EXERCISE NO. 1 **DATE :**

ECONOMIC IMPORTANCE OF INSECTS IN VEGETABLE, ORNAMENTAL AND SPICE CROPS

Economic Classification of Insects:

Beneficial Aspects of Insects:

(i) **Direct advantages:** Insects provide us silk, honey, wax and shellac.

(ii) **Galls:** Some insects produce galls on the plants, some of which yield tannic acid used in leather and fur industry and materials that make the most important ink and dyes.

(iii) **Pollination:** It is well known fact that most of the plants are cross pollinated and it has been estimated that 5 % flowers are self pollinated, 10 % by wind and water and 85 % are pollinated by insects which clearly indicates the value of insect in this aspect.

(iv) **Parasites and predators:** Insect pests destroy our crops and stored grains worth rupees ten crores every year in India alone. These pests are kept under some control by some other insects called as parasites and predators. The insects which lay their eggs on or within the body of host insects and their immature stages feed on or within the body of hosts are called as parasites, where as those which catch the caterpillars or devour them are called as predators.

(v) **Drugs and ornament:** Insects and their products haved limited used in medicine. Some specific drugs are prepared from the insects. E.g. Allantipini chemical is recovered from the larvae of housefly which had got a healing power for wounds. There are many insects used as ornaments e.g Glow worms.

(vi) **Aesthetic and entertainmants:** Their shapes, attractive wing colour patterns have served as models for artists.

(vii) **Use in scientific research:** Drosophila flies.

(viii) **Soil Fertility:** Some insects improve the physical conditions of soil by burrowing into it, the dead bodies and excreta of these promote soil fertility.

(ix) **Scavengers:** There are certain insects, which act as scavengers by way to eating waste materials e.g. flies.

(x) **Week killers:** The weeds which are harmful to crops, are kept under control by insects by way of feeding on them..

(xi) **As a food:** Some insects like queen termites, locust, caterpillars, are use in the form of food by man in different parts of the world.

Harmful Aspects of insects:

(A) Direct Losses:

(i) **Root:** The insects living in the soil (soil inhabitors) cause considerable damage to the roots resulting in the death of the plants, while some plants become weak and sick in appearance.

(ii) **Stem:** Many insect pests enter the stem of various plants and cause very serious damage (stem borers).

(iii) **Leaf : The leaf eaters of defoliators** are insects having biting and chewing type of mouth parts and feed on the leaves may be put under this category e.g. grasshoppers. In case of **Leaf miners** they live between the upper and lower epidermis of leaves and devouring its green part. Eg. Citrus leaf miner, pea leaf miner. **Leaf rollers** – Some of the larvae besides feeding upon the leaves cause them to roll up which after some time shrivel and fall down. Eg. Cotton leaf roller *Sylepta derogata*. **Sap suckers –** Many insects pests possess piercing and sucking type of mouth parts drain the sap from leaves due to which leaves become brown or yellow and fall e.g. aphids, whitefly, leaf hoppers, jassids etc.

(iv) **Flower and fruit feeders:** Among the flower feeders blister beetle, thrips and jassids are the important pests where as the fruits are damaged by a variety of insect pests namely fruit sucking moths, fruitfly and fruit borers. The damage caused by these pests lowers the quality as well as the quantity of fruits.

(v) **Seed feeders and insects of godowns:** There are some insects which feed either on the developing seeds or the mature seeds in plants. E.g. tobacco caterpillar, gram pod borer. Certain insects viz., rice weevil, pulse beetle cause damage to the seeds in the field as well as godowns.

(vi) **Wood and bark feeders:** Some insects feed on the bark and wood of the plants. E.g termites, bark eating caterpillars etc.

(B) Indirect Losses:

(i) **Disseminate diseases in man and animals:** About 150 diseases are known to be exclusively transmitted bu insects and their arthropod relatives. They transmit viruses, bacteria, protozoa, namatodes, fungi responsible for transmitting the diseases to man and animals. E.g. malaria, typhoid, cholera, dysentery, filarisis, dengue, yellow fever, black fever, plague etc.

(ii) **Vectors of plant diseases:** A number of insects species are known to transmit viral and plasma like diseases in plants. The insect vectors which belong to this group are sesamum jassid, white flies, aphids etc.

(iii) **Insect venoms:** Many insects are venomous, they insert their venom into the body of human beings by their piercing mouth parts (bed bug, mosquitoes), sting (bees, wasps) and netting hairs (larvae of some moths).

(iv) **Destroyers of articles:** Insect destroy almost every article which is used by man e.g. stored foods, clothing, woolens, drugs, furniture, paper, books etc.

What is an Insect Pest:

"An insect whose population increases to the extent that it starts causing annoyance, inconvenience or injury to man, domesticated animals, plants and material possessions will be called as insect pest".

OR

"All insects that cause significant and economic damage of 5 per cent or more to the crops, stored products, poultry birds and domestic animals are called pests".

Types of pests:

If an insect causes a loss of less than 5 per cent, the infestation is said as negligible. Insects which normally cause a loss ranging from 5 to 10 per cent are said to be minor pest and those which cause a loss of 10 per cent or more of yield are called as major pests.

(i) **Regular pests:** They occur most frequently on the crops and such insects have close association with particular crop e.g, jassids and bollworms on cotton, fruit borer on brinjal and lady's finger or okra, thrips on chilles, hoppers on mango etc.

(ii) **Occassional pests:** They rather occur infrequently and close association with the particular crop is absent. E.g. *Helicoverpa* on wheat, mango stem borers, locusts etc.

(iii) **Seasonal pests:** Insects which occur mostly during a particular part of the year are called as seasonal pests. The incidence of these pests are largely governed by the climatic and weather conditions in a particular area e.g., hairy caterpillar on cotton.

(iv) **Persistant pests:** Insects which occur on a crop almost throughout the year are called as persistent pests. E.g., scales and mealy bugs, termites etc.

(v) **Sporadic pests:** They occur in few isolated localities and their population remain low and insignificant for long periods of time e.g., paddy root weevil, white backed plant hopper etc.

On the basis of feeding habits they may be classified as under:

(i) **Monophagous insects:** They are confined to a single species of plants and feed on a group of closely related plants. E.g. mulberry silk worm, mango hoppers etc.

(ii) **Oligophagous insects:** They feed on a group of botanically related plants usually within a single plant family like potato tuber moth which attacks only potato, tobacco and other plants related to family solanaceae, diamond back moth, mustard saw fly is confined to plants of family cruciferae.

(iii) **Polyphagous insects:** These insects feed on many plants from a diverse group of plant families e.g., locusts, grasshoppers, hairy caterpillars, gram pod borer etc.

Pest management :

"It is the system in the context of associated environment and population dynamics of the pest, utilizes all possible techniques or practices to maintain the pest population that will not cause economic damage or losses".

Economic Threshold Level (ETL) :

It is the pest population density at which control measures should be undertaken to prevent an increasing pest population from reaching the economic injury level.

e.g. Yellow rice stem borer : 5 per cent dead hearts OR one egg mass/sq.m. area **Economic Injury Level (EIL) :**

The lowest population density that will cause economic damage.

O Pests will be dealt in respect with the following points :

Nomenclature :

Taxonomic position :

Every living organism are known by common name and scientific name. Particular insects are known by common name in certain area/locality and not all over the world. They are recognized in scientific community by scientific names which consists of two names, *viz., Earias vittella* – the first name indicates genera and the second specify the species name. The system of nomenclature is called binomial system of nomenclature. Similarly, trinomial system of naming is in existence for some insects where in three names are given.

e.g. Athelia lugens proxima, Amrasca biguttella biguttella **Marks of identification :**

Description of different developmental stages for *e.g.* Tomato fruit borer egg, larva, pupa and adult is important for correct identification of pest.

Hosts :

These are the plants on which insect use to feed upon for completion of its life cycle. When main host is not available, insect can feed on other hosts for survival are called alternate hosts.

Life history :

Means the development of insect – for instance in most of the insects development take place from egg to adult stages eg. Tomato fruit borer. The object to study the life history is to find out certain weak points of the insects *viz.,* site of oviposition, site of pupation, carry over from one season to next, habit and habitat of pest. These are to be pointed out for deciding the control strategies of the pests.

Nature of damage :

There is hardly any plant which is not infested by the pest. Pests injure host plants by damaging one or the other parts of the plant *viz.,* roots (root feeders), stem/shoot (stem borers), leaves (leaf feeders), buds, flowers, fruits (fruit borers) and grains also. Depending upon feeding habit, pests are categorized as sucking pests, chewing pests. According to the symptoms are produced on damaged plant parts.

Management of the pest :

While managing the pest, there should be an Integrated Pest Management (IPM) approach in order to keep pest population below a level of economically acceptable damage (ETL).

EXERCISE NO. 2 **DATE :**

ECOLOGY AND PEST MANAGEMENT WITH REFERENCE TO VEGETABLE, ORNAMENTAL AND SPICE CROPS

The word ecology is the modified form of **"Oekologie**" derived form the greek word **"Oikos"** meaning Home and **"Logus"** meaning Study introduced by Reiter in 1869 and later analysed to Ecology.

Ecology is an multidisclipinary subject and derives support from other sciences. Individual organisms of the same species live together as a population. **Population** can be defined as 'a group of individuals or a species occurring in a given area or locality at a specific time'. Populations of different species live together and form a **"Community**", meaning "all populations in the area at a specific time'. The community is influenced by its physical environment. The complex system of biotic and abiotic factors constitutes an **'Ecosystem".** Whereas the crops, insects, other animals and the physical abiotic factors together constitute the **"Agro-ecosystem".**

Ecology is 'the science of inter-relations between the living organisms and their environment including both the physical and the biotic environments and emphasizing inter species and intra species relations' (Allee, 1949).

Odum (1953) defined ecology as ' the study of the structure and functions of nature (or Environmental biology)'.

Ecology is divided mainly into 'Autecology' and 'Synecology'. **Autecology** is the study of individual organisms or an individual species in relation to the environment while **Synecology** is the study of group or groups of organisms associated in a community in the same environment i.e., in relation to various other species living in the same environment.

Importance of Ecology in Insect Pest Management:

Indiscriminate uses of pesticides lead to a regular resurgence of pests due to the fact that the natural enemies get killed. The increase in pest population is also due to the interference of man by monoculture, using high yielding and susceptible varieties, giving more number of irrigations, use of high nitrogenous fertilizers etc. Because of which the balance of life in nature gets disturbed/upset and the pest appears in severe form every year. The importance of ecology was then felt and integrated approaches in pest management are now made to avoid the violent fluctuations in pest populations.

Ecological studies assist/help pest control programmes by explaining pest problems and suggesting alternate ways of combating insects. The outbreaks of the pests can be predicted. The ecological studies investigate the causes for the changes inb population number and the mechanism of natural control. The key mortality factors in the natural population help to integrate the various methods of control, without disturbing the balance of nature. The pest surveillance programmes form part of ecology. Forecasting of the possible attack by different pests can be done accordingly the control measures can be initiated in time. Suitable chemicals can be selected depending on the presence or absence of natural enemies. As such ecological studies form a basic part of the approach to the integrated pest management (IPM).

In nature the living organism and the non-living substances of environment interact to form ecosystem. The environmental complex constitute

(1) **Biotoic factors** known as 'Density dependent factors' include

(i) **Food:** Each insect species has certain nutritional requirements for completion of its life cycle. Under normal conditions there is a happy adjustment between host and particular species of insect. But in the event of sudden increase in population, the densities of population become too high to be supported by the food available in the area. Hence competition for food as well as space will be there.

(ii) **Other organisms:** Include beneficial and harmful insects. Association of individuals of the same species is known as intra-specific relations and it may be beneficial. Such association of two sexes, parental care, associations of social insects etc. phenomenon like overcrowding is harmful since shortage of food and space results. Disease outbreak and cannibalism may occur. Beneficial associations are **Symbiosis-** Inter relationship between organisms of different species which live in close union without harmful effects and **Commensalism** (gall forming insect) – One insect is benefitted by living on or inside another insect without injuring the other and **Mutualism –** When both the symbionts are benefitted. E.g. Ants and aphids, Termites and flagellates.

(2) **Abiotic factors** known as 'Density independent factors' comprises

(i) Temperature – This is the most important physical factor which determines the duration of the various stages in the insect life cycle and consequently the number of generations during any period of time. It acts directly on the survival and development which determine the abundance of pests.

(ii) Humidity: Different species and their different immature stages have their own humidity ranges. Humidity effects the speed of development, fecundity, colour etc. If water content of the body is high, dry air accelerates the development. Locust sexually mature quicker and the number of eggs laid are more at 70 % R.H.

(iii) **Rainfall:** Relative humidity is dependent on rainfall. The total amount of rainfall distribution in time influences the abundance of insects in an area. E.g Desert locust does not lay eggs and even if laid does not hatch unless soil has sufficient moisture. Rain induces emergence of most of the insects in soil.

(iv) **Light :** It the greatest single source of energy for almost all biological systems. It is an non lethal factor. It helps in orientation or rethamic behavior of insects, bioluminescence, period of occurrence and inactivity, growth, moulting and fecundity of insects.

(v) **Wind and air currents:** Most of the insects will not take flight when speed of wind exceeds the normal flight speed. Air currents, especially in the upper air being strong carries many insects like aphids, white flies, scales to far-off places and is an important factor in dispersal.

(vi) **Soil:** Sandy and loamy soil allow digging and burrowing operations and are usually favourable for insects. *Agrotis* spp. Live in soil of fairly light texture in which they move around freely in response to daily or seasonal temperature and moisture changes.

EXERCISE NO. 3 **DATE :**

PEST SURVEILLANCE IN IMPORTANT VEGETABLE, ORNAMENTAL AND SPICE CROPS

Survey : Survey is the planned activity to collect some data.

Surveillance : When survey of the same area/plot or locality is carried out at regular intervals to record some observations or to ascertain the changes in the subject of study, it is called as surveillance. In other words pest surveillance is the close and constant vigil on insect population in a particular area.

Pest surveillance is the systemic monitoring of biotic and abiotic factors of the crop ecosystem in order to predict the pest outbreaks or it is the study of the ecology of the pest which provides the necessary information to determine the feasibility of a pest management programme. By the Pest Surveillance programmes, the population dynamics and the key natural mortality factors operating under field conditions can be known which in turn helps in devising the appropriate management strategies.

Objectives of survey and surveillance:

- To monitor the pest population and /or damage regularly to arrive at a decision whether control measures are required or not, if required when to initiate the control measures.
- Pest forecasting with reasonable precision.
- Endemic areas of various pests may also be marked
- To predict future population trends or the corresponding potential damage to the crops or both

Types of survey:

- **Qualitative:** To identify the different insect species present over an area or their density whether abundant, common, rare, in traces, etc
- **Quantitative:** To estimate the exact number of one or more species of insects in time and space.

Sampling insect populations:

- In quantitative survey a count of insects is required.
- Due to large number and/or secretive nature it is not possible or even desirable to count each and every individual in a population.
- Hence more efficient method is by sampling.
- Randomization and the choice of sampling unit are the fundamentals of sampling.
- The total number of samples to be taken depends upon the degree of precision required.

Sampling unit:

- Sampling unit is a portion of the habitat from which insect counts are to be made e.g. a plant, branch, leaves or fruiting bodies, a clump, a micro plot of 1 m^2, etc.
- Sampling unit must be distinct and should not overlap.

Sample: A group of sampling units from which an estimate is made.

Sampling technique: It is the method used to collect information form a single sampling unit.

Sampling programme: Sampling programme is the procedure that employs the sampling technique to obtain sample and make a density estimate.

Sampling programmes :

1. Extensive programmes:

- Conducted over a large area to determine information like species distribution, status of injurious insect stages.
- Usually a single insect stage is sampled.
- Only one or few samples are taken per season.
- Only moderate levels of precision are required and emphasis on low cost.

2. Intensive programmes:

- Conducted as part of research in population ecology.
- Here sampling is done frequently, in a small area.
- All or most stages in the life cycle are sampled.
- High degree of precision in sought.

Common sampling techniques :

- Insitu count

- Knock down (By jarring, by chemicals, by heating)
- Netting
  - Sweep netting
  - Vacuum netting
  - Aerial netting
- Trapping
  - Light trap
  - Bait trap
  - Pheromone trap
  - Malaise trap
  - Suction trap
  - Window trap
  - Water trap
  - Sticky trap
  - Pitfall trap
- Mark, release and recapture technique
- Sequential sampling

Advantages:

1. One can know how a pest is multiplying in an area and when it is expected.
2. Minimize the cost of plant protection by reducing the amount of pesticides used and in turn reduce environmental pollution.
3. Pest control measures can be initiated in time due to advance forecasting.
4. Useful for pest forecasting.
5. To find out natural enemy population.
6. To study the influence of weather parameters on pests.
7. Mark endemic area.
8. Maintain the stability of the agro ecosystems.

Components of pest surveillance:

1. Identification of the pest.
2. Distribution and prevalence of the pest and its severity.
3. The different levels of incidence and the loss due to the incidence.
4. Pest population dynamics.
5. Assesment of weather.
6. Assesment of natural enemies.
   This study will give advance knowledge of probable pest infestation and will help to plan cropping patterns and to get best advantage of pest control measures.

Forecasting for Pest Management:

The pest surveillance programmes are highly useful in forecasting of the pests. It is the advance knowledge of probable infestation by the pests in a crop. Insect forecasting may serve:

1. To predict the forthcoming infestation levels of a pest which is very useful in taking control measures and
2. To find out the critical stages at which the application of insecticides would afford maximum protection.

Locust warning station in India was established in year 1939 in Jodhpur, Rajasthan.

Forecasting is mainly of two types :

1. **Short term forecasting:** Covers one or two seasons mainly based on the populations of the pest within the crop by sampling methods.
2. **Long term forecasting:** It covers large areas and based mainky on the possible effects of weather on the insect abundance e.g., locust warning stations.

