important species of mulberry cultivated in India are:

a) *Morus alba*

b) *Morus indica*

c) *Morus bombycis.*

d) *Morus sinensis*

e) *Morus multicaulis.*

They belong to family Moraceae. The cultivation of mulberry is called as **Moriculture**.

Mulberry leaves:

- Silkworm prefers fresh, soft, succulent, smooth leaves with low fibre content.
- The three different kinds of factors influencing the feeding behaviour are:

a) Attracting factors

- Essential oils like citral, terpenyl acetate, linalol and –hexanol –excite the olfactory sensillae.

b) Biting factors

- Flavonoids like isoquercitrin and morin, terpenoids like -sitosterol and sugar like sucrose and inositol act on gustatory sensillae.

c) Swallowing factors

- Cellular supplementary mineral factors like potassium, dibasic phosphate, silica as well as inositol induce continuous feeding.

Composition of mulberry leaves:

Moisture 75-82%;	Crude fiber 9-11%; Crude
protein 24-56%;	Ash (minerals) 7-8%
Crude fat 3-4%;	Carbohydrate 12-20% and also rich in Vitamins

Soil:

Mulberry is a deep rooted, perennial, hardy crop. The quality of soil of mulberry garden influence not only the leaf yield, but also leaf quality, which in turn influences the growth and development of silkworm, subsequently the quantity and quality of cocoon production. The soil should be deep, fertile, well drained, clayey loam to loamy in nature, friable, porous with good moisture holding capacity. The pH of the soil should be around 6.2 to 6.8. Saline and alkaline soils are not preferred and need improvement through the use of soil amendments like gypsum, sulphur or green manuring *etc*

Climate:

Mulberry comes up well above 600-700 MSL. It can be grown in areas with rainfall of 600 mm to 2500 mm. Mean temperature of 24-28^{0}C, relative humidity of 65-80% are ideal for growth of mulberry. It can be grown with sunshine hours of 5.0-10.2 hrs/day in temperate conditions and 9.0-13.0 hrs/day under tropics.

Planting season:

Planting after the onset of monsoon is ideal under both rainfed and irrigated condition. Planting in winter and summer is to be avoided. Cuttings are to be planted either in north-south or east-west direction depending on sun shine hours and wind direction.

Land preparation:

The land should be tilled properly before planting to bring the soil to fine tilth. Land should be free from weeds and stubbles and leveled properly. FYM is to be incorporated @ 10 and 20 t/ ha for rainfed and irrigated crops, respectively as basal dose.

Preparation of planting material:

Mulberry can be propagated in two ways:

a) Sexual propagation by means of seedlings.

b) Asexual propagation by means of cuttings.

Propagation through cuttings is most common and widespread practice.

Shoots of proper maturity and thickness with active, well developed buds are chosen for cutting. The tips of tender branches and the bases of over matured branches are rejected. Branches with pencil thickness (10-12 mm dia) from 8-10 months old plants of desired variety are used for cuttings. The branches are cut into 18-20 cm (7-8") long cuttings with a minimum of 3 internodes with well developed buds. The ends are cut clearly with sharp knife with no splits or peelings in the bark. The cuttings are placed in the nursery bed with about 2.5 cm of cutting with one node projecting above the soil. The cuttings are watered regularly. In ten days, the roots develop from buds in the internodes below the soil and the leaves from bud in the internode above the soil. The cuttings may be planted directly in fields or may be grown in nursery for 2-3 months and then transplanted.

Planting systems:

a) Row system:

It is followed under irrigated conditions. Ridges and furrows are made at 60 cm distance. Two cuttings are planted at each spot along the edges of ridges. The crop is grown as bush type.

b) Pit system:

It is followed under rainfed condition with wider spacing. Pits of 40 x 40 x 40 cm are

dug and filled with 1 kg each of FYM, red soil and sand. Three cuttings are planted in a triangle in each pit. Spacing is 90 x 90 cm for bush type of cultivation. Wider spacing of 180 x 90 cm and 270 x 270 cm is adopted for high bush and tree plantation, respectively.

c) Kolar system:

It is nothing but row system with slight modification in spacing, followed in Kolar district of Karnataka. A spacing of 30-45 cm between the rows and 10-15 cm within the row is adopted.

d) Strip System:

It is followed in West Bengal and similar to Kolar system. Mulberry is grown in strips of 2-3 rows. Each strip is separated by a wide distance so that harvesting, inter cultivation etc. is easy. Within the strip distance between rows and between plants within the row is 15 cm.

e) Angular System:

Mostly followed in hill regions of Nilgiris. Distance between plants is similar to pit system *i.e.,* 90 cm. Plants in adjacent rows are planted in such a way they form a triangular shape. It allows more plants per unit area.