Forecasting is made through -

1. Population studies carried over several years.
2. Studies on the pest life history.
3. Field studies on the effect of climate on the pest and its environment.
4. Predictions from the empirical deata on the pests of the previous season.

Pest surveillance and monitoring in India:

Pest surveillance and monitoring form an integral part of IPM technology. Directorate of Plant Protection, Quarantine and Storage (DPPQS), Faridabad, is organizing regular rapid roving pest surveys on major field crops in different agro ecosystems in collaboration with ICAR and SAU's and a consolidated report then issued by Plant protection Advisor (PPA) to the Government of India.

EXERCISE NO. 4 **DATE :**

GOOD AGRICULTURAL PRACTICES IN RELATION TO PEST MANAGEMENT

Good agricultural practices in pest management :

- Apply field sanitation and hygiene measures and use clean cultivation practices.
- Use resistant cultivars and varieties, crop sequences (mixed cropping, relay cropping, inter cropping) and cultural practices (deep ploughing, alter time of sowing, trap crops, crop rotation, balanced use of manures and fertilizers, use of organic amendments in soil, collection and destruction of crop residue, trimming of bunds etc.) that minimize the pressure and maximize biological prevention of pests.
- Understand and use non-chemical pest management practices (E.g. Use of Pheromone traps for Tomato fruit borer, *Helicoverpa armigera*, Tobacco leaf eating caterpillar, *Spodoptera litura*, Fruit fly, *Bactrocera dorsalis* etc., use of light traps for nocturnal insects, tin bands around coconut trees for rat control, paint greasy bands or wrap alkathene sheet around trunk of mango plant for control of mealy bugs etc.).
- Avoid impact of any pest management activity on non-target areas.
- Appropriate weed control which harbour the harmful pests E.g. Destruction of Gulwel and Vasanwel weeds which harbour larvae of Citrus fruit suckig moth, *Eudocema fullonica, E. materna.*
- Promotion of biological control measures. Use of biocontrol agents (e.g. Egg parasite - *Trichogramma*, *Goniozus nephantidis*, Predator – *Chrysoperla carnea,* Dragonflies, Damsel flies), biopesticides (e.g. *Bacillus thuringeinsis*, *Ha*NPV) and botanicals (e.g. Neem products).
- Conservation of important beneficial organisms. E.g. Parasites, predators, Frogs, birds, lizards, snakes etc.
- Maintain regular and quantitative assessment of the balance status between pests and beneficial organisms of all crops.
- Apply pest forecasting techniques where available E.g. Locust.
- Regular monitoring of harmful pests. Monitoring of pests at larger level can help for early warning, early detection E.g. Locust survey and forewarning.
- Establishing of Economic Threshold levels (ETLs) E.g. 5 caterpillars per plant for Tomato fruit borer, *Helicoverpa armigera*, increasing number of adult moths in pheromone traps for consecutive 5 days for tobacco leaf eating caterpillar, *Spodoptera litura,* Diamond back

moth, *Plutella xylostella,* Tomato fruit borer, *Helicoverpa armigera,* 10 nymps/plant for leaf hoppers etc.

- Observations of the field regularly is necessary to assess crop development, insect pests and non- insect pests (rats, snails, slugs, mites) population.
- **Pesticide use as a last resort.**
- Decide on interventions following consideration of all possible methods and their short- and long-term effects on farm productivity and environmental implications in order to minimize the use of agrochemicals, in particular promote integrated pest management (IPM).
- Store and use agrochemicals according to legal requirements, e.g. registration for individual crops, rates, timings, and pre-harvest intervals.
- Assure that agrochemicals are only applied by specially trained knowledgeable persons.
- Assure that equipment used for the handling and application of agrochemicals complies with established safety and maintenance standards.
- Maintain accurate records of agrochemical use.
- Avoid any point source pollution from agrochemicals resulting from use, storage, cleaning and disposal of products or application equipment.

EXERCISE NO. 5 **DATE :**

STUDY OF PESTS OF OKRA OR LADYS' FINGER OR BHINDI

Sr. No.	Common Name	Scientific Name	Order	Family
1.	Bhendi shoot and fruit borer	*Earias vitella Earias insulana*	Lepidoptera	Noctuidae
2.	Aphid	*Aphis gossypii*	Hemiptera	Aphididae
3.	Jassid	*Amrasca biguttula biguttula*	Hemiptera	Cicadellidae
4.	Thrips	*Anaphothrips dorsalis*	Thysanoptera	Thripidae
5.	Mites	*Tetranychus telarius*	Acarina	Tetranychidae
6.	Red cotton bug	*Dysdercus cingulatus*	Hemiptera	Pyrrhocoridae
7.	Leaf roller	*Sylepta derogata*	Lepidoptera	Pyralidae
8.	Whitefly	*Bemisia tabaci*	Hemiptera	Aleurodidae
9.	Flea beetle	*Podagrica bowringi*	Coleoptera	Chrysomelidae

1) Bhendi shoot and fruit borer : *Earias vitella* Fab.
Earias insulana Boised. Lepidoptera; Noctuidae

Marks of identification :

The moths of *E. vitella* have pale white upper wings with broad greenish band in the middle. The moths of *E. insulana* possess completely greenish coloured forewings. The hind wings in both species are pale white. The moths of both species measure about 10 mm in length and 25 mm across the wings. The caterpillars of both the species are brownish white with a dark head and prothoracic shield. Caterpillars have number of black and brown spots on the body. Full-grown larva measures about 19 mm in length. Eggs are spherical and bluish green in colour.

Nature of damage :

In the beginning of the crop growth (when the crop is only a few weeks old), larvae bore into the tender top shoot and feed internally causing shoots to droop, wither and dry up. When flowers, flower buds and fruits appear, the larvae are seen boring into them and feeding internally. The infested flowers and flower buds drop down prematurely. Damaged fruits present deformed appearance. The infested fruits show holes plugged with excreta. Infested fruits fetch less price in the market. The severely infested fruits are made unfit for human consumption.

Host plants:

Cotton, Bhendi, Ambadi, Hollyhock and several other malvaceous plants, shoeflowers (Oligophagous).

Life history :

The females lay bluish green eggs singly or in batches on tender shoots, flowers, flower buds and young fruits. Fecundity varies from 60 to 432. Incubation period is 3 to 7 days. Larval development

takes place within 9 to 20 days. Pupal period varies from 5 to 9 days. Pupation takes place in silken cocoon either on host or in the soil or in fallen leaves. One generation completed in 19 to 21 days in summer and 30 to 31 days in winter. Total number of generations completed in a year are 12.

Control measures :

i) Removal and destruction of infested shoots and fruits and shed materials helps in reducing intensity of infestation.

ii) Use Trichocards of 1cc each @ 4-5 cards /ha. iii) Give four sprays of following insecticides at 15 days interval starting from 15 days after germination.

Cypermethrin 25 EC 0.01 per cent OR
Fenvalerate 20 EC 0.01 per cent OR
Deltamethrin 2.8 EC 0.01 per cent OR
Lambda cyhalothrin 5 EC 0.0015 per cent OR
Profenofos 50 EC 0.08 per cent.

2) Bhendi leaf roller : *Sylepta derogata*

Lepidoptera; Pyralidae

Marks of identification:

Moths are yellowish white, with black and brown spots on the head and thorax. They measure abovt 28-40 mm across wings and have a series of dark-brown wavy lines on the wings. The full grown caterpillars measures about 25-30 mm in length and are greenish grey or pink in colour.

Nature of damage:

This is an sporadic pest. The larva is the damaging stage. It rolls the leaf and feed on the green tissues in the early stage of infestation. The larva eats up a large portion of the leaf as it grows. In case of severe attack, the plants may be defoliated completely.

Host plants:

Bhendi, cotton and some other malvecious plants.

Life history:

The female moths lays 200-300 eggs singly on the undersurface of the leaves. The eggs hatch within 2-6 days. There are sevel larval instars and larval development is completed in 1535 days. The full grown larva pupate either on the plant, inside the rolled leaves, or among the plant debris in the soil. Pupal period varies from 6-12 days. One life cycle is completed in 23-53 days and 5-6 generations are completed in a year.

Control measures:

Spray the crop with 500 ml cypermethrin 10 EC or 400 ml decamethrin 2.8 EC or 250 ml fenvelarate 20 EC or 2.5 kg Carbarly 50 WP or 2 litres of Quinalphos 25 EC or 1.250 litres of monocotophos 36 SL in 500 litres of water per ha. Five to six sprays at 10 days interval should be applied.

3. Leaf hopper: *Amrasca biguttula biguttula* Ischida.
Hemiptera; Cicadellidae
(Given under potato)

4. Aphid: *Aphis gossypii G.*
Myzus persicae S.
Aphis fabae K.
Hemiptera; Aphididae
(Given under brinjal)

5. White flies: *Bemisia tabaci* Gen.
Hemiptera; Aleurodidae
(Given under tomato)

EXERCISE NO. 6 **DATE :**

STUDY OF PESTS OF BRINJAL

Sr. No.	Common name	Scientific name	Order	Family
1.	Brinjal shoot and fruit borer	*Leucinodes orbonalis*	Lepidoptera	Pyralidae.
2.	Brinjal leaf roller	*Antoba olivacea*	Lepidoptera	Noctuidae
3.	Brinjal lace wing	*Urentius echinus U. sentis*	Hemiptera	Tingidae
4.	Jassid	*Amrasca biguttula biguttula Empoasca devastens*	Hemiptera	Cicadellidae
5.	Aphid	*Aphis gossypii*	Hemiptera	Aphididae
6.	Brinjal stem borer	*Euzophera perticella*	Lepidoptera	Pyralidae
7.	Epilachna beetle	*Henisepilachna vigintioctopunctata*	Coleoptera	Coccinellidae
8.	Thrips	*Scelenothrips indicus Scirtothrips dorsalis*	Thysanoptera	Thripidae
9.	Mites	*Tetranychus urticae*	Acarina	Tetranychidae

1) Brinjal shoot and fruit borer : *Leucinodes orbonalis* Guen.
Lepidoptera; Pyralidae

Marks of identification :

Adult is medium sized moth with whitish wings having large brown patches all over. Head and thorax are blackish brown. The moths measure about 10 mm in length and 20 mm in wing expanse. The caterpillars are pale white and measure about 15 mm in length when full grown.

Nature of damage :

Infestation of pest starts from a few weeks after transplanting of crop and pest continues to damage the crop till the harvest of fruits. Caterpillars bore into the terminal shoots, petioles and midribs of large leaves. As a result, terminal portions wither and finally dry up. Later, when fruits develop, caterpillars are found boring into them and feeding internally. In case of young fruits, caterpillars make their entry below calyx. These entry holes get plugged with excreta leaving no visible sign of infestation. The larger holes seen on the fruits are usually the exit holes of the larva. Under conditions of severe infestation, damage to the fruits is reported to be as high as 70 per cent. The varieties with spherical or round fruits are relatively more preferred than those with

medium long and slender fruits, more compact vascular bundles, lower protein and sugar contents.

Host plants :

Brinjal, Potato, Bottle gourd, Pea pods.

Life history :

Each female lays about 250 eggs singly on tender shoots, leaves and young fruits. Eggs hatch out in 3 to 5 days. On hatching, caterpillars start boring into tender shoots and fruits when present. They become full grown in 7 to 13 days. Full grown caterpillars come out and pupate in cocoons either on shoots, fruits or in soil. Pupal period lasts for 7 to 11 days. Moths live for 2 to 5 days.

Control measures :

i) Remove and destroy the infested shoots and fruits alongwith larvae to avoid further build up of pest population.

ii) Avoid continuous cropping of brinjal and potato in the same field as it may encourage the pest activity and hence, proper rotation should be followed.

iii) Apply phorate 10 G in the seed bed @ 25 gm per seed bed of a size 2 m ×1 m. iv) Dip seedlings in the insecticidal suspension of imidacloprid 200 SL (10 ml / 10 litres of water) before transplanting.

v) Apply 6 to 7 sprays of following insecticides at 15 days interval commencing from two weeks after sowing in nursery

Carbaryl 50 WP 0.2 per cent OR

Neem Seed Extract (NSE) 4 per cent - 400 gms/500 liters of water.

vi) Brinjal varieties like Pant samrat, S_{519}, S_{520}, S_{521}, SM-202, SM-17, Pusa Purple Cluster etc., are relatively least affected while Manjari gota is highly susceptible.

2) Aphid or Plant lice or Greenfly : *Aphis gossypii G.*
Myzus persicae S.
Aphis fabae K.
Hemiptera; Aphididae

Nature of damage :

Nymphs and adults suck the cell sap from undersurface of leaves and tender shoots and reduce their vigour. Affected leaves curl downwards, turn yellow, become wrinkled and ultimately die. Aphids are responsible for transmission of viral diseases like "leaf curl", “mosaic” and “veinal necrosis”.

Control measures :

Spray 0.03 per cent dimethoate

OR

0.025 per cent methyl demeton OR

0.05 per cent formothion as soon as pest appears.

3. Brinjal stem borer : *Euzophera perticella* (Rag.)
Lepidoptera; Pyralidae

Marks of identification :
Adult is medium sized, straw yellow coloured moth with wing expanse of 32 mm. Hind wings are whitish. The full grown caterpillar measures about 20-22 mm in length, creamy white in colout with few bristly hairs. Pupae are dark brown.

Nature of damage:
The caterpillars are mostly found inside the stem near root portion about 5 cm above the ground feeding on central tissues. As a result of this, tunnels are made inside the stem which are often found filled with excreta and frass. Sometimes, gum like substance oozes out from the entry holes. The frass and excreta may be seen at the collar region of the plant. Both old and young plants are attacked by the pest. The young plants are killed outright while older plants remain stunted. "Bantiware local" variety of brinjal is highly susceptible to the attack while 'Manjari gota', 'Pusa Purple Cluster', 'Pusa Purple Long', 'Annamalai', S_4, S_{16}, 'Pb-Bahar' are least affected.

Host plants:
Brinjal, Tomato, Potato and Chilli.

Life history:
Females lay about 104 to 363 eggs singly or in batches on the stem and sometimes on leaves and leaf petioles. Hatching period is 3 to 10 days. Larval development is completed in 26 to 58 days. Pupation takes place within a cocoon inside larval tunnel. Pupal period varies from 9 to 16 days. One generation occupies 35 to 76 days. About 5 to 6 generations completed in a year. Pest hibernates as caterpillar inside the stem of old plant.

Control measures:
(i) Remove and destroy severely infested plants.
(ii) Use light traps @ 1 trap/ha to attract and kill the moths.
(iii) Conserve larval parasitoids *Pristomerus testaceus, P. euzopherae*.
(ii) Application of carbofuran 3G @ 16.5 kg/ha in the soil or spray the plants with decamethrin 2.8 E.C. at concentration of 0.005 per cent or carbaryl 50 WP at the concentration of 0.1 per cent.
(iii) Grow least affected varieties of brinjal like Pusa purple cluster, Pusa purple long. Manjari gota, S_4, S_{16}, Annamalai etc.

4. White fly: (Given under Tomato)

5. Mites: (Given under Tomato)

6. Leaf hopper: (Given under potato)

7. Epilachna beetle: (Given under potato)

EXERCISE NO. 7 **DATE :**

STUDY OF PESTS OF TOMATO

Sr. No.	Common Name	Scientific Name	Order	Family
1.	Tomato fruit borer	*Helicoverpa armigera*	Lepidoptera	Noctuidae
2.	Jassids	*Amrasca biguttula biguttula*	Hemiptera	Cicadellidae
3.	Whiteflies	*Bemisia tabaci*	Hemiptera	Aleurodidae
4.	Tomato stem borer	*Euzophera perticella*	Lepidoptera	Pyralidae
5.	Leaf eating caterpillar	*Spodoptera litura*	Lepidoptera	Noctuidae
6.	Epilachna beetle	*Henisepilachna vigintioctopunctata*	Coleoptera	Coccinellidae
7.	Tomato leaf miner	*Liriomyza trifolii* *Liriomyza brassicae*	Diptera	Agromyzidae

1) Tomato fruit borer : *Helicoverpa armigera* Hubn.
Lepidoptera; Noctuidae

Marks of identification :
Adult is medium sized, light yellowish brown coloured moth with wing expanse of 37 mm. Forewings are pale brown with a dark brown minute circular dots on it. Hindwings are smoky-

white with a broad blackish outer border. Caterpillars are apple green in colour with whitish and dark grey broken longitudinal strips. Caterpillars measure about 40 to 48 mm in length when full-grown. Pupae are dark brown and measure about 11 to 14 mm in length. Eggs are yellowish white, dome shaped, 0.4 to 0.5 mm in diameter.

Nature of damage :

The caterpillar causes damage initially by feeding on the foliage for couple of days and subsequently boring into fruits and feeding on the internal tissues by introducing it's head and anterior half part of the body alone within. Larva is migratory in habit. It moves from one fruit to another damaging as many as 2 to 8 fruits in it's life time. Young larvae feed on tender foliage while advanced stage larvae (4^{th} instar onwards) attack the fruits.

Host plants :

Castor, Cotton, Citrus, Indigo, Groundnut, Sorghum, Millets, Pulses, Safflower, Soyabean, Sunflower, Marigold, Tobacco, Linseed, Okra. It is highly polyphagous pest.

Life history :

Females lay about 500 eggs singly on leaves, flowers and sometimes on fruits as well. Hatching period is 6 to 7 days. Larval development takes place within 14 to 38 days. Pupal period varies from 6 to 12 days. One generation is completed in 4 to 6 weeks. About 5 to 6 generations are completed in a year. Pest pupates in the soil. Infestation is carried from one season to another through hibernated pupae in the soil.

Control measures :

i) Hand picking of caterpillars and their mechanical destruction in the early stage of infestation can keep the population of this pest under check. ii) Deep ploughing after the harvest of crop helps to destroy hibernated pupae. iii) Infested fruits should be collected and destroyed promptly.

iv) Mass release *Trichogramma pretiosum* egg parasite 50,000 adults/ha five times at weekly interval from initiation of flowering.

OR

Give five sprays of HaNPV 250 LE (larval equivalent) @ 500 ml/ha at weekly interval after initiation of 50 per cent flowering. OR

Spray 5 per cent Neem Seed Extract (NSE) @ 500 gm / 500 litres of water.

v) Trap crops like "**Lubia"** or "**Marigold"** may be planted around the border of main crop.

2) Whitefly : *Bemisia tabaci* Gen.
Hemiptera; Aleurodidae

Marks of Identification:

Winged adults are 1.0 to 1.5 mm long, and their yellowish bodies are dusted with a white waxy powder. They have two pairs of pure white wings and have prominent long white wings.

Nature of damage :

Both nymphs and adults suck the cell sap from ventral surface of leaves. As a result, infested leaves become yellowish, wrinkled, curled downwards and are ultimately shed. The vitality of the crop is reduced. Consequently, the growth of the plant is adversely affected and when the attack appears late in the season, the yield is lowered considerably. Pest also acts as a vector transmitting **"leaf curl"** virus disease.

Host plants:

A polyphagous pest. Tomato, cotton, tobacco, sweet potato, cabbage, cassava, cauliflower, sarson, melons, brinjal, okra and many wild and cultivated plants.

Life history :

Eggs are laid on undersurface of leaves. Pupation takes place on leaves. One life cycle occupies 2 to 15 weeks. About 12 generations are completed per year.

Control measures :

Spray 0.05 per cent formothion or 0.03 per cent dimethoate or 0.03 per cent oxydemeton methyl as soon as incidence is noticed.

3) Tomato leaf miner : *Liriomyza trifolii*
Liriomyza brassicae
Diptera; Agromyzidae

Marks of identification :

Adult is a minute dipterous fly with single pair of transparent wings. Adult has yellowish body and black brown head. It measures about 2.5 mm in length. The newly hatched maggot is whitish but turns yellowish when full-grown. The maggot measures about 2.1 mm in length.

Nature of damage :

Maggots on hatching mine into leaves and feed on inner content causing serpentine or zigzag mines. Matured leaves are mostly preferred than freshly emerged. The severe infestation on seedlings results into retarded growth. Young crop is badly damaged.

Host plants :

Cruciferous crops, peas, tomato, onion, pepper, radish, mustard, cauliflower, turnip, sunhemp, safflower, sunflower, brinjal, cucumber and methi.

Life history :

The female punctures series of minute holes with its ovipositor along the margin of tender leaves and lays about 35 to 55 eggs singly. Hatching period is 3 to 6 days. Maggot development takes place in 3 to 6 days. Pupal period is 9 to 11 days. Maggots cut triangular opening on the upper

surface of leaf and drop down on the ground for pupation. Longevity of adult is 9 to 11 days. One generation occupies 2 to 3 weeks.

Control measures :

i) Collection and destruction of infested leaves in the early stage of infestation.

ii) Spray carbaryl 0.2 per cent or acephate 0.07 per cent immediately after the incidence is noticed.

4. Aphid : (Given under Brinjal)

5. Thrips: (Given under Chilli and Bell pepper)

6. Mites: *Tetranychus neocaledonicus* Andre, *Tetranychus urticae* Koch., *Tetranychus telarius*
Acarina; Tetranchiidae

Marks of identification :

Adults female measure about 0.4 mm in length. They are reddish or reddish brown or greenish in colour. They spin find webs on under surface of leaves. Male smaller than female.

Nature of damage :

The nymphs and adults of red spider mites remain on undersurface of leaves in colonies and suck the cell sap. Due to continuous draining of tha sap the brown coloured dried patches develops on the leaves resemble to bronzening and stippling. Heavily infested leaves are sheded and plant became weak that adversely affect on growth and development of plant.They cause devitalization of crop.

Control measures :

1. Dusting sulphur 300 mesh @ 20-25 kg per ha controls the mite infestation effectively.
2. Use of Acaricides like Kelthane, Aramite @ 0.05 %.

EXERCISE NO. 8 **DATE :**

STUDY OF PESTS OF BELL PEPPER/CAPSICUM

1. Thrips : *Scirtothrips dorsalis*
Thysanoptera; Thripidae

Marks of Identification:

The adults of these tiny insects are slender, yellow, active and pointed at both the ends. The females have four extremely slender wings which have long fringe at their posterior margins. The male is similar to female excepr that it is smaller and lighter in colour.

Nature of Damage:

Both adult and nymphs lacerate the plant tissues and suck the sap from young developing leaves. Affected leaves curl upwards along the margin and get crinkled and reduced in size. They also feed on floral parts and fruits. Fruit damage result in rough brown patches affecting their quality and drastically reducing the market value.

Host plants: Bell pepper, Chilli, Tomato etc.

Life History:

Females lay 50 to 60 fertilized or unfertilized eggs inside the leaf tissues generally on lower side of leaves. Average incubation, larval, prepupal, pupal stages last for 8 to 9, 4 to 6, 2 and 3 days, respectively. Prepupal and pupal stages are generally found in soil. One generation is completed in 2 to 2½ weeks. About 25 overlapping generations completed in a year.

Control Measures:

A) **Nursery treatment :**

Apply phorate 10G @ 10kg /ha or 70gm/m^2 area in the seed bed before sowing the seed in line.

If phorate is not available then give two sprayings of dimethoate 0.03 per cent at 15th and 30th days after seed germination in nursery. B**)** **Field treatment :**

Apply phorate 10G @ 10kg/ha –10 days after transplanting

OR

If phorate is not applied, give 3 sprays of following insecticides at 10 to 15 days interval starting from 10 days after transplanting. Dimethoate 30 EC 0.03 per cent

OR

Thiometon 25 EC 0.02 per cent

2. Mites: *Polyphagotarsonemus latus*

Acarina; Tarsonemidae **Marks of Identification:**

Commonly called as broad mite or yellow mite. Newly emerged female whitish in the beginning later on turn yellowish brown. Elliptical in shape. They possess four pair of legs and found on the undersurface of the leaves covered with fine webs.

Nature of damage:

Both nymphs and adults suck the cell sap by scrapping the terminal shoots and leaves and devitalize the plants. As a result leaves become narrow, twisted with elongated petioles. The damage is characterized by downward curling of leaves and stunted growth of plants and dropping of flowers. Damage is more in hot and humid conditions.

Host plants: Bell pepper, Chilli, Brinjal.

Life history :

Female lays eggs singly on the undersurface of leaves. Fecundity 17-41 eggs. Oviposition period 7.9 days. Total developmental period from egg to adult : for female – 86.36 hrs and males – 84.15 hrs. Adult longevity : female – 8.66 days and males – 7.24 days.

Control Measures:

1. Apply wettable sulphur 80 WP @ 3g/litre or any acaricide (directing the spray on the ventral surface of leaves).
2. Spray neem seed powder extract 4% at 10 days interval when the pest incidence is low. As and when the pest incidence increases, spray with synthetic acaricides like Dicofol 18.5 EC @ 2.5ml/litre and repeat the spray after 10 days, if required.
3. Under protected conditions spary acaricides like Abamectin 1.9 EC @ 0.5ml/litre of water or Dicofol 18.5 EC @ 2.5 ml/l or Fenazaquin 10 EC@ 1ml/litre.

3. Tobacco leaf eating caterpillar: *Spodoptera litura*

Lepidoptera; Noctuidae

It is one of the cosmopolitan and polyphagous pests. It is sporadic in occurrence but sometimes breaks out in epidemic form especially when there is a good start of rains followed by a long dry spell. Complete failure of crop is also common in case of heavy attack. Pest is also commonly called as “Tobacco leaf eating caterpillar”.

Marks of identification :

Adult is medium sized moth with pale grey or dark brown forewings having weavy white markings. The hind wings are whitish. The caterpillars are pale greenish brown with dark head and prothoracic shield. The full-grown caterpillars measure about 37.5 mm in length. The pupae are dark brown and eggs are round and greenish white in colour.

Nature of damage :

Pest is nocturnal in habit, during daytime caterpillars hide in leaf whorl or in soil. Caterpillars feed gregariously on tender foliage and juicy stems at night when they are young and become isolated in their advanced stages of growth. In case of severe infestation, only midribs and leafstalks are left over. The infested field looks like as if it is grazed by cattle. The complete failure of crop has also been noticed. The pest usually breaks out in serious proportion particularly when there is good monsoon rain followed by long dry spell. The pest remains active from June to November.

Host plants :

Polyphagous pest. Sorghum, maize, bajara, potato, brinjal, rice, tomato, cotton, leguminous crop, banana, tobacco, sesamum.

Life history :

Female lays about 500 to 2000 eggs in cluster in parallel rows on central leaves. The eggs hatch in about a week. Larval development is completed in 3 to 4 weeks. Full-grown larvae drop down and pupate in soil at a depth of 0.5 to 6 cm. Pupal period is 8 to 10 days. One generation completed in 5 to 6 weeks. There are several generations in one year. Pest usually hibernates as pupa in the soil.

Control measures :

i) Hand collection and destruction of egg masses and caterpillars in early stage of infestation helps in reducing pest infestation.

ii) Deep ploughing of infested fields after harvest for exposing and killing hibernating pupae. iii) Clean cultivation and optimum plant population per unit area help in reducing pest infestation.

iv) Light traps may be set up to destroy adult moths.

v) Spray of NSKE @ 4 per cent at early growth stage of the crop.

vi) Spray of *Sl*NPV @ 250 L.E. per hectare. vii) Natural enemis like *Bracon* sp. *Telonomus* sp. and *Bacillus thuringiensis* viii) As soon as pest appears apply :-

Cypermethrin 0.006 per cent

OR

Quinalphos 0.05 per cent

OR

Methyl parathion 2 D @ 25 kg/ha.

4. Cutworm: (Given under Potato).

5. Fruit borer: (Given under Tomato).

6. White fly : (Given under Tomato).

EXERCISE NO. 9 **DATE :**

STUDY OF PESTS OF CRUCIFEROUS AND ROOT CROPS (CABBAGE, CAULIFLOWER, BROCOLLI, RADISH, CARROT, KNOL-KHOL)

Sr. No.	Common name	Scientific name	Order	Family
1.	Mustard aphid	*Lipaphis erysimi*	Hemiptera	Aphididae
2.	Mustard sawfly	*Athalia lugens proxima*	Hymenoptera	Tenthridinidae
3.	Painted bug	*Bagrada hilaris B. cruciferarum*	Hemiptera	Pentatomidae
4.	Cabbage butterfly	*Pieris brassicae*	Lepidoptera	Pieridae
5.	Flea beetle	*Phyllotreta cruciferae*	Coleoptera	Chrysomelidae
6.	Diamond back moth	*Plutella xylostella*	Lepidoptera	Plutellidae
7.	Bihar hairy caterpillar	*Diacrisia obiqua*	Lepidoptera	Arctiidae
8.	Cabbage borer	*Hellula undalis*	Lepidoptera	Pyralidae
9.	Leaf miner	*Liriomyza brassicae* Riley *Liriomyza trifoli*	Diptera	Agromyzidae

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

Marks of identification :

Adult is brownish gray coloured moth measuring about 8 to 10 mm in length and 15 mm across the wings. The hind wings have a fringe of long fine hairs. There are three pale white triangular markings on hind margins of forewings. When the wings are closed, three diamond shaped yellowish white markings are clearly visible by joining both the forewings. On account of this, the pest is commonly known as "Diamond back moth". The full-grown larvae are yellowish green in colour with fine erect black hairs scattered on body and they measure of about 12 mm in length.

Nature of damage :

The newly hatched larvae feed on the epidermal tissues of the leaves producing typical whitish patches. The advanced stage larvae feed on the leaf lamina by biting small holes in the leaf lamina. These larvae also bore into the heads of cabbage and cauliflower. In case of severe infestation, plant may be completely skeletonized.

Host plants :

Cabbage, Cauliflower, Knol-khol, Radish, Turnip, Mustard *etc*.

Life history :

Females deposit 40 to 60 eggs singly on the lower surface of leaves. Incubation period is about a week. Larval development is completed within two to three weeks. Pupation takes place on the leaves in silken cocoons. Pupal period varies from 7 to 11 days. One generation occupies in 21 to 39 days. Longevity of adult is 10 to 18 days. About 5 to 7 generations are completed in a year.

Control measures :

Pest can be controlled effectively by spraying quinalphos 25 EC - 0.05 per cent or Bt formulation (*Bacillus thuringensis*) @ 1 kg / ha, or abamectin 1.8 EC - 0.001 per cent.

2) Mustard sawfly : *Athalia lugens proxima* Klug.
Hymenoptera; Tenthridinidae

Marks of identification :

Adult is 8 to 10 mm long, small insect having black head and thorax, orange coloured abdomen and two pairs of translucent smokey wings with black veins. The adult is not able to fly long distance. They hop from one leaf to another leaf or from one plant to another plant. Female adult has a saw like ovipositor and hence the common name "Mustard sawfly". The newly hatched larva is smooth, cylindrical, greenish grey in colour and 2 to 3 mm long. Full grown larva is smooth, cylindrical, greenish black in colour and 16 to 20 mm in length. Larva possesses 8 pairs of prolegs in addition to 3 pairs of thoracic legs. Larvae have tendency to curl and drop down on the ground on being touched. They look and behave like caterpillars.

Nature of damage :

The larvae on hatching nibble the margins of tender leaves and later on bite holes in the leaves. The larvae are diurnal in habit. They feed generally during early morning and evening hours and remain practically motionless at night.

Host plants :

Cabbage, Cauliflower, Mustard, Turnip, Knol-khol and some other cruciferous crops.

Life history :

A female lays 20 to 100 eggs with an average of 35, singly along the periphery of leaves. Hatching period is about a week. Larval period is 2 weeks. Pupation takes place in soil. Pupal period is 1 to 2 weeks. The over-wintering takes place in pupal stage which lasts for about 14 weeks. In North India, 3 generations are completed during cold season whereas in South India, as there is no severe cold, pest completes 10 overlapping generations / annum.

Control measures :

1) The larvae can be hand picked from infested plants during dawn and dusk and destroyed mechanically if area under crop is limited.
2) Spray the crop with 0.1 per cent malathion 50 EC or 0.05 per cent dichlorvos 76 EC.

3) **Cabbage butterfly:** *Pieris brassicae* (Linnaeus)
Lepidoptera; Pieridae

Marks of identification :

Full grown larva measures 40-50 mm in length. Newly hatched larvae are pale yellow and turn greenish yellow later on. They have short hairs on the body. Medium size butterflies are pale white with black markings. The wing expanse in female is 6.5 cm and have two black circular dots on the dorsal side of each forewing and while in male, the black spots are on the underside of each forewing. Males are smaller than the female.

Nature of damage :

The damage is caused by the caterpillars only. Freshly hatched caterpillars scrape the leaf surface and feed on the green matter initially. Later on the older larvae eat up the leaves from margins inward, leaving intact the main vein. Sometimes the leaves of entire plant are eaten up and the plant is defoliated.

Host plants :

Cabbage, cauliflower, knoll-khol, turnip, raddish, sarson and other cruciferous plants.

Life history :

The female butterfly lay on an average 164 yellowish conical eggs in clusters of 50-90 on upper or lower surface of leaves. The incubation period is 11-17 days in November-February and 3-7 days in March-May. There are 5 larval instars and larval development is completed within 14-21 days. The larvae pupate in brans on or trees away fom host plant. The pupal period is 17.7 to 14.4 days and 20-28 days in March-April and November-February, respectively. About four generations are completed from October to April.

Control measures :

1. Hand picking and mechanical destruction of caterpillars during early stage of attack can reduce the infestation.
2. Spraying with 1 litre of Malathion 50 EC (0.1 %) in 625 litres of water/ha and repeat the spraying at 10 days intervals, if necessary.

4) Cabbage head borer/ Cabbage borer : *Hellula undalis*
Lepidoptera; Pyralidae

Marks of identification :

Caterpillars are creamy yellow with a pinkish tinge and have several purplish brown longitudinal stripes. Moths are slender, pale yellowish brown, have grey wavy lines on the fore wings. Hind wings are pale dusky.

Nature of damage :

Damage is caused by the caterpillars. Caterpillars first mine into leaves and feed on the chlorophyll. Later on feed on the leaf surface sheltered within the silken passage. As they grow bigger they bore into the heads of cabbage and cauliflower. When the attack is heavy, the plants are riddled with caterpillars.

Host plants : Serious pests of all cruciferous crops.

Life history :

Female lay about 28-214 eggs on leaves of cabbage. Eggs hatch in 2 to 4 days. Larval development is completed in 6-18 days. Pupal period varies from 4-19 days and pupation takes place on leaves. Adult longevity is 3-8 days (female) and 2-6 days (males). About 12 generations are completed from April to November months.

Control measures :

1. Monitoring of pest at seedling or early growth stage.
2. Collection and destruction of early stage caterpillars.
3. Indian mustard as trap crop.
4. Spraying with bio pesticide *Bacillus thuringeinsis.*
5. Some cauliflower lines like Early Kumari, 78-1S, 234-S, Sel. 916 and Sel. 1012 were resistant to this pest (Brar *et al.,* 1993).
6. The pest can also be controlled by spraying the crop with malathion @ 0.1 per cent.

5) Cabbage aphid : *Brevicoryne brassicae* Linn.
Lipaphis erysimi Kalt.
Hemiptera; Aphididae

Marks of identification :

Eggs: Pale-yellow with greenish tinge. Nymphs: 1-1.5 mm long and yellow green with light ash grey tinge. Adults: About 2 mm in length and ash grey in colour.