Table 13.1 Different recommended Varieties

Sl. No.	Situation	Varieties recommended
1.	Irrigated	Kanva-2, S36,RFS135, RFS175,V1
2.	Rainfed	S13, S34, AR11, Anantha
3.	Alkaline with pH up to 9.5	AR12
4.	Intercrop in coconut	Sahana
5.	Moisture stress and low input	RC-1
6.	Fertile soils with low input	RC-2
7.	Exclusively for chawki worms	G-2
8.	Exclusively for late age worms	G-4

Ex. No: 14 Date:

Study on Lac Culture

Lac is a resinous substance secreted by a tiny insect called *Kerria lacca* (popular name "lac insect")
Shellac is the purified lac usually prepared in the orange or yellow flakes.

Lac or shellac is used in many ways

- Commonest use is in polishing wooden furniture. The granules are dissolved in spirit and then are applied in very thin layers on the wooden surfaces
- In sealing parcels, packets and envelopes
- As insulating material in electrical work
- In making phonograph records (now replaced by synthetic material)
- In shoe polishes
- In toys and jewellery

Utilization of lac for various purposes has been very ancient in India. A "lac palace" is described in Mahabharata, which was intended to be used for burning the Pandavas alive.

Lac insect

The lac insect lives on native trees in India, Burma (now called Myanmar) and Malaysia. In India it is chiefly grown on trees like "Kusum", " Palas", and "Ber".

– The minute young lac insect (also called crawler) finds a suitable branch.

– The insect inserts its beak into the plant tissue to obtain nourishment.

– It grows in size and secretes a resinous material around itself.

– The resinous material hardens on exposure to air.

– Thousands of crawlers settle side by side and the resinous secretion builds up around them and completely encases the twig.

– Most crawlers develop in about 3 months into female which occupy small cavities in the resinous mass. The females can never come out of these masses.

– Eggs develop inside the body of the female and she assumes a sac like appearance.

– The female dies, the eggs hatch, the crawlers escape and move to a nearby-uninfected part of the twig, and the process is repeated.

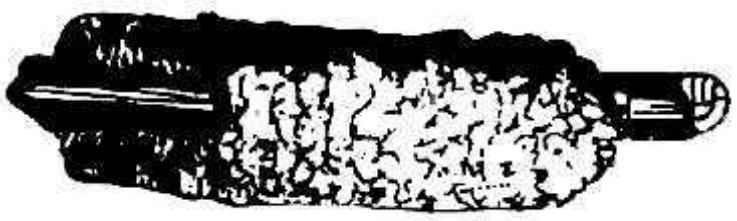

Fig. 14.1 A piece of twig encrusted with lac

Extraction of lac

The encrusted twigs are known as **stick lac**. Such twigs are harvested.

- The stick lac is ground largely in crude mortars, and the resulting granular lac is called **seed lac**.
- The fine particles or the dust separated from the granular lac is used in making toys, bangles etc.
- The wood portion is used as fuel.
- The seed lac is washed, melted, spread out in a thin layer and dried. This is the shellac of commerce.

Earlier, the lac insects were found in great abundance in India and people directly or indirectly find livelihood in through lac culture.

Indian Institute of Natural Resins and Gums (IINRG), earlier known as Indian Lac Research Institute in Namkum, Ranchi conducts research on the various aspects of the lac insect. Synthetic lacquers have been produced by the modern industry, which is replacing true shellac for many purposes.

QUESTIONS:

1. **What is the scientific name and family of the lac insect?**

2. **List any three common uses of lac.**

Ex. No: 15 Date:

Lac Host Plants and Methods of Inoculation

Host plants:

1) Palas – *Butea monosperma* – Jharkhand, Chattisgarh, West Bengal
2) Kusum – *Schleichera oleosa* – Jharkhand, Chattisgarh
3) Ber – *Zizyphus mauritiana* – Jharkhand, Chattisgarh, W.Bengal
4) Ghont – *Zizyphus xylopyra* – Chattisgarh
5) Arhar – *Cajanus cajan* – Assam
6) Jalari – *Shorea talura* – Tamil Nadu
7) Raintree – *Samanea saman* – W. Bengal
8) Fig – *Ficus* species- Jharkhand, Punjab, Karnataka