Nature of damage :

Damaging stages are nymphs and adults. Nymphs and adults suck the cell sap from tender leaves/shoots which results in stunted growth and poor head formation. Under severe infestation there is a drying of entire plant. When seedlings are infested they loose vigor, gets distorted and become unfit for transplanting. They excrete honeydew which attracts sooty mould and interferes with photosynthesis. If attack starts in early stage of crop, heavy losses can occur.

Host plant : All cruciferous crops.

Life history :

A single female can produce 40-45 young ones. Mode of reproduction is mostly agamic viviparity (asexual reproduction) and sexual reproduction also occurs during severe cold. Period required for completing one generation is 10 to 45 days. Pest is active from October to April. About 21 generations are completed per year.

Control measures :

1. Cut and destroy the infested leaves/ shoots mechanically as soon as the aphid attack appears.
2. Spray of fine pulverized mica powder @ 0.2 per cent to repel the alates.
3. Conventional insecticides like malathion (0.05%) or oxy- demeton methyl (0.025%) or dimethoate (0.03%).
4. Predators like coccinellids, syrphids and chrysopids; and parasitoids like *Aphidius* spp also reduce the population.
5. Cabbage cultivars like Red Drum Head and KK cross were moderately resistant to this aphid (Lal, 1991) and can be used.

6. **Semilooper :** *Thysanoplusia orichalcea* (Fabricius)
   Lepidoptera; Noctuidae

Marks of identification :

Distribution North-Western India.

Larvae: It is a 40 mm long semilooper and body is long and slender. Larvae are plump and pale green having three pairs of prolegs and are generally found mixed with the caterpillars of *P. brassicae.*

Adults: Stout moth with straw coloured forewings with golden yellow patch and measures about 42 mm across the wings. Eggs are cream coloured.

Nature of damage :

Larva cause the damage by biting round holes in the leaves. Larvae feed individually biting holes of varying size depending on the stage of development. Later they feed from leaf margin and defoliate leaving midribs in case of severe incidence.

Host plants :

Cabbage, cauliflower and other winter vegetables, sunflower, cotton, legumes, oil seeds, sweet potato, cucurbits etc.

Life history :

The pest is active from March to October. Moths lay eggs on the leaves. Incubation period is 4-5 days. Pupate in white transparent silken cocoon in leaf litter or plant debris. Total life cycle is completed within 30 days. Moths are very active at dusk.

Control measures :

Same as recommended for Cabbage butterfly, *Pieris brassicae*

7. Leaf miner : *Liriomyza brassicae* Riley
Liriomyza trifoli
Diptera; Agromyzidae
(Given under Tomato)

8. Tobacco leaf eating caterpillar : *Spodoptera litura*
Lepidoptera; Noctuidae
(Given under Bell pepper/Capsicum)

9. Cutworm / Greasy cutworm or caterpillar : *Agrotis ypsilon* Hufn.
A. segetum
Lepidoptera; Noctuidae
(Given under Potato)

EXERCISE NO. 10 **DATE :**

STUDY OF PESTS OF CUCURBITACEOUS CROPS (PUMPKIN, RIDGE GOURD, BITTER GOURD ETC.)

Sr. No.	Common name	Scientific name	Order	Family
1.	Pumpkin beetle	*Red : Raphidopalpa foveicollis* Black : *R. intermedia* Grey : *R. cincta* *Blue : R. lewisii* Yellow : *R. ceratia*	Coleoptera	Chrysomelidae

2.	Fruit fly	*Bactrocera cucurbitae* *B. dorsalis* *B. zonatus, B. ciliatus*	Diptera	Trypetidae
3.	Blister beetle	*Mylabris pustulata Lytta* spp.	Coleoptera	Meloidae
4.	Jassids	*Amrasca biguttula biguttula*	Hemiptera	Cicadellidae
5.	Aphids	*Aphis gossypii*	Hemiptera	Aphididae
6.	Mites	*Tetranychus telarius*	Acarina	Tetranychidae
7.	Epilachna beetle	*Henisepilachna dodecastigma H. vigintioctopunctata*	Coleoptera	Coccinellidae
8.	Leaf eating caterpillar	*Spodoptera litura*	Lepidoptera	Noctuidae
9.	Snake gourd semilooper	*Anadevidia peponis*	Lepidoptera	Noctuidae

1) Pumpkin beetle : Red : *Raphidopalpa foveicollis* L.
Grey : *R. cincta* F.
Blue : *R. lewisii*
Yellow : *R. ceratia* Black : *R. intermedia* J.
Coleoptera; Chrysomelidae

Marks of identification :

Adults are small beetles, 6 to 9 mm long, brilliant red coloured dorsally and black ventrally. The grubs are creamy yellow with brown head and 10 to 14 mm long. Eggs are elongated, yellowish-brown initially but soon become orange in colour. Pupae are pale white and are found in earthen cells, 150 to 250 mm deep in the soil.

Nature of damage :

On hatching, grubs feed on the roots and underground portion of host plants as also fruits touching the soil. The damaged roots and infested underground portion of the stems start rotting due to secondary infection by saprophytic fungi and the unripe fruits of such vines dry up. Infested fruits become unfit for human consumption. Adult beetles are mainly responsible for the damage of the plant above ground attacking on the flowers, leaves and fruits. Adult beetles feed voraciously on leaf lamina making irregular holes. They prefer young seedlings and tender leaves. Damage at that stage may even kill the seedlings. The beetles are active from March to October, though the peak period of activity is April to June.

Host plants :

Cucurbitaceous vegetables, melons, leguminous crops.

Life history :

A female lays 150 to 300 eggs singly or in clusters in moist soil around the host plants. Hatching period is 5 to 8 days. Grub development is completed in 13 to 25 days. Pupal period is 9 to 22 days. Pupation takes place in soil at a depth of 150 to 250 mm. Total lifecycle is completed in 32 to 65 days. Adult longevity is about a month. 5 to 8 overlapping generations are completed in a year. Overwintering takes place in adult stage.

Control measures :

1. Preventive measures like burning of old creepers, ploughing and harrowing of field after harvest of crops are recommended for the destruction of adults, grubs and pupae.
2. Collection and destruction of beetles in early stage of infestation
3. Dusting with 5 per cent carbaryl OR 5 per cent malathion dust is effective and safe to use.
4. Spraying with 0.05 per cent dichlorvos (DDVP) OR 0.2 per cent carbaryl OR 0.05 per cent malathion has also been suggested.

2) Fruit fly : Melon fruit fly : *Bactrocera cucurbitae* Coq.
Ethiopian fruit fly : *Dacus ciliatus* Loew.
Oriental fruit fly : *B. dorsalis* H.
Diptera; Trypetidae

Marks of identification :

The adult flies are reddish brown with lemon yellow markings on the thorax and have fuscous areas on the outer margins of their wings. The maggots are legless, thicker at one end and tapering to a point at the other. It measures about 9-10 mm long and 2mm in breadth.

Nature of damage :

On hatching, maggots feed inside on the pulp of fruits. The infested fruits can be identified by the presence of brown resinous juice which oozes out of the punctures. These punctures serve as entry for various bacteria and fungi. As a result, infested fruits start rotting, get distorted and malformed in shape and fall down prematurely. About 50 per cent fruits are damaged by this pest.

Host plants:

Melons, tomato, chillies, guava, citrus, pear, fig, cauliflower etc.

Life history:

The adult females puncture fruits by its ovipositor to lay eggs, singly or in clusters of 512. Hatching period is 1-9 days. The larvae are full grown in 3 days in summer and 21 days in winter. Pupation takes place in soil. The pupae are barrel shaped, light brown and pupal development is completed in 6-9 days. There are several generations in a year.

Control measures :

i) Grow resistant and early maturing varieties e.g. Arka tinda – a variety of round melon.

ii) Fruits should be harvested before they start ripening. iii) Fallen fruits should be collected and destroyed.

iv) Installation of "Rakshak" fruit fly traps containing Cuelure developed by Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli @ 4 traps/ha.

v) Raking soil or ploughing after harvest to destroy hibernated pupae.

vi) Application of spray bait containing 20 ml malathion + 200 gms jaggery + 20 litres of water.

vii) Spray malathion 0.05 per cent OR 0.2 per cent carbaryl during flowering to reduce intensity of infestation.

3) Blister beetle: *Mylabris pustulata, Lytta spp.*
Coleoptera; Meloidae

Marks of identification :

Adults of *Mylabris pustulata* are bigger in size with body measuring about 25 mm in length and 12.5 mm in breadth. They are dark black in colour with yellowish brown stripes across their fore wings. In case of *Cylindrothorax tenuicollis*, adults are medium sized light brown or greenish blue in colour. Adults of both the species have rather soft body and their forewings are also thinner than those of other beetles. Beetles secrete acidic substances and if crushed on human body cause blisters and therefore, they are called blister beetles. First instar grub is active with long legs and is referred to as triungulin. The final instar (7^{th}) grub is small, white and apodous.

Nature of damage :

Beetles attack inflorescence and feed on pollens and petals of flowers. This adversely affects fruit setting. In case of severe infestation, there is no fruits formation. Pest is active from August to December. Grubs feed on the eggs of grasshoppers and thus are beneficial.

Host plants :

Besides cucurbits, pest attacks bajra, sorghum, beans and other millets except maize.

Life history :

The beetles have unusual life cycle. Female lays large number of whitish eggs, often 2000 to 10,000 on the ground or in the soil. Incubation period is 15 days. Grubs on hatching move in search of eggs of grasshoppers. The triungulin feeds on the eggs of its host and moults six times before they undergo pupation in soil. Adult beetles emerge from pupae in a year. The beetles undergo a hypermetamorphosis in their development which is rather complex.

Control measures :

i) Beetles can be collected by hand nets.

ii) Set up light traps in the field for trapping adults as they are attracted to light.

iii) As and when pest appears, apply methyl parathion 2 D @ 20 kg/ha @ 20 kg/ha.

4) Epilachna beetle or Hadda beetle: (Given under Potato)

5) Leaf miner : (Given under Tomato)

6) White fly : (Given under Tomato)

7) Mites : (Given under Tomato)

EXERCISE NO. 11 **DATE :**

STUDY OF PESTS OF POTATO

Sr. No.	Common name	Scientific name	Order	Family
1.	Potato tuber moth	*Phthorimaea operculella*	Lepidoptera	Gelechidae
2.	Potato cutworm	*Agrotis ypsilon* *A. segetum*	Lepidoptera	Noctuidae
3.	Aphid	*Myzus persicae Aphis gossypii*	Hemiptera	Aphididae
4.	Leaf hoppers	*Amrasca biguttula biguttula* *Empoasca kerri* *Empoasca punjabensis*	Hemiptera	Cicadellidae
5.	Thrips	*Scelenothrips indicus*	Thysanoptera	Thripidae
6.	Termites	*Odontotermes obesus*	Isoptera	Termitidae
7.	Epilachna beetle	*Henisepilachna vigintioctopunctata*	Coleoptera	Coccinellidae
8.	White grub	*Lachnosterna longipennis*	Coleoptera	Scarabaeidae
9.	Leaf eating caterpillar.	*Spodoptera exigua*	Lepidoptera	Noctuidae

I) Potato cutworm / Greasy cutworm or caterpillar : *Agrotis ypsilon* Hufn.
A. segetum
Lepidoptera; Noctuidae

Marks of identification :

Adult is medium sized moth, measuring about 25 mm in length and 42 to 56 mm in wing expanse. Each of the forewings has dark or blackish grey patches. Fullgrown caterpillar measures about 45 mm in length and smooth, dull gray in colour with small shining black spots on the body. The caterpillar has a habit of coiling at the slightest touch. Since the caterpillars are greasy in appearance, the pest is also known as **'Greasy caterpillar'** or **'Greasy cutworm'**.

Nature of damage :

The common name implies to the fact that the caterpillars cutoff the stalk of the young plant from the ground level. The caterpillars are nocturnal in habit. During day time, they hide under the clods of earth or cracks and crevices present in soil or debris around the plants. They come out and feed on the plants during night by cutting them close to the soil surface. Destruction is much more than actual feeding. Very occasionally, caterpillars are found nibbling the tubers. Damage to the extend of 37 per cent has been reported.

Host plants :

Potato, Tomato, Brinjal, Barley, Oat, Lucerne, Tobacco, Linseed, Mustard, Pea, Gram and other leguminous crops, Cotton, Chilli (Polyphagous).

Life history :

Females lay about 300 creamy white, spherical eggs singly or in batches on the lower surface of leaves or on stem close to the ground surface or sometimes on ground itself.

Hatching period is 2 to 13 days. Larval period is 10 to 30 days. Pupation takes place in the soil after forming earthen cocoons. Pupal period varies from 11 to 18 days. One generation is completed in 5 to 9 weeks.

Control measures :

i) Clean cultivation by regular interculturing operations helps to reduce the intensity of pest infestation.

ii) Heaps of green grasses may be kept at suitable interval in infested field during evening to trap the caterpillars. These heaps of grasses may be removed next day early in the morning alongwith larvae and destroyed mechanically.

iii) Irrigation brings the caterpillars to upper soil surface where they are destroyed by birds and other natural enemies.

iv) Apply fenvalerate 2 per cent dust in soil once each at planting and earthing up operations @ 50 kg/ha or undertake drenching with chlorpyriphos 20 EC @ 2500 ml / 1000 litres of water.

2) Potato tuber moth : *Phthorimaea operculella* Zell.
Lepidoptera; Gelechidae

Marks of identification :

Adult is 6 mm long grayish brown moth with narrow wings having wing expanse of 12 mm. The posterior margin of hindwings has fringe of hairs. The full grown caterpillars are 18 mm long, pinkish white or greenish in colour with dark brown head.

Nature of damage :

Pest causes damage to potato crop both in the field as well as in the stores. In the field, caterpillars feed on plant by mining into the leaves, by boring into petioles, terminal shoots and potato tubers underneath the soil. The infested leaves show blisters on them, while the shoots wither and wilt.

In storage, caterpillars are found boring into the stored potato through minute hole made near eyebud and feeding on the pulp. The infested potatoes ultimately rot and are made unfit for seed purpose as well as human consumption. The secondary infection of bacteria sets on such infested tubers. The presence of black spot and faecal matter around eyebuds helps to detect the pest infestation in storage. A single potato may have several caterpillars. As a result of pest infestation, the pulp and the eye buds of potatoes are destroyed. Under indigenous storage methods, pest causes losses to the extent of 30 to 70 per cent.

Host plants :

Potato, Brinjal, Tomato and several solanaceous weeds.

Life history:

About 100 to 150 eggs are laid by each female on the underside of leaves or on exposed tubers. Hatching period is 3 to 4 days. Larval development is completed in 2 to 3 weeks. Pupation takes place in a silken cocoon outside the tuber. Pupal period is 7 to 10 days. One generation completed in 4 weeks and 8 to 9 generations are completed in a year.

Control measures:

i) Use healthy potatoes free from the attack of PTM for planting.
ii) Timely earthing up of crop to cover the exposed tubers in the field.
iii) Store harvested potatoes immediately in well ventilated dry and cool place with temperature not exceeding 21ºC.
iv) Infested tubers in storage can be treated with suitable fumigants like methyl bromide (@ 1 kg / 27 cubic meter area for 3 hours) or carbon disulphide (@ 1 kg / 27 cubic meter space for 48 hours) or ED/CT mixture.
v) The potatoes meant for seed purpose may be treated with carbaryl 10 per cent dust @ 150 g/q of seed potato.
vi) The walls of godown may be treated with suitable insecticide like carbaryl once in every 3 months.
vii) Release four times the egg larval parasite ***Copidosoma koehleri*** Blanchard @ 1250 mummies/ha/release at weekly interval starting from 45 days after planting or release egg larval parasite- ***Chilonus blackburni*** or egg parasite - ***Argilus lepidus*** @ 60,000 adults/ha, four times at weekly interval.
viii) Apply following insecticides in soil at 60 days after planting :-

Carbaryl 10 D @ 20 kg/ha

OR

Malathion 5 D @ 40 kg/ha

3) Epilachna beetle or Hadda beetle : *Henisepilachna vigintioctopunctata* Fab.
Epilachna dodecastigma M.
Coleoptera; Coccinellidae

Marks of identification :

Adult is medium sized, 8 to 9 mm long, yellowish brown coloured, hemispherical beetle having 12 to 28 black spots on it's elytra. Grubs are stout, yellowish in colour with dark brown hairs on body. Pupae are hemispherical in shape. Eggs are elongated, cigar shaped and yellowish in colour.

Nature of damage :

Both grubs and adults feed voraciously by scraping the chlorophyll content of the leaves between the veins and cause characteristic skeletonized patches on leaves.

Host plants :

Potato, Brinjal, Bitter gourd and wild cucurbits.

Life history :

Females deposit 450 eggs in cluster (each containing 15 to 65 eggs) on the lower surface of leaves with their tips pointing upwards. Hatching period is 3 to 7 days. Grub development lasts for 1 to 3 weeks. Pupal period is 2 to 4 days during summer and 4 to 15 days in winter. All the stages of the pest are found on the plants only. One generation occupies 18 to 25 days in summer and about 50 days in winter. As many as 7 generations are completed in a year.

Control measures :

1) Hand collection of grubs and hand netting of adult beetles can help in reducing the damage in early stages of infestation.
2) Spray 0.05 per cent DDVP or 0.05 per cent malathion as and when infestation is noticed.

4) Potato leaf hopper : *Amrasca biguttula biguttula* Ischida.
Hemiptera; Cicadellidae

Marks of identification :

Adult is pale green or grey brown coloured, wedge shaped, slender, very active insect measuring about 3.5 mm in length. One black spot is present at the centre of each of the forewing and two black spots are present on the forehead. The nymphs are smaller than adult, yellowish green in colour and wingless. Both nymphs and adults walk diagonally.

Nature of damage :

Both nymphs and adults of leaf hopper cause damage by sucking the cell sap from mesophyll or from the lower surface of leaves. The margins of infested leaves curl upward, turn yellow and subsequently become reddish brown. Due to excessive feeding on foliage, tuber yield is reduced considerably. Besides causing direct damage to the plant, pest is known to transmit some mycoplasma entities like witches broom, purple top roll, marginal flavescence *etc.* The pest is common throughout the year but is more abundant in the kharif season.

Host plants :

Potato, Brinjal, Cotton, Bhendi and many other malvaceous plants.

Life history :

About 300 eggs are laid in the leaf tissues along the veins which hatch out in about a week. Nymphal development is completed within 2 to 3 weeks. Several generations in a year.

Control measures :

i) Apply granular insecticides in soil at the time of planting.

Carbofuron 3 G @ 33 kg/ha OR
Phorate 10 G @ 10 kg/ha

ii) Apply following insecticides in the field four times at 10 to 15 days interval starting from 25 days after planting, if soil application is not done with granules :-
Dimethoate 30 EC 0.05 per cent OR
Methyl demeton 25 EC 0.025 per cent
OR
Thiometon 25 EC 0.025 per cent

EXERCISE NO. 12 **DATE :**

STUDY OF PESTS OF SWEET POTATO AND YAM

(A) PESTS OF SWEET POTATO :

Sr. No.	Common Name	Scientific name	Order	Family
1.	Sweet potato weevil	*Cylas formicarius*	Coleoptera	Curculionidae
2.	Sweet potato leaf eating caterpillar	*Agrius convolvuli*	Lepidoptera	Sphingidae
3.	Leaf eating caterpillar	*Spodoptera litura*	Lepidoptera	Noctuidae
4.	Hairy caterpillar	*Diacrisia obliqua*	Lepidoptera	Arctiidae
5.	Cutworm	*Agrotis ypsilon*	Lepidoptera	Noctuidae

1) Sweet potato weevil : *Cylas formicarius* Fab.
Coleoptera; Curculionidae

Marks of identification :
Adult is small, 6 to 8 mm long, steel black coloured weevil with a brown elongated snout like head. The thorax is coloured like the head. The grubs are 8 to 10 mm long, pale yellow in colour and apodous. Adults look like ant, hence the species name "*formicarius*".

Nature of damage :
This is important pest of sweet potato both in the field and in storage. The grubs bore into the tubers and feed on the pulp making them unfit for human consumption. The grubs may induce terpenoid production inside the tuber. The grubs also bore into the vines by making a hole at

collar region. As a result, the thickness of vine is enlarged forming gall like structure at the point of pest infestation. The adults feed on leaves, vines and tubers but cause negligible damage. Loss in yield to the extent of 60 to100 per cent has been reported.

Host plants :

Sweet potato only (monophagous).

Life history :

Weevils bite small cavities on vines and tubers and deposit about 200 eggs singly. Hatching period is 5 to 7 days. Grub development lasts for 2 to 3 weeks. Pupation takes place inside infested vines and tubers. Pupal period 7 days. Infestation of pest is carried from one field to another field through infested vines and from one season to another season by breeding in the tubers left over in the field after harvest. One life cycle occupies 5 to 7 weeks.

Control measures :

i) Collect and destroy all plant debris or all remains of the harvested crop.
ii) Use healthy cuttings for planting, free from the attack of sweet potato weevil. iii) Follow proper crop rotation.
iv) Dip the cuttings in insecticidal suspension of 0.1 per cent carbaryl for 10 minutes at the time of planting.
v) Mulch the field with paddy straw or black plastic cover. vi) Timely earthing up of crop at 30 and 60 days after planting, irrigate the field regularly to fill up soil cracks
vii) Install sex pheromone trap in the field @ 1 trap/100 m^2 area.
viii)Store sweet potatoes by mixing them with sand. ix) Fumigate infested sweet potatoes with methyl bromide.
x) Give three applications of 0.05 per cent malathion or 0.1 per cent fenthion or 0.1 per cent carbaryl at triweekly interval starting from 1½ month after planting.
xi) Apply phorate 10 G @ 10 kg/ha in soil at the time of planting and 45 days thereafter.

2) Sweet potato leaf eating caterpillar : *Agrius* (*Herse*) *convolvuli* L.
Lepidoptera; Sphingidae

Marks of identification :

Adult is grey coloured moth with black pointed head. Abdomen has pink and white lateral bands. Adult has well developed and coiled proboscis. Wing expanse of adult is 10 cm. The caterpillars are 7.5 to 10 cm in long, dark brown with sharp curved anal horn at the tail end.

Nature of damage :

Caterpillars feed voraciously on foliage and defoliate the vines completely. It feeds on the leaf blade causing large irregular holes, or may start feeding on the leaf edges eventually eating the entire leaf blade, leaving only the petiole. They are initially found at the shoot tip, preferring young leaves, but will eat all leaves if population is high. Frass can be found near the infested plant part. Yield is reduced significantly.

Host plants :

Sweet potato, Black gram, Green gram and Sesamum.

Life history :

Females lay eggs singly on the undersurface of leaves. Egg stage lasts for 5 to 11 days. Larval period varies from 2 to 3 weeks. Pupation takes place in soil. Pupal period is 7 to 10 days. One generation occupies in 2 months. Pest hibernates in pupal stage in soil.

Control measures :

i) Hand picking of caterpillars and their mechanical destruction in early stage of pest infestation.
ii) Deep ploughing after harvest to destroy the pupae.
iii) Apply carbaryl 10 D @ 20-25 kg /ha as soon as pest infestation is noticed.

(B) PESTS OF YAM :

1) Yam beetle : *Galerucida bicolor* Hope.**,** *Heteroligus meles, H. appius*

Coleoptera; Chrysomilidae

Nature of damage :

The adults of *Galerucida bicolor* feed on the leaves, and the grubs, which are gregarious, skeletonise them completely and later gnaw into the leaf stalks and the main stem.

The adults and grubs of *Heteroligus meles* and *H. appius* attack the tubers and feed internally thereby preventing the tubers from sprouting.

Life history :

The eggs are laid in clusters in the soil near the plants. In South Malabar, breeding begins with the rains in late May or early June, when the plants are sprouting, and the larvae appear about mid-June. A month later they are full-fed and enter the soil to pupate. The pupal stage lasts about a fortnight. If the rains continue up to the end of July, a large second generation occurs in mid-August, but after this the beetles disappear, possibly because they enter hibernation.

Control measures :

1. They can be easily controlled by hand-picking or shaking them off the infested leaves into a pan of kerosinized water.

2. Hoeing or ploughing the soil round the plants in July will destroy the pupae.
3. Dusting the crop with 0.5 per cent Lindane dust.

2) Yam scales: *Aspidiella hartii* (Cokrellel)
Hemiptera; Diaspididae

Marks of identification:
Adults are moderately convex, 1-2 mm in diameter, brownish-grey with a slight purplish tint. Females are circular in shape while the males are oval in shape. The first instar nymphs are active crawlers for a short time before selecting a feeding site. Once feeding begins the waxy protective shield starts to form. Eggs are elongated.

Nature of damage:
Both the nymphs and adults suck the cell sap from the tender parts of the vines resulting in yellowing, defoliation and reduction in plant vigour. They also feed on stored yams and destroy them completely.

Host plants: Yams, Ginger, Turmeric

Control measures:
1. Use scale-free and healthy planting material for planting.
2. Dusting the crop with 0.5 per cent lindane dust.

3) Yam mealy bug: *Geococcus coffeae, Planococcus dioscoreae, Planococcus citri*
Hemiptera; Pseudococcidae

Both the nymphs and adults feed on the tubers and roots of yam thereby reducing the vigour and vitality of crop. They also cause shriveling of stored tubers. They also attack the aerial parts by desapping the vines.

Control measures:
1. Use clean and healthy planting material for planting.
2. Spraying the crop with 0.1 per cent malathion.
3. Dusting the crop with 0.5 per cent lindane dust.

EXERCISE NO. 13 **DATE :**

STUDY OF PESTS OF LEAFY VEGETABLES (AMARANTHUS, CORIANDER, FENUGREEK, SPINACH, SALAD CROPS)

Sr. No.	Common name	Scientific name	Order	Family
1.	Cutworm	*Agrotis* spp.	Lepidoptera	Noctuidae
2.	Aphid	*Acyrthosiphon malvae*	Hemiptera	Aphididae
3.	Leaf eating caterpillar	*Hymeria recurvlis*	Lepidoptera	Noctuidae
4.	Grasshopper	*Atractomorpha crenulata*	Orthoptera	Acrididae
5.	Amaranthus stem weevil	*Hypolixus truncatullus*	Coleoptera	Curculionidae
6.	Termite	*Odontotermes obesus*	Isoptera	Termitidae
7.	Mite	*Teranychus* spp.	Acarina	Tetranychidae
8.	Mustard sawfly	*Athalia lugens proxima*	Hymenoptera	Tenthridinidae

9.	Flea beetle	*Phyllotreta chotanica*	Coleoptera	Chrysomelidae
10.	Leaf miner	*Liriomyza trifoli*	Diptera	Agromyzidae
11.	Leaf hopper	*Amrasca biguttula biguttula*	Hemiptera	Cicadellidae

1) Amaranthus leaf eating caterpillar : *Hymeria recurvlis* Fabricius
Lepidoptera; Noctuidae

Nature of damage :
On hatching, the caterpillars feed on epidermis and on tissues of leaves, later they web together with the leaves and silken threads secreted by them and feed within. Gradually these webbed leaves become completely devoid of chlorophyll and dry up.

Host plants :
Amaranthus, spinach, grasslands and pastures.

Life history :
Oviposition on leaves preferably on top shoots. Pupation in the soil. A life cycle is completed in 3 to 4 weeks.

Control measures :
To control these caterpillars, spray 0.05 per cent malathion or 0.1 per cent carbaryl.

2. Cut worm: *Agrotis spp.*
(Given under Potato).

3. Leaf miner: *Liriomyza trifoli*
(Given under Tomato)

4. Mustard saw fly: *Athalia lugens proxima*
(Given under cruciferous crops)

5. Leaf hopper: *Amrasca biguttula biguttula*
(Given under Potato)

6. Aphids: *Acerthosiphon malvae*
Hemiptera; Aphididae

Nature of Damage:
Nymphs and adults suck the cell sap from undersurface of leaves and tender shoots and reduce their vigour. Affected leaves curl downwards, turn yellow, become wrinkled and ultimately die. Aphids are responsible for transmission of viral diseases like "leaf curl", “mosaic” and “veinal necrosis”.

Control measures :

Spray 0.03 per cent dimethoate

OR

0.025 per cent methyl demeton

OR

0.05 per cent formothion as soon as pest appears.

EXERCISE NO. 14 **DATE :**

STUDY OF PESTS OF PEAS AND BEANS

Sr. No.	Common Name	Scientific Name	Order	Family
I)	**Pests of mungbean, ricebean (*Vigna radiata*), uridbean (*V. mungo*)**			

1	Whitefly	*Bemisia tabaci*	Hemiptera	Aleurodidae
2	Green jassid	*Empoasca* spp.	Hemiptera	Cicadellidae
3	Bihar hairy caterpillar	*Diacrisia obliqua*	Lepidoptera	Arctidae
4	Red hairy caterpillar	*Amsacta moorei*	Lepidoptera	Arctidae
5	Green semilooper	*Anomis flava*	Lepidoptera	Noctuidae
6	Mite	*Aceria cajani* Channa.	Acarina	Eriophyidae
7	Pea stem fly	*Melanogromyza phaseoli*	Diptera	Agromyzidae
8	Til hawk moth	*Acherontia styx*	Lepidoptera	Sphingidae
9	Tur plume moth	*Exelastis atomosa Meyr.*	Lepidoptera	Pterophoridae
10	Pulse beetle	*Callosobruchus chinensis* L. *Callosobruchus maculatus* F. *Callosobruchus analis* Fab.	Coleoptera	Bruchidae
II)	**Pests of field peas (*Pisum sativum*)**			
11	Pea leaf miner	*Chromatomyia horticola*	Diptera	Agromyzidae
12	Pea pod borer	*Etiella zinckenella*	Lepidoptera	Pyralidae
13	Gram pod borer	*Helicoverpa armigera*	Lepidoptera	Noctuidae
14	Pea stem fly	*Melanagromyza phaseoli*	Diptera	Agromyzidae
15	Pea green aphid	*Acyrthosiphon pisum*	Hemiptera	Aphididae
16	Pea blue butterfly	*Lampides boeticus*	Lepidoptera	Lycaenidae

1. Pea Stem fly : *Melanagromyza phaseoli* (Tryon)
Diptera; Agromyzidae

Marks of identification :

Adult is a small sized metallic black coloured fly measuring about 2.75 mm in length. Adults have pubescent eyes, strong legs and transparent wings. Newly hatched maggots are 0.61 mm in length, 0.12 mm in breadth and whitish in colour. Fully-grown maggot is creamy white in colour, 1.25 to 1.5 mm in breadth and 3.75 to 4 mm in length. Pupae measure about 2.5 mm in length and 1.5 mm in breadth.

Nature of damage :

The maggots burrow into the stem causing withering and ultimate drying of affected shoots, thus reducing the bearing capacity of the host plant. The adults also cause damage by puncturing the leaves and feed on the liquid that oozes. Owing to feeding the injured portion turns yellow. Seedlings are more affected than grown up plants.

Host plants :

Pea, soyabean, cowpea, lab-lab bean, niger.

Life history :

The female inserts her ovipositor into the leaf and sometimes in the stem and petiole and make an elliptical cavity under the epidermis. A female lays 14-64 elongate, oval and white eggs. The incubation period is 2-4 days. The larval development is completed in 6-7 days in March-April and 9-12 days in November-December. The larva pupates in its gallery. There are three larval instars. The pupal period lasts for 5-9 days. About 8-9 generations are completed in a year under favourable conditions.

Control measures :

i) Collection and destruction of infested plants parts in the initial stage of attack.

ii) Spray crop with dimethoate 30 EC 0.03 per cent (500 ml/500 litres water/ha) OR monocrotophos 36 WSC 0.04 per cent (550 ml/500 litres of water) during pod formation.

iii) Advanced sowing of pea in the month of May instead of July prevents the damage by stem fly.

2. Pea pod borer : *Etiella zinckenella* Treitschke
Lepidoptera; Pyralidae

Marks of identification :

The moths are grayish-brown with a white line on the anterior margin and a transverse yellow band and pale hind wings. The wing expanse is 25 mm. the full grown larvae are rosy, with purplish tinge on the body.

Nature of damage :

The injury is caused by larvae which consumes floral part, newly formed pods and feed on the developing seeds. One or rarely two larvae may be seen in a single pod. After feeding a larva moves to another pod. Due to feeding on grains, the reduction in yield up to 5 per cent may occur.

Host plants :

Pigeon pea, lentil, lima beans, green peas, cowpea, horse gram, lab lab, niger etc.

Life history :

The pests breed throughout the year. The moths are nocturnal and emerge in FebruaryMarch. The female lays whitish, elliptical eggs singly or in small groups on various parts of the plant including developing pods. The incubation period is 5 days. the larva feeds inside the pods and become full-grown in 10-27 days. Pupation takes place in the soil at a depth of 2-4 cm and pupal development is completed in 10-15 days. About 5 generations are completed in a year.

Control measures :

1. Collection and destruction of infested plants parts in the initial stage of attack.
2. At flowering initiation, spray the crop with 0.2 per cent Carbaryl 50 WP and repeat the treatment after three weeks, if necessary for effective control of the pests.

3. **Gram pod borer :** *Helicoverpa armigera*
Lepidoptera; Noctuidae

Marks of identification:

Adult is medium sized, light yellowish brown coloured moth with wing expanse of 37 mm. Forewings are pale brown with a dark brown minute circular dots on it. Hindwings are smoky-white with a broad blackish outer border. Caterpillars are apple green in colour with whitish and dark grey broken longitudinal strips. Caterpillars measure about 40 to 48 mm in length when full-grown. Pupae are dark brown and measure about 11 to 14 mm in length. Eggs are yellowish white, dome shaped, 0.4 to 0.5 mm in diameter.

Nature of damage:

The young larvae feed on foliage for couple of days and subsequently bore into pods of leguminous crops by thrusting their head inside and keeping rest of the body outside. They feed on grain. Larva is migratory in habit and hence it damages so many plants and pods. In Bengal gram, the pest causes serious damage during March when the crop is in the pod formation stage. Red gram varieties which mature early during November are generally more severely damaged by this pest.

Host plants:

Gram, red gram, pea, cotton, tobacco, tomato, safflower, sunflower and sorghum.

Life history:

Female lays 400 eggs singly on tender leaves, shoots and pods. Hatching period is 3 to 7 days. Larval period is 14 to 38 days. Pupal period is 6 to 12 days. Pest pupates in soil. Hibernation takes place in the pupal stage in soil. Number of generations completed in a year is eight.

Control measures:

i) Hand collection of larvae and their mechanical destruction. ii) Collect and destroy infested plant parts *i.e.,* leaves, pods *etc*. iii) Deep ploughing after harvest to destroy hibernated pupae. iv) Trap crops like Lubia (chawli), marigold along the border of main crop may be grown. v) Pheromone traps are commercially available. These are used to destroy moths and monitoring pest population in the field.

vi) Biocontrol agents :

Solitary larval parasite : *Campoletis chlorideae*

Egg parasite : *Trichogramma confusum*

Larval parasite : *Bracon kitcheneri*
Larval predator : *Andrallus spinidens*

vii) Spray 5 per cent NSKE OR NPV of *Helicoverpa armigera* @ 250 LE/ha. viii) As soon as pest appears or 50 per cent flowering has taken place, give two applications at two weeks interval with any one of the following insecticides. Quinalphos 25 EC 0.05 per cent (1000 ml/500 litre/ha)

OR

Quinalphos 1.5 D @ 20 kg/ha

OR

Carbaryl 10 D @ 20 kg/ha.