Lac	Crop	Inoculation	Harvesting
Rangeeni	Rainy (*Katki*)	June- July	Oct –Nov
	Summer (*Baisakhi*)	Oct -Nov	June-July
Kusmi	Winter (*Aghani*)	June-July	Jan-Feb
	Summer (*Jethwi*)	Jan- Feb	June-July

Lac cultivation:

It is done by putting brood lac on suitably prepared specific host plants. The brood lac contains gravid females which are to lay eggs to give birth to young larvae. After emergence from mother cells, the young larvae settle on fresh twigs of host plants, suck the plant sap and grow to form encrustations.

a) Local practice:

In this method, the host plants are continuously exploited without giving rest for recoupment. Only natural inoculation occurs. Partial harvesting is done leaving few branches untouched for auto inoculation of next crop and no pruning is done. The host trees lose the vigour and cannot throw out new succulent shoots. In course of time, the trees become weak and die.

b) Improved practice:

The principle in improved practice is to provide much needed rest to host plants after harvest. For this, coupe system of lac cultivation is adopted. In this, the trees are divided into coupes *i.e.,* groups that consist certain number of trees. In practice, only few numbers of trees in a coupe are inoculated. After harvest, these trees are made to rest and recoup the last vigor while other trees are ready with succulent twigs for inoculation. Thus, in a coupe system, alternate groups of trees are put to lac cultivation. In case of slowly growing kusum, 18 months rest is given by dividing trees into 4 coupes and inoculating each coupe once in two years. In case of rangeeni hosts, trees are divided into 3 coupes *i.e.,* two large and one small in ratio of 3:1:3. The baisakhi crop is raised in 2 large coupes in alternate years. So that each coupe has a rest of 15 months in between and the katki crop is raised in small coupe every year allowing a rest period of 7 months between two successive crops.

Inoculation Methods, Cropping and Enemies of Lac Insect

Inoculation Methods:

Propagation of lac insects is done by inoculation of newly hatched (brood) nymphs on the same or different host plants.

a) Natural/self/auto inoculation: This is a simple and common process, when the swarmed nymphs infest the same plant again. Natural inoculation, repeated on the same host, makes the host plant weak and thereby nymphs do not get proper nutrition. Uniform sequence of inoculation does not take place.

b) Artificial inoculation: The old weak and diseased twigs of host plants are pruned in January or June. It induces host plants to throw out new succulent twigs. The cut pieces of brood twig (*i.e.,* 20 x 30 cm in length) are tied to fresh twigs in such a way that each stick touches the tender branches at several places. The nymphs swarm from brood and migrate to tender and succulent twigs and infest them.

Following swarming, brood twigs should be removed from the host plant to prevent pest infestation.

Precautions for artificial inoculation:

a) Use fully matured and healthy brood
b) Don't keep the brood meant for inoculation for long and use immediately after cutting.
c) Tie the brood stick on upper surface of branches securely.
d) Raise brood sticks at room temperature to 20^0C to induce swarming.
e) Avoid cultivation of rangeeni in kusumi area and vice versa.
f) Inoculate only on non rainy day.

Harvesting of lac (Cropping):

It is done by cutting the lac encrusted twigs when the crop is mature. It is of 2 types.

a) **Immature harvesting:** In this method, lac is collected before swarming. The lac, thus, obtained is known as "ARI LAC". In this method, lac insect may be damaged during harvest. Ari lac harvesting is recommended on Palas only.

b) **Mature harvesting:** In this method, lac is collected after swarming. The lac obtained is known as mature lac. Symptoms of swarming of nymph include the following.

a) A yellow spot develops on the posterior side of lac cell towards crop maturity.

b) Dried out appearance of encrustation two weeks before swarming and appearance of cracks on the encrustation at a later date.

Cutting of twigs for harvest can be done at any time between stages while yellow spot occupies one third to one half of the cell area. It is sometimes desirable to wait till the emergence of first few nymphs.

The kartiki crop is harvested in Oct/Nov, baisaki in May/June; aghani in Jan/Feb and Jethwi in June/July. The brood lac left after emergence of nymphs is known as stick lac or phunki lac.