4. Tur plume moth or Pod caterpillar : *Exelastis atomosa* Meyr.
Lepidoptera; Pterophoridae

Marks of identification :

Adult is 12 mm long, delicate moth with plumose light brown wings. Forewings are divided into 2 parts and hindwings cut into 3 parts and are provided with a fringe like border. Caterpillar is 13 mm in length when full-grown and greenish brown in colour. Larva has short hairs and spines on the body. Pupa is covered with thin hairs. Eggs are oval in shape and greenish in colour. **Nature of damage :**

The tiny larva soon after hatching bores into the pods and feeds on the seeds. Attack starts from terminal shoot, flowers, flower buds and developing seeds. Sometimes larvae are seen biting into unopened flower buds consuming developing anthers. Larvae never enter the pod completely.

Host plants :

It is specific pest of red gram but also infests lablab and horse gram.

Life history :

About 17 to 19 eggs are deposited by female on tender parts of the plant or terminal shoots having buds and flowers. Hatching period is 3 to 4 days. Larval development takes place in 10 to 25 days. Larva pupates outside the pod on its surface or in the entrance hole. Pupal period is 3 to 12 days. One life cycle is completed in 17 to 42 days.

Control measures :

i) Collection and destruction of infested pods during the early stage of attack.
ii) Avoid growing leguminous crops consecutively in same field. Follow proper crop rotation.
iii) Field applications (two) of the following insecticides at two weeks interval starting from pod formation. First at pod formation and second two weeks after first application.

Quinalphos 0.05 per cent OR
Monocrotophos 0.04 per cent OR
Quinalphos 1.5 D @ 20 kg/ha
OR
Carbaryl 10 D @ 20 kg/ha
OR
Methyl parathion 2 D @ 20 kg/ha

5. Pulse beetle : *Callosobruchus chinensis* L., *C. maculatus* F., *C. analis* Fab.
Coleoptera; Bruchidae

Marks of identification :

Adult is small, 3 to 5 mm long chocolate or dark brown beetle having serrated antennae. When viewed from above, it presents a heart shaped two ivory coloured spots in the middle of the dorsal side of its body. Adult has conspicuously swollen abdomen. Grub is whitish with light brown head and mouth parts. It measures about 6 to 7 mm in length and is always found inside the grain.

Nature of damage :

Both grubs and adults of pulse beetle are destructive to various pulses. It is a major pest of pulses in storage but field infestation is also not uncommon Attack starts in the field on the ripening crop. The grubs on hatching bore into the pods and feed on the developing seed consuming entire contents. Such grains are made unsuitable for sowing and human consumption. In case of severe infestation seed yield is reduced significantly. Pest infestation is carried from field to storage.

Host plants :

Pea, cowpea, red gram, black gram, lentil, beans, chick pea, cotton seed, sorghum and maize.

Life History:

The eggs are laid on the pods and flowers. Pupation takes place inside the infested pods/seed.

Control measures:

i) Remove and destroy infested pods. ii) Apply malathion 5D @ 20 to 50 kg/ha just before flowering.

6. Pea green aphid : *Acyrthosiphon pisum*
Hemiptera; Aphididae

Marks of identification:

Adults measure up to 4 mm long. They have red eyes and the body colour varies between green, yellow, pink and red. Nymphs are similar to adults but are smaller in size and are wingless.

Nature of damage:

Nymphs and adults feed on the upper leaves, stems and terminal buds of their host plants. Heavy infestations can result in deformed leaves, wilting and yellowing, stunted plant growth, leaf curling and leaf drop, and reduced dry matter production. Secretion of honeydew can cause secondary fungal growth, which inhibits photosynthesis and can decrease plant growth. In pulse crops, aphid feeding damage (in the absence of virus infection) can result in yield losses of up to 90% in susceptible varieties, and up to 30% in varieties with intermediate resistance. Pea aphids transmit several important plant viruses including cucumber mosaic virus(CMV), bean yellow mosaic virus(BYMV), alfalfa mosaic virus (AMV) and pea seed-borne mosaic virus(PSbMV).

Host plants: Peas, beans, Lucerne, alfalfa, cucumber etc.

Control measures:

Spray 0.03 per cent dimethoate OR
0.025 per cent methyl demeton OR
0.05 per cent formothion as soon as pest appears.

7. Mites: *Aceria cajani* Channa.
Acarina; Eriophyidae

Marks of identification :

These mites are difficult to see with the naked eye. They are 0.2 mm long , light pink, spindle shape and are normally found feeding on the undersurface of the leaf.

Nature of damage :

This mite infests the under side of tender leaves of red gram in Karnataka, Maharashtra and Delhi. The infestation causes yellowing of leaves and suppression of flowering and fruiting. Infected plants are bushy and pale green in appearance with reduced leaf size, leaf distortion, mosaic and mottling of leaves. This mite also transmits the pigeon pea sterility mosaic virus. Infected plants show partial or complete sterility.

Life history :

Eggs are milky white. Hatching period is 4 to 5 days. Nymphal stages last for 2 to 5 days. Life cycle is completed in about 2 weeks. Male slightly smaller than female.

Control measures :

- Destruction of alternate host plants.
- Growing resistant varieties *viz.,* Bahar, ICPL – 151, Hyd 3C, ICPL – 7035.
- Crop rotation.
- Alteration in sowing dates.
- Destroy the infected plants during crop season and voluntary diseased plants during the off season.
- Soil application of phorate @ 1 kg a.i./ha at sowing + foliar spray with monocrotophos (0.05 %) on 30th day from sowing.
- Carbofuron @ 1.2 kg a.i./ha or aldicarb @ 1.5 kg a.i./ha applied to soil at sowing protected the crop for 75 days.
- Acaricides tetradifon or dicofol @ 0.1 per cent kills more than 90 per cent of mite population (Reddy *et al.,* 1990b and Ghanekar *et al.,* 1992).
- Wettable sulphur @ 2.5 gm/lit. of water 60 and 90 DAS.
- Spraying with NSKE @ 5 per cent and neem oil @ 3 per cent.

EXERCISE NO. 15 **DATE :**

STUDY OF PESTS OF ROSES

1) Rose aphid : *Macrosiphum rosaeformis* Das
Hemiptera; Aphididae

Marks of identification:

The non-winged rose aphid has an elongated body measuring 2.5-2.6 mm, large red eyes, black cornicles and a yellowish green tip of the abdomen.

Nature of damage :

Cool and cloudy weather during October-February favour pest build up. Blackish green coloured aphids cluster on tender shoots, buds, flower and lower surface of leaves. Both nymph and adult suck cell sap and devitalize the plants. The tender shoots wither, bud dropped down prematurely and flower loose their beauty and lasting capacity. Heavy incidence favours development of black sooty mould.

Host plants :

Rose, *Rosa* spp.

Life history :

The pest reproduced by parthenogically and viviparously. The nymphal period is 11-14 days in non-winged forms while in winged forms the nymphal development is 14-19 days, in March fastest development takes place. The population increases progressively and is the highest in March, declining early in the April as the season warms up.

Control measures :

1. Spraying with dimethoate 0.03 % or oxydemeton methyl 0.03 % or malathion 0.03 % give effective control of aphid up to 25 days.
2. Neem or pongamia oil 1.0 % followed by dimethoate 0.03 % or oxydemeton methyl 0.05 % offers effective control in openly cultivated roses.
3. Spraying with imidacloprid 0.007 % or cartap hydrochloride 0.05 % controls aphids on polyhouses.

2) Bud borer: *Helicoverpa armigera*

Lepidoptera;Noctuidae

Marks of Identification:

Moth medium sized, stout with pale reddish brown tinge. Fore wings olive green, hind wing are black and wings expanse of 30-40 mm. Full grown larvae are apple green coloured with dark gray longitudinal strips 40-48 mm in length.

Nature of Damage:

Infestation of bud borer is severe in open cultivated roses from January to March. Larvae bore in to buds by making holes and feed on growing petals. Caterpillar also damage flowers by eating petals and leaving excreta.

Host plants :

Castor, Cotton, Citrus, Indigo, Groundnut, Sorghum, Millets, Pulses, Safflower, Soyabean, Sunflower, Marigold, Tobacco, Linseed, Okra, Rose. It is highly polyphagous pest.

Life History:

Female moth deposit 500-600 cream coloured dome shaped eggs singly on young buds. Full-grown larvae pupate in cracks and crevices of soil Pupae dark brown 11-14mm length. Total life cycle completes within 5-6 weeks.

Control measures:

1. Application HaNPV @ 250 L.E. / ha.
2. Application of *Microbracon bravicornis*, *Chelonomus narayani, Tetrastichus israelae*.
3. Application of B.t. @ 1.5 g/lit.
4. Collection and destruction of larvae.
5. Release *Trichogramma chilonis* @ 75,000 adults/ha.
6. Ploughing of soil will expose the pupae to sunlight and predators.
7. Sapraying with 4 % NSKE
8. Spraying with ethofenprox 0.01 % controls the pest effectively.

3) Thrips: *Rhiphorothrips cruentatus, Dendrothrips* spp**.**
Thysanoptera; Thripidae

Marks of Identification:

Adults are slender bodied, 1.4 mm long, blackish brown with two pairs of narrow and fringed wings. Nymphs are reddish or yellowish brown. They are minute and fast moving creatures. Eggs are bean or kidney shaped.

Nature of Damage:

Both the stages are observed on underside of leaves during March to November. Nymphs and adults with rasping mouth parts scrape the tissue from leaf surface as well as petals and suck the cell sap oozing out from wound. The attacked leaves show brown patches, get distorted, finally wither and drop down. This adversely affects the flowering capacity by shedding of flower buds. Brown patches on petals affect the beauty of flowers. These insects leave minute excreta around their colony on the undersurface of leaves. The activity of the pest is more under cloudy weather conditions (April-June and September-December) and overwintering takes place in soil from November to March.

Host plants :

Grapevine, jamun, rose, oak, guava, mango, almond, cashew nut, *Calotropis* etc.

Life History:

Both sexual and parthenogenic reproduction occur side by side. The eggs are laid inside the plant tissue and lasts for 3-8 days. The nymphs moult for 3 times to become pupa and finally adult. Nymphal period is 11-22 days and pupal period is 2-5 days. One life cycle is completed in about 14-33 days. About 5 to 8 generations are completed in a year.

Control measures:

1. Spraying the crop with 0.03 per cent dimethoate or 0.03 per cent methyl demeton or cypermethrin 0.0075 per cent or 0.1 per cent dichlorovas effectively controls the pest.
2. Soil application of 10 per cent phorate granules will also give sufficient protection against the pest.

4) Rose leaf hoppers/Jassids: *Edwardsiana rosae*
Hemiptera; Jassidae

Marks of Identification:

Jassids are wedge shaped, small insects measuring about 2.0-2.5 mm in body length. They are yellowish-green in colour and walk diagonally. Nymphs are light coloured, smaller in size, resembles with adults but are wingless.

Nature of Damage:

Both nymphs and adults suck the cell sap from tender leaves, flowers, shoots and stem. Due to injection of toxins during feeding, leaves become curly, turn yellow, dry and drop down; flowers get disfigured by curling the petals. Thus market value of the flowers is adversely affected. They also secrete honeydew like substance on leaves that create sooty moulds which affect the photosynthesis activity of the plant and further growth and quality of flowers.

Host plants : Rose

Life History:

Eggs are embedded in tender parts of rose plants. After hatching the newly emerged nymphs start feeding on cell sap of rose by injecting its rostrum into tender parts. The nymph moult 4 times to become an adult. Many generations are completed in a year.

Control measures:

Spray the crop with Azadirachtin 0.03 per cent or dimethoate 0.03 per cent or methyl demeton 0.04 per cent as and when the pest is noticed.

5) Two spotted spider mite: *Tetranychus urticae* Koch.
Acarina; Tetranychidae

Heavy incidence of mite is found from March to May when hot and dry conditions prevail. Cream coloured nymphs and red coloured adults with two black spots are found in colonies on lower side of matured leaves covered by webs. In case of severe infestation population spreads to entire plant including buds and flowers. Mites scrap tissues and suck the sap resulting in discolouration, yellowing, stippling, drying and dropping of attacked leaves. Damage to buds and flowers lead to retardation and drying.

Control measures:

1. Proper ventilation, clean cultivation and frequent watering to bring down temperature keep the pest under check.
2. Cutting and burning of heavily infested shoots.
3. Spraying with dicofol 0.05 %, fluvalinate 0.012 %, wettable sulphur 0.03 %, oxydemeton methyl 0.05 %.
4. Spraying with vertimec 0.0025 %, flufenoxuron 0.01%, amitraz 0.05 %, profenophos 0.05 % offer very good solution in protected roses.

6) Leaf eating caterpillars/Hairy caterpillars: *Spilarctia oblique*
Lepidoptera; Arctiidae
Euproctis lunata
Lepidoptera; Lymantriidae

(Bihar Hairy Caterpillar): *Spilarctia oblique*

The caterpillars of this polyphagous pest feed on leaves and floral parts of the plant. In many cases the whole leaf is eaten away by the caterpillars.

(Castor hairy caterpillar): *Euproctis lunata*

The young larvae eat the leaf margins of the host plants. The full grown caterpillars, however, feed on the entire leaf lamina and cause maximum damage during these months.

Control measures:

1. Collection and destruction of leaves along with egg masses and early instars.
2. Spraying with quinalphos or chlorpyriphos 0.05 %.
3. Spraying with NSKE 4 % after insecticide **4.** Application of *B.t.* @ 1.5 g per litre of water.

EXERCISE NO. 16 **DATE :**

STUDY OF PESTS OF CHRYSANTHEMUM AND MARIGOLD

1) Lacewing bug: *Cadmilos retiaris*
Hemiptera; Tingidae

Marks of Identification:

The adult lace wing bug is typically reticulated with lace like wings. The adult measures about 4 mm in body length and are blackish in body colour. The wings are transparent. Nymphs are lighter than adults in body colouration but they have also reticulation on their body.

Nature of Damage:

Both nymphs and adults suck the cell sap from the tender parts of chrysanthemum plant and inject toxins into the plant body resulting curling of leaves and petals of the flowers. The infested leaves turn yellowish brown, their edges start drying, finally the entire leaf is dried and drop down. Flowers become disfigured, colour of flower gets changed, they look sick and unhealthy in appearance. The market value of the flowers is adversely affected.

Host plants :

Chrysanthemum, sunflower, Gaillardia, Marigold, Vernonia, Daisy, Aster, weeds like *Argemone* spp. etc.

Life History:

Eggs are singly laid in plant tissues. Incubation period is 5-7 days. Nymphal period is 2-3 weeks during which the nymph moults five times to become adult. Many generations are completed in a year.

Control measures:

1. Collection and destruction of infested plant parts along with the pest stages.
2. As an when the pest appears spray the crop with 0.05 per cent dimethoate or 0.03 per cent DDVP or 0.03 per cent malathion or 0.03 per cent diazinon.

2) Aphid : *Macrosiphoniella sanborni* Gillete
Hemiptera;Aphididae

Greenish black nymphs and chocolate brown adults suck the cell sap from tender shoots and lower side of leaves. Damage result in yellowing and premature leaf fall, loss of vigour and stunted growth of the plant. Black sooty mould develops on heavily infested leaves. In severe case flower buds reduces in size and remain unopened.

Control measures:

1. Spraying with oxydemeton methyl or dimethoate 0.05 % followed by sparys of pongamia kernel extract 4 % or neem oil 1 %.

2. Spraying with imidacloprid 0.007 % or cartap hydrochloride 0.05 % also provides good control.
3. Use of *Verticillum lecanii* reduces aphid menace.
4. Release of one day old *Chrysoperla carnea* larvae at 5:1 ratio (Aphid:chysopid) eliminate aphid population in glasshouse.

3) Thrips: *Microcephalothrips abdominalis* (Crawfd.), *Fraqnkliniella* spp. Thysanoptera; Thripidae

More than three species are reported on chrysanthemum grown under cover and open conditions, of which above two are common. Slender nymphs and adults feed on tender leaves causing mottling, distortion and bronzed appearance. Affected flowers look discoloured and scorched.

Control measures:

1. Sparying with oxydemeton methyl or dimethoate or phenthoate 0.05 % or acephate 0.1% effectively reduces thrip damage.
2. Spraying with cartap hydrochloride or ethofenprox or profenophos 0.05 % in polyhouse.
3. Raking and drenching of soil with chlorpyriphos 0.1 % kills pupal stages and avoid further infstation.
4. Covering of flower buds with polythene bag with holes prior to blooming protects the flowers from attack.

4) Bud borer: *Helicoverpa armigera*
Lepidoptera Noctuidae

Borer incidence is observed in September- October. Adult female lay eggs on bracts of buds and flowers. Larvae feed on petals and damage flowers resulting in considerable loss.

Control measures:
Same as rose.

5) Leaf folder : *Hedylepta indicata* (Fab.)
Lepidoptera;Pyralidae

This is a serious pest of chrysanthemum. Pale white eggs are laid in groups on lower side of leaves, which hatch in 10 days. There are six larval instars. Green coloured larvae with white stripes and brown head fold the leaves and feed on chlorophyll resulting in skelotinization and drying. Pupae are seen inside the rolled leaves. The larvae also damage flowers leading to heavy loss occasionally.

Control measures:

1. Cutting and burning of rolled leaves.

2. Spraying of ethofenprox 0.01 % or fenvalerate 0.01 % follwed by quinalphos or profenophos 0.05 % gives effective control.

6) Leaf miner: *Liriomyza trifolii*
Diptera; Agromyzidae

This is a serious pest of polyhouse as well as cultivated chrysanthemum. The incidence is abundant during March – June. Eggs are deposited in leaf by puncturing the tissues. Larvae make tunnels in leaves and feed on chlorophyll leaving characteristic trails. Damaged leaves bear extensive mining marks that turn brown and dry.

Control measures:

1. Removal and destruction of weeds, which act as a alternate hosts.
2. Cutting and burning of heavily mined leaves.
3. Install yellow sticky traps coated with chlorpyriphos 0.05 % to trap adult population.
4. Dipping of chrysanthemum cuttings in Margosan 3 % for 2 hours and foliar spray of it at 0.4 % reduce the number of pupae and adults.
5. Spraying of cypermethrin 0.01 % or deltamethrin 0.0015 % at initial stage of infestation followed by triazophos 0.06 % offer good control.
6. Release of *Diglyphus* spp. a larval parasitoid @ 1000 parasites /week.

7) Spider mite : *Tetranychus* spp.
Acarina; Tetranychidae

Mite colonies are usually seen on lower surface of leaves and population spreads to entire plant in severe cases of attack. Damage starts in March and reaches to peak during MayJune. Affected leaves become discoloured, dry and fall while damaged shoots dry up.

Control measures:
Same as two spotted mite of rose.

8) Common garden slug : *Laevicantis alte* ; *Limax* sp.
Class Gastropoda; Phylum Mollusca

Feeds on number of ornamental plants like balsam, portulaca, pot- marigold, verbena, dahlia, cosmos, narcissus and lily. Slugs appear as sporadic pests in those places where damp conditions prevail. They defoliate the plants completely also feed on the bark of plant. When their population in high, they may do serious damage.

Control measures :

1. Low population can be collected and destroyed.
2. Dust 15 per cent metaldehyde dust or spray 20 per cent metaldehyde liquid or sprinkle 5 per cent metaldhyde pellets around infested fields.

EXERCISE NO. 17 **DATE :**

STUDY OF PESTS OF JASMINE AND TUBEROSE

1. Jasmine Thrips: *Thrips orientalis* Bagnall
Thysanoptera; Thripidae

Marks of identification:

Thrips are slender bodied, brownish insects which have two pairs of narrow and fringed wings. Adults measure about 1.0 mm in body length. Nymphs are smaller than adult and are wingless. Eggs are kidney shaped or bean shaped.

Nature of damage:

Both nymphs and adults feed on tender shoots, tender leaves and petals of flower by rubbing their mouth parts over tender portion and feeding on oozing sap of the crop plant. Appearance of the plant and flowers adversely affected due to such feeding by the pest. The insect cause decaying look to the crop.

Host plants:

Jasmine *Jasminum multiflorum, J. grandiflorum*

Life history:

The eggs are laid singly in slits made with saw like ovipositor into the tender tissues of Jasmine. The eggs, nymphal and pupal stages are completed in 3 to 8, 11 to 25 and 2 to 5 days, respectively. Pupation takes place in soil. Pupae possess power of locomotion and when disturbed, they walk sluggishly. One generation is completed in 14 to 33 days. Many generations are completed per year.

Control measures :

Spray Malathion 0.05 per cent

OR
Dimethoate 0.03 per cent OR
Methyl demeton 0.02 per cent immediately after incidence is noticed.

2. Jasmine leaf webworm/gallery worm: *Nausinoe geometralis*
Lepidoptera; Pyraustidae

Marks of identification:
The young caterpillars are light yellow initially but older ones become darker. The pupa is obtect type, brown and tapering towards posteriorly. Moth is brown like with hyaline patches on the wings. The abdomen is purplish brown in colour. Eggs are greenish yellow and rounded.

Nature of damage:
The caterpillars feeds on leaves and in case of severe infestation they can sceletonized the entire plant. The caterpillars make webbings in the leaves and shelter themselves within. The caterpillars in first few instars are gregarious in condition. As a result of collective attack, the vitality of the crop is affected. Flower setting and quality and quantity of flowers is adversely affected.

Host plants: Jasmine.

Life history:
The mated female can lay about 15-20 eggs singly on leaf lamina of jasmine plant. Eggs hatch in about 3-4 days. The larval period is 12 to 15 days. There are five instars of larvae. The full grown caterpillar spin webbings in the shaded portion of the plant along with leaves and pupate in the typical shelter prepared. Pupal period is 6-7 days. The life cycle is completed within 22 to 24 days. The pest is most active in the month of July-August.

Control measures :

1. Collection and destruction of caterpillars and pupae from the webbing of the plant.
2. Spray the crop with 0.03 per cent Azadirachtin or 0.03 per cent malathion as soon as the incidence is noticed.

3. **Jasmine budworm:** *Hendecasis duplifascialis* Hampson
Lepidoptera; Pyraustidae

Marks of identification:
The moth is pale white. The larva is yellowish green in colour with a distint black head and prothoracic shield.

Nature of damage:

The caterpillar bore into immature bud and feed on the internal contents. The larva feed voraciously on the corolla leaving only the corolla tube in mature buds. In case of younger buds the larva remain outside the buds and feed on the inner floral whorl through a small hole in the corolla tube. The infested flower turns violet and eventually dries out. A single larva may damage upto 6 buds.

Host plants: Jasmine.

Life history:

The freshly laid eggs are round, creamy and glued to the flowerbuds. The eggs hatch in 3-4 days and the larva passes through five instars. The total larval duration varies from 11.5 to 17.0 days depending on the jasmine species. The pupal stage lasts for 6.5 to 9.0 days and the life cycle is completed in 21-29 days.

Control measures :

1. Spray the crop with 0.03 per cent dimethoate or 0.01 per cent cypermethrin as soon as the incidence of pest is noticed.

4. Jasmine eriophyid mite: *Aceria jasmini* Chanana
Acarina; Eriophyidae

Marks of identification:

The female is cylindrical 150-160 µ long and 44 µ thick. The males are rare and generally 95 µ long.

Nature of damage:

It is a serious pest. Causes hairy outgrowth on leaves, tender stems and flower buds. Owing to their activity the growth of the plant is retarded and and affected plant shows stunded growth. The production of the flowers is suppressed. Kakada variety of jasmine is more susceptible than other cultivars.

Host plants: Jasmine.

Control measures :

1. Spray the crop with 0.04 per cent oxydemeton methyl or 0.05 per cent dimethoate or 0.08 per cent malathion as soon as the incidence of pest is noticed.
2. Wettable sulphur @ 2.5 g/lit. or dicofol @ 2.5 ml/lit. provides effective control of this pest.

5. Tuberose Bud borer/ Leaf eating caterpillar: *Helicoverpa armigera*
(Given under Rose)

6. Aphids: *Aphis spp.*

(Given under Rose, Chrysanthemum and Marigold, Gerbera and Carnation)

EXERCISE NO. 18 **DATE :**

STUDY OF PESTS OF ASTER AND GLADIOLUS

(A) PESTS OF ASTER

1. Leaf hopper: *Macrosteles fascifrons*
Hemiptera; Cicadellidae

Marks of identification:
Jassids or leaf hoppers are wedge shaped insects, about 2-2.5 mm long, and walk diagonally. Nymphs are miniatures and lack wings.

Nature of damage:
Adults as well as nymphs suck the cell sap from plants as a result leaves and petals become curly, disfigured and discoloured which affect the quality and marketability of china asters.

Host plants: China aster, cotton, other malvaceous plants.

Life history:
Bean shaped eggs are embedded into the soft plant tissues. After hatching the eggs, newly emerged nymphs start sucking cell sap from tender portions of plant and moult for 3 times before becoming adults.

Control measures:
Spray the crop with 0.03 per cent Malathion or 0.02 per cent diazinon or 0.02 per cent metasystox or 0.2 per cent carbaryl for effective control of the pest.

2. Aphid: *Aphis maidiradicis, Macrosiphum solanifolii*
Hemiptera; Aphididae

Marks of identification:
Adults are pale grayish, nymphs lighter in colour. Aphids are soft bodied, pear shaped, with a pair of cornicles on the abdomen. Nymphs are miniatures and lacking wings.

Nature of damage:
Nymphs as well as adults suck the cell sap from roots of the plant. Inject toxins into the plant body resulting in curly leaves and petals of the flowers. The pest also secrete honey dew like substance which create sooty mould in the leaves and flowers and affect the quality of flowers. Yellowing, dwarfing and wilting of plants are some very important aspects of pest damage. Root knots are formed to plant roots by the aphids.

Host plants: Aster, carnations, maize, jowar, graminaceous weeds etc.

Life history:
Aphids reproduce parthenogenetically. They can also reproduce viviparously and complete many generations in a year.

Control measures:
1. Collection and destruction of infested plant parts along with the different stages of the pest.
2. Spray the crop with 0.03 per cent malathion or 0.03 per cent azadirachtin or 0.03 per cent dimethoate or 0.2 per cent carbaryl or 0.03 per cent metasystox.

3. **Black blister beetle:** *Epicauta* spp., *Lytta* spp.
Coleoptera; Meloidae

Marks of identification :

Adult beetles are 12.5 mm long and black, metallic shining. They form blisters on human skin when crushed on the body. Grubs are whitish, pupae are brownish and exarate type.

Nature of damage :

Beetles attack inflorescence and feed on pollens and petals of flowers. As a result of which there is considerable reduction in the flower yield. Pest is active from August to December. Grubs feed on the eggs of grasshoppers and thus are beneficial.

Host plants :

Carnations, chrysanthemum, zinnia, clematis etc.

Life history :

Eggs are laid in soil. Grubs develop in soil. Pupation takes place in soil.

Control measures :

i) Beetles can be collected by hand nets.

ii) Set up light traps in the field for trapping adults as they are attracted to light. iii) Application of diazinon to soil for killing grubs and pupae.

iv) As and when pest appears, spray the crop with carbaryl 0.2 per cent as per the need or incidence.

(B) PESTS OF GLADIOLUS

1. Thrips : *Taeniothrips simplex* Morison
Thysanoptera; Thripidae

Marks of identification:

Adults are dark brown or black 1-2 mm long, narrow with fringed wings. Nymphs are pale yellow, smaller than adults.

Nature of damage:

Nymphs as well as adults suck the cell sap from flowers, white dirty specks are developed on flowers.

Host plants: Gladiolus.

Life history:

Kidney or bean shaped eggs are embedded in plant tissue. Incubation period is 5-6 days, nymphal period is 8 days and pupal period is abot 18 days.

Control measures:

1. Spray the crop with 0.05 per cent malathion or 0.02 per cent methyl demeton.

2. **Gladiolus seed corn maggot:** *Hylemya cilicrura* Rondani (*Delia platura* Meigen)
   Diptera; Anthomyiidae

Marks of identification:

The adult is a bristly, gray coloured fly measuring about 6-7 mm in length with large wings and three stripes on their back. The maggots are dirty white with a yellow tint, cylindrical and tapering in shape. The eggs are white and elongated.

Nature of damage:

Damage to the gladiolus consists primarily of feeding on the soil covered sprouts and in case of severe infestation all the primary shoots are attacked. Several maggots may be seen feeding in a single shoot. Due to feeding activity the shoots are destroyed and it affects the vigour and quality of plant.

Host plants: Gladiolus, corn, beans, peas, cucumber, potato and other vegetables.

Life history:

Female lays on an average 270 eggs in soil with adundant decaying organic matter. The hatching period is 2-4 days. The larval period lasts for about 3 weeks. The pupae are 5 to 6 mm long, dark brown to black, barrel shaped and found in the soil near roots. Pupal stage lasts for 10 days. The maggots survives the winter in the pupal stage in the soil.

Control measures:

Application of Phorate 10 G @ 10 kg per hac or Carbofuran 3G @ 16.5 kg per ha in the soil controls the pest effectively.

3. Cut worm: *Agrotis ypsilon*
Lepidoptera; Gelechidae

Nature of damage:

Caterpillars cut down the seedlings of carnation and feed upon them in night. They are nocturnal in habit.

Host plants:

Polyphagous. Carnations, Gladiolus, Dahlia, Lilies, Lawns, grams, peas, wheat, lentil, linseed, maize, jowar, tobacco, potato, vegetable, pulses and several weeds.

Control measures:

1. Ploughing and digging the field for exposing eggs, larvae and pupae to natural mortality factors.
2. Heavy irrigation or flooding kills the caterpillars.
3. Collection and destruction of pest stages i.e., eggs, larvae, pupae and adults.
4. Heaps of grasses may be kept in garden as shelter for caterpillars and further they may be collected and destroyed.
5. Spray the crop with 0.1 per cent carbaryl or 0.03 per cent malathion or 0.03 per cent DDVP or 0.03 per cent azadirachtin.

4. Aphids: (Given under Rose, Gerbera and Carnation, Aster).

5. Mites: (Given under Rose, Carnation).

EXERCISE NO. 19 **DATE :**

STUDY OF PESTS OF GERBERA AND CARNATION

1) Gerbera mites: *Polyphagotarsonemus latus*
Steneotarsonemus pallidus
Acarina; Tetranychidae

It is called as yellow or broad mite. Newly emerged females are whitish in the beginning. Gradually turn to yellowish brown and elliptical in shape.

Nature of damage :
Mites cause the damage by sucking the cell sap from tender portions of the gerbera plant and affect the growth and quality of plant and flowers. The leaves become rusty and curled, flowers get disfigured. At the time of flower opening the petals of outer ray florets will be uneven and bear white specks.

Host plants : Gerbera, Chrysanthemum and Dahlia.

Life history :
Female lays eggs singly on the ventral surface of leaves. Fecundity is 17-41. Total duration of development from egg to adult for females is 86.36 hrs and males 81.15 hrs. Adult longevity for female is 8.66 days and for male it is 7.24 days.

Control measures :
(i) Spray 0.01 per cent abamectin 1.8 EC or 0.04 per cent dicofol or kelthane or Dimite as soon as incidence is noticed.
(ii) Spraying with fenazaquin @ 1.7 ml/lit. or profenophos @ 1.0 ml/lit.

2) Whitefly : *Trialeurodes vaporarium*
Hemiptera; Aleurodidae

They are whitish and mostly found on green house plantation. The nymphs are like scales attached to underside of leaves. They give out certain amount of honey dew resulting into formation of sooty mould, giving black appearance.

Control measures :
Under green house, pest can be controlled by spraying with 0.4 per cent Neemark + 0.05 per cent quinalphos or 0.1 per cent cartap hydrochloride.
Under field conditions, spraying the crop with 0.05 per cent methyl demeton or malathion will control the pest effectively.

3) Green peach aphid : *Myzus persicae*

Hemiptera; Aphididae

Marks of identification:

Aphids are soft bodied louse like insects having two pairs of transparent wings. Nymphs are smaller in size and without wings. Both winged and non winged adults are seen. A pair or cornicles is present on the abdomen in both the nymphs and adults. Adults are 2-2.5 mm long, yellowish green.

Nature of damage:

Both nymphs and adults suck the cell sap from leaves and flowers of carnation and thereby devitalize the plant. The quality of the flowers is badly affected. They also act as a vector of certain plant viral diseases.

Host plants:

Carnations, cruciferous plants, bean, peach, potato, mustard etc.

Control measures :

1. Collection and destruction of infested carnations.
2. Spray the crop with 0.08 per cent malathion or 0.03 per cent dimethoate or 0.02 per cent diazinon.

4) Thrips : *Thrips tabaci*

Thysanoptera; Thripidae

Marks of identification:

Adults are yellowish brown, 1 mm long, sledder bodied, wings are narrow and fringed. Nymphs are light coloured and without wings.

Nature of damage:

Adults and nymphs scrap their mouth parts on the petals and tender leaves of carnation resulting disfiguring and discolouration of the flowers and leaves.

Host plants:

Carnations, marigold, onion, garlic, melon, turnip, cucumber, cabbage, cauliflower, bean etc.

Life history:

About 60 kidney shaped eggs are laid by the female which are embedded into the plant tissue. Incubation period is 5-10 days. There are 4 instars. Nymphal period is 4-6 days. pupal period is 2-4 days. Life cycle is completed within 12 days. Many generations are completed per year.

Control measures :

Spray the crop with 0.03 per cent malathion or 0.04 per cent monocrotophos or 0.02 per cent methyl demeton as and when the pest appears.

5) Bud borer: *Helicoverpa armigera*

(Given under Rose)

EXERCISE NO. 20 **DATE :**

STUDY OF PESTS OF LILY, ANTHURIUM AND ORCHIDS

(A) PESTS OF LILY

1. Lily moth: *Plytela gloriosae* Fabricius
Lepidoptera; Noctuidae

Marks of identification:
The moth has mosaic pattern of red, yellow and black on fore wings, with a row of black and yellow dots on the apical margin. The hind wings are black. The full grown larva measures about 40 to 42 mm in length and possess black, white and red mosaic patterns on the body.

Nature of damage:
The larvae feed on the green matter of the leaves which may result in complete defoliation of the lily plant.

Host plants: Lily.

Life history:
The female moth lays round, yellowish eggs on the apical portion of the undersurface of leaves in clusters of 13-42. The hatching period is 3-6 days. Larval period is 16-20 days. Pupal period is 15-20 days. Pupation in soil in earthern cocoon. Two generations are completed in a year.

Control measures:
1. Spraying the crop with 0.05 per cent malathion controls the pest effectively.

(B) PESTS OF ORCHIDS

1. Orchid aphid: *Cerataphis orchidearum* (Westwood)
Hemiptera; Aphididae

Marks of identification:

Adults of non winged forms are small, flattened, broadly oval, dorsal surface dark reddish brown to black dusted with wax, about 1.5 mm long, while winged forms are 2.0 mm long.

Nature of damage:

Nymphs and adults suck the cell sap from orchids and affect the beauty of orchids by disfiguring and discolouring. The pest also secrete honeydew like substance which invite sooty mould to form on the plant, that affect photosysthesis and growth of the plant adversely.

Host plants: Orchids.

Life history:

They produce parthenogenetically. Many generations are completed in a year.

Control measures:

1. Collection and destruction of infested plant parts along with the different stages of the pest.
2. Spray the crop with 0.03 per cent malathion or 0.03 per cent azadirachtin or 0.03 per cent dimethoate or 0.2 per cent carbaryl or 0.03 per cent metasystox.