Composition of lac:

Lac resin	: 68%
Lac wax	: 6%
Lac dye	: 1-2%
Others	: 25%

Lac processing:

1. Stick lac:

After harvest, lac encrustations are removed from the twigs of host plant by scraping. The raw lac thus obtained is known as **crude/scraped/stick lac**. The crude lac consists of resin, encrusted insect body, lac dye, sand and twig debris. The stick cannot be stored for long duration, as the lac has a tendency to form lump and there is a loss in quality of lac. High moisture content is responsible for lump formation. The optimum moisture content is 4% for storage of stick lac to avoid lump formation.

2. Seed lac/ grain lac:

The stick lac is crushed and sieved to remove sand and dust. It is then washed in large vats repeatedly to break open the encrusted insect bodies, to wash out the lac dye and twig debris. Decaying bug bodies turn the water a deep red that is processed further to get the byproduct, lac dye. The remaining resin is dried, winnowed and sieved to get the semi refined commercial variety product called seed lac. The seed lac is in the form of grain of 10 mesh or smaller and yellow/reddish brown in colour

3. **Shellac:** The seed lac is processed into shellac by any of the 3 methods: *i.e.,* handmade country process/heat process/solvent process.

Handmade process:

The seed lac is filled into long sausage shaped cloth of 2" diameter and 30 ft long. The long bag is passed gradually in front of a charcoal fired heat hot enough to melt the lac. By twisting the bag, molten lac is squeezed through cloth. The residue left inside cloth bag is another variety of refuse lac known as Kirilac. The molten filtered mass is stretched into sheets approximately 0.5 cm thick. Alternatively the molten mass is allowed to solidify in the form of discs and then it is called button lac.

Heat Process:

To the granular seed lac 4 -5 % resin and 2 -3% yellow pigment are added and the mixture is filled in cloth bags of about 3″long × 2″ in diameter The mixture is melted before the furnace in which charcoal is kept burning. The material is cooled inside and oozes out through the cloth and drops on the stone slab in front of the furnace. When sufficient amount has been collected on the stone slab, the molten mass is rapidly transferred to a porcelain cylinder containing hot water and spread flat with palmyrah leaves. This is again warmed before the furnace and stretched by men into a thin sheet with the help of his hands and feet. Defects like knots, air bubbles, etc are punched and removed out. This is broken into pieces and is known as shellac.

Solvent process:

The seed lac is dissolved in refrigerate alcohol and filtered through filter press to remove wax and impurities. The colour may be removed by any required standard by charging with activated carbon and then alcohol is recovered. The molten shellac is stretched with a roller.

4. Button lac:

It is manufactured by pouring the molten lac into dies in a zinc sheet instead of streching for shellac preparation. This results in buttons of lac 7 cm diameter and 0.6 cm thick.

Enemies of lac insect:

Include both predators and parasites and non insect pests like monkeys, squirrels, rats, birds and lizards.

Predators:

Larvae of *Eublema amabilis* (Noctuidae) and *Holcocera pulviria* (Gelichidae) are predators on lac both in field and store. Adult moths lay eggs on or near lac encrustation. The caterpillars bites its way into the encrustation and makes the tunnel lined with silk, excrete or pieces of lac in which it spends whole of its larval and pupal life. A single caterpillar *E. amabilis* can devour 40-45 lac cells.

H. pulviria is more severe in stores than in fields. Katki and Aghani crops are greatly affected than Baisaki and Jethwi crops.

Methods of Control:

a) Select brood lac from healthy trees.
b) Cut the brood lac from the trees as near the time of swarming, never more than a week before.
c) Remove the brood lac sticks immediately after two weeks of inoculation
d) Remove the lac sticks from field after harvest
e) Do not leave the crop in field for natural inoculation
f) Pack the brood lac in 30-60 mesh wire net before inoculation.

One to 20 kg of brood stick is necessary for inoculating a tree depending up on its size in case of kusumi strain, 0.4 to 5 kg in case of Rangeeni strain.

g) Heavier inoculation is not desirable as it may result in death of host tree.

h) The crawlers start moving out in one/two days after inoculation. The brood lac sticks are to be removed within three weeks of inoculation. Otherwise, the enemies of lac insect may be spread from broad lac to fresh crop.

Yield: About 2.5 to 3 times the weight of brood lac can be expected as yield

QUESTIONS

1. **What are the two strains of lac insect? Mention their time of inoculation and harvesting**

2. **Write about the composition of lac?**

3. **Mention the different categories of potential enemies of lac insect.**