2. Orchid weevil: *Diorymerellus laevimaryo*

Coleoptera; Curculionidae

Marks of identification:

Adults have snout which is a extension of head. Adult weevil is about 3.0 mm long , black smooth and shining. The grubs are comma shaped, whitish 1.5 mm long and legless. Pupa is brownish and exarate type.

Nature of damage:

Weevils can also feed on roots. However there main damage is to the young and tender leaves, to the sheath around the flower buds and to the bulbs. They also feed on the flower petals before the flower open. They prepare numerous holes to the flowering bodies and invites pathogenic attack to plant, resulting in decay in blossoms. Grubs feed on the roots hollowing out the inside and causing the tips to turn black.

Host plants: Orchids.

Life history:

Eggs are laid in soil. After hatching the newly emerged grubs feed on roots of the orchids. Full grown grubs pupate in soil and become an adult in a period of one to two weeks.

Control measures:

1. Ploughing or digging the field for exposing life stages of the pests to natural mortality factors.
2. Collection and destruction of weevils.
3. Spray the crop with 0.04 per cent Methoxychlor or 0.1 per cent malathion.

3. Orchid fly: *Eurytoma orchidearum*
Hymenoptera; Eurytomidae

Marks of identification:

Adult is small black wasp, 3-4 mm in length. It has petiolate abdomen and reduced venation in the wings. Grubs are whitish typically tapering towards both the ends. Eggs are elongated and whitish.

Nature of damage:

Grubs feed on the tips of the roots and arrest the growth of the plant and also form unsightly nut like galls which affect the beauty of the orchid and food transportation. In case of severe infestation the bud turn brown black and no flowers are formed.

Host plants: Orchids.

Life history:

Female deposits its eggs at the bases of the pseudostems or some times on the young leaves and rhizomes. Incubation period is 7-14 days. The full grown pupates inside the galleries and then the adults emerge out.

Control measures:

Spray the crop with 0.04 per cent methoxychlor.

4. Orchid Mealy bug: *Pseudococcus microcirculans*
Hemiptera; Pseudococcidea

Mealy bugs are flat bodied, orange or mahogany coloured insects which are covered with cottony, mealy like powder on the body. Males are winged and females and nymphs are non-winged.
Both nymphs and adults suck the cell sap from the orchids and affect the quality of flowers and entire plant.

Control measures:

1. Collection and destruction of infected plant parts along with pest stages.
2. Spray the crop with 0.03 per cent malathion or 0.03 per cent dimethoate or 0.02 per cent diazinon or 0.03 per cent metasystox.

(C) PESTS OF ANTHURIUM

1. Aphid: *Myzus circumflexus* Hemiptera; Aphididae

Nymphs and adults suck the plant sap which causes yellowing and distortion of leaves and poor growth of the plant. Honeydew excretion causes black sooty mould fungus.

Control measures:

1. Spraying of any insecticides like dicofol 0.04 per cent or malathion 0.1 per cent.
2. A formulation containing pyrethrum extract gives effective control.
3. Field release of parasitic wasp *Aphidius colemani* @ 5/m^2 area per week.

2. Thrips: *Haetanaphothrips orchidii*
Thysanoptera; Thripidae

Nymphs and adults suck the sap from leaves. As a result the leaves curl and there is mottled effect on foliage and flowers.

Control measures:

1. Foliar sprays of cyfluthrin 2 EC and chlorpyriphos 25 EC @ 1ml/lit are effective in reducing the number of injured flowers.
2. Spraying of dimethoate 30 EC 0.03 per cent or phosphamidon 85 WSC 0.04 per cent also controls thrips.
3. Field release of predatory mite *Amblyseius cucumeris* @ 5,00,000/ha

3. Whitefly: *Bemisia tabaci, Aleurotulus anthuricola* Hemiptera; Aleurodidae

Both nymphs and adults suck the cell sap from ventral surface of leaves. As a result, infested leaves become yellowish, wrinkled, curled downwards and are ultimately shed. The vitality of the crop is reduced. Consequently, the growth of the plant is adversely affected

Control measures:

1. Spray 0.05 per cent formothion or 0.03 per cent dimethoate or 0.03 per cent oxydemeton methyl as soon as incidence is noticed.
2. Field release of parasitic wasp - *Encarsia formosa* @ 3/m^2 can be followed.

4. Red spider mite: *Tetranychus cinnabarinus*
Acarina; Tetranychidae

Nymphs and adults are red in colour. Eggs are laid on the ventral surface of the leaves and are whitish, spherical in shape.

Spider mite causes - yellowish mottling of the leaves. Leaves shrivel and turn brown. A fine web is spun on the undersurface of leaves.

Control measures:

1. Spraying the affected plants with dicofol 18.5 EC 0.03 per cent.
2. Field release of predatory mite - *Phytoseiulus persimilis* @ 6/ m^2 area.

EXERCISE NO. 21 **DATE :**

STUDY OF PESTS OF BLACK PEPPER

1. Pollu beetle: *Longitarsus nigripennis*
Coleoptera: Chrysomelidae

Marks of identification:

The adult is a small shining yellow and blue flea beetle with stout hindlegs. The full-fed grub is about 5 mm long and yellowish with black head.

Nature of Damage:

This is a most important pest of pepper in India occurring regularly in the plantations. Damage is caused by both adults and grubs. Adult causes damage by feeding on the leaves, the growing shoot tip and on the surface tissues of the tender spikes. Feeding on the spikes leads to their partial damage. The grubs damage by boring into the growing tips, into spikes and into the berries. The shoot tip die and dry up together. The spikes infested by the grubs also die and dry up and may drop. The attacked berries appear dark in colour, are hollow inside and crumbled when pressed. Such berries are known locally as "**pollu berries".** Upto 35 per cent of the berries are lost

in this way by the attack of the grubs. Single grub destroys around 3-4 or even more berries during its life time.

Host plants:

Pepper. No alternate host is seen to be infested by the insect.

Life history:

The female lays about 100 eggs on the sides of the tender berries or on the growing shoot tips. Eggs hatch in 5-8 days. Grubs become full grown in 20-32 days. Full grown grub drops to the ground to pupate in an earthen cell in soil 5-7.5 cm deep. Pupal period is 6-7 days. One life cycle takes from 39-50 days for completion. 4 generations are completed between July to January.

Control measures:

Spraying quinalphos 25 EC 0.05 per cent, first at the time of spike initiation and then a month when the berries are still tender can control the pest effectively.

2. Pepper shoot borer: *Laspeyresia (Cydia) hemidoxa*
Lepidoptera; Tortricidae

The full grown caterpillar is grayish-green in colour. Adults are crimson and yellow colour moths. Pupation takes place inside the shoots within the tunnels.

Nature of damage:

Larvae bore into tender terminal shoots and feed on internal tissues resulting in blackening, decaying and drying of affected shoots. The pest infestation is higher during July to October when numerous succulent shoots are available in the vines

Control measures:

Spray quinalphos 0.05% each on tender terminal shoots; repeat spraying at monthly intervals (during July - October) to protect emerging new shoots.

3. Scale: *Lepidosaphes piperis* Gr. Hemiptera; Diaspididae

These elongated, oval, dark grey hard scales covered the stems, leaves and petioles in large numbers desapping them. The infested vines fade, wither and dry up. Nurseries are severely affected sometimes.

Control measures:

The pest can be controlled by applying contact insecticides like chlorpyriphos 1.5 D @ 20 to 25 kg/ha.

4. Mealy bug: *Ferrisia virgata* (Ckll.)

Hemiptera: Pseudococcidae

These mealy bugs (crawlers and adults) cluster on terminal shoots, leaves, berries and suck the cell sap. Yellowing, withering and drying of plants or shedding of berries are the symptoms of attack. The vitality of crop is reduced. It is known to transmit badnavirus disease of black pepper.

Control measures :

Spraying malathion 0.1 per cent of dimethoate 0.05 per cent is effective for the control of mealy bugs.

EXERCISE NO. 22 **DATE :**

STUDY OF PESTS OF CLOVE AND CINNAMON

(A) PESTS OF CLOVE:

1. Stem borer: *Sahyadrassus malabaricus* Lepidoptera; Hepialidae **Nature of damage**:

The stem borer infests the main stem of young trees at the basal region. The larva of the pest girdles the stem and bores downward into it. The girdled portion and bore-hole is covered with a mat- like frass material. The infested trees wilt and succumb to the pest attack subsequently.

Control measures:

Spray quinalphos 0.1 per cent around the bore-hole and inject the same into the borehole after removing the frass. Swab the basal region of the main stem with carbaryl and keep the basins free of weeds.

2. Scale insects:

a. Black Scale: *Saissetia nigra*

Female adults are elliptical, flattened and shiny black. It infests tender leaves, shoots and twigs. Sooty mould fungus is observed on leaves due to honey dew secretion.

b. Masked scale: *Mycetaspis personata*

Female adults are elliptical, flattened and black in colour. Dome shaped and greyish brown scale will be seen on the undersurface of leaves especially of young clove plants. The infested leaves become discoloured and completely yellowish and finally may fall down.

c. Green scale: *Lecanium* sp.

Flat and green coloured soft scales are found feeding on leaves and tender shoots.

3. Mealy bug: *Pluvinaria psidii*

Hemiptera; Pseudococcidae

Nature of damage:

Soft green mealy bug with a white mealy ovisac is seen on the undersurface of tender leaves. The feeding causes yellowing and withering of leaves. Sooty mould developing on the honey dew secreted by the bug.

4. Chilli thrips: *Scirtothirps dorsalis*

Thysanoptera; Thripidae

Nature of damage:

Both the nymphs and adults suck the cell sap from tender regions and cause the leaves the shrivel. The affected leaves show a pinkish discolouration. Flower shedding is also noticed. There is malformation of leaves, buds and fruits. The attacked plants are stunted and finally dry up. It also transmits some viral diseases.

Control measures:

Removal of affected leaves and branches will prevent the spread. Spray dimethoate 0.03 per cent or methyl demeton 0.02 per cent.

(B) PESTS OF CINNAMON:

1. Cinnamon butterfly: *Chilasa clytia*
Lepidoptera; Papilionidae

Marks of identification:
Freshly hatched larva is jet black in colour with white patches which later undergo various changes of colour pattern. The upper side of the adult moth is rich velvety brown, while on the underside of the body, the colour varies from soft pale brown to rich dark velvety brown.

Nature of damage:
On hatching the first instar larva starts feeding on the lamina of the freshly emerged leaves. The later instars feed on the tender leaves voraciously leaving only the mid-ribs with portions of veins. In case of severe infestation , the growth of the plant is adversely affected.

Host plants:
A number of wild species of cinnamon and other forest plants.

Life history:
The female butterfly lays small, round and pale yellow colour eggs singly on the upper and lower surface of young leaves, petioles and even tender shoots. Larva hatch in 3-5 days. The larva moults five times to complete its development in 12-18 days. The pupa is attached to the stem with the help of two silken girdles and anal end. The pupal period is completed within 11-13 days. The adults live for 3-5 days and total life cycle is completed within 24-36 days.

Control measures:
1. Collection and destruction of butterflies with the hand net.
2. Spraying quinalphos 0.05 per cent on tender and partly mature leaves.

2. Leaf miner: *Conopomorpha civica*
Lepidoptera; Gracillaridae

Marks of identification:
The larvae are pale gray initially and later become pink. The adult is a minute silvery gray moth.

Nature of damage:
Larvae feed on the tissues between the upper and lower epidermis of tender leaves resulting in linear mines that end in 'blister' like patches. The infested leaves become crinkled and the mined areas dry up leading to the formation of large holes on the leaves.

Control measures:

Spraying quinalphos 0.05 per cent during emergence of new flushes is effective in preventing the pest infestation.

3. Shoot and leaf webber : *Sorolopha archimedias* Meyrick
Lepidoptera; Tortricidae

Nature of damage :

The larvae of the shoot and leaf webber web tender shoots and leaves and feeds from within generally during the post-monsoon period.

Life history :

Eggs are laid on newly emerged leaves and they hatch in 3-4 days. Larvae are pale green and the larval period lasts for 10 days. Pupation occurs in a silken cocoon within the webbed leaves. The pupal period lasts for 6-7 days. Adults are small grey moths with a wingspan of 15 mm and black spots on the forewings.

Control measures:

Spraying quinalphos (0.05%) is recommended for the management of the shoot and leaf webber.

4. Chafer beetle : *Popillia complanata* Newman
Lepidoptera; Scarabaeidae

Adults are brown beetles with a metallic green head and thorax and measure 15 x 6 mm in size.

Nature of damage:

Adult beetle feed on tender leaves of cinnamon.

Life history :

The eggs are laid near the root zone and the incubation period lasts for 5 days. Newly emerged grubs are creamy white and measure 2.5 mm in length. The grubs also feed on cinnamon roots and the grub period lasts for 10 days. Pupation takes place in the soil in earthen cocoons and the pupal period lasts for 15 days.

Control measures:

Spraying quinalphos (0.05%) is recommended for the management of chafer beetle.

EXERCISE NO. 23 **DATE :**

STUDY OF PESTS OF CARDAMOM

Sr. No.	Common name	Scientific name	Order	Family
1.	Cardamom thrips	*Sciothrips cardamomi*	Thysanoptera	Thripidae
2.	Shoot and capsule borer	*Dichocrocis (Conogethes)puntiferalis*	Lepidoptera	Pyralidae
3.	Hairy caterpillars	*Eupterote cardamomi* *Eupterote canarica* *Eupteorate fabia*	Lepidoptera	Eupterotidae Bombycidae Bombycidae
4.	White flies	*Dialeurodes cardomomi*	Hemiptera	Aleurodidae
5.	Cardamom aphid	*Pentalonia nigronervosa*	Hemiptera	Aphididae
6.	Root grubs	*Basilepta fulvicorne*	Coleoptera	Scarabidae
7.	Rhizome weevil	*Prodioctes haematicus*	Coleoptera	Curculionidae

1) Cardamom thrips: *Sciothrips cardamom*
Thysanoptera; Thripidae

Marks of identification:
The adult is grayish brown and and measures about 1.25 to 1.50 mm in length. Nymphs are pale in colour and smaller than the adult.

Nature of damage:
The pest is active throughout the year except the rainy season. The thrips suck the cell sap from tender blossoms and the bunch part of the cardamom. The severe infestation causes heavy curling of leaves and stunting of crop, buds and flowers are damaged. Yield loss may be from 10 to 90 per cent.

Host plants:
Cardamom, Tea, Grapevine, Castor, Cotton etc.

Life history:
The insect reproduce sexually as well as parthenogenetically. The female thrips inserts the eggs into the veins of leaves and may lay 5 to 71 eggs. Nymphs emerge from the eggs in 9-12 days. The life cycle occupies 25-30 days.

Control measures:
Spray 0.1 per cent dimethoate or 0.1 per cent quinalphos as and when the pest is noticed.

2) Shoot and capsule borer: *Dichocrocis (Conogethes) punctiferalis*
Lepidoptera; Pyralidae

Marks of identification:

Adult is small sized bright orange yellow coloured moth with numerous black markings on both the wings. Adult measures about 10 mm in length and 22 mm across the wings. Full grown caterpillars measure 15 to 25 mm in length, reddish brown in colour with black blotches all over the body and a pale stripe on the lateral side.

Nature of damage:

This a serious pest of nursery plants and young green pods. The caterpillars bore into the stem and cause dead hearts. The tender seeds of young berries are also eaten away by the pest.

Host plants:

Cardamom, Castor, guava, rhizomes and stems of ginger and turmeric, inflorescence of mango, earheads of sorghum, cocoa, pear, avocado, arrowroot, mulberry pomegranate, sunflower, cotton, tamarind, hollyhock etc.

Life history:

A female lays eggs in small group of 2 to 3 on inflorescence and seed capsules. Hatching period is above a week. Larval period is 2 to 3 weeks. Pupal stage lasts about 7 to 25 days. Pupation takes place inside the seed or stem or under the frass that accumulates after feeding. Pest completes about 4 to 5 generations in a year.

Control measures:

1. Collection and destruction of infested plant parts and alternate host plants.
2. Spray 0.1 per cent malathion or 0.1 per cent phosalone.

3) Hairy caterpillars: *Eupterote cardamomi*
Lepidoptera; Eupterotidae
E. fabia, E. canarica
Lepidoptera; Bombycidae

Marks of identification:

The full grown caterpillar measure about 90 mm in length and are hairy , dark grey in colour with pale brown head, bearing conical tuft of hairs on th dorsal side of the body. The adults are large moths with post medial lines on the wings.

Nature of damage:

The pest is sporadic in nature. The last instar larvae feed on leaves of shedded trees drop down with the help of silken threads on the cardamom plants growing underneath. The caterpillars start feeding voraciously and defoliate the plants causing heavy reduction in the yield. The other hairy caterpillars *E. fabia, E. canarica* also appear sporadically and inflict damage to cardamom plants.

Host plants: Cardamom.

Life history:

The moth emergence coincides with the onset of monsoon in June and July. A female moth lays yellowish, dome shaped 400-500 eggs in flat masses each containing about 50-160 eggs on the undersurface of the leaves. The incubation period is 15-17 days. Full grown caterpillars passes through ten moults and complete its development in 140-151 days. pupation takes place in soil in silken cocoon at a depth of 5-8 cms and lasts for 7-8 months. The longevity of adult is 20 days. The pest completes only one generation in a year.

Control measures:

Spray 0.04 per cent oxydemeton methyl or 0.05 per cent dimethoate or 0.08 per cent malathion for effective control of the pest.

4) Cardamom aphid: *Pentalonia nigronervosa*
Hemiptera; Aphididae

Marks of identification:

Adult is 1 to 2 mm long, brownish coloured, soft bodied insect having black veined wings. Both winged and wingless forms exist. The nymphs are smaller than adult, apterous and pale brown in colour. Both nymphs and adults are found within the leaf axils on tender leaves and at base of the culm at the ground level. The cornicles are present on either side of abdomen.

Nature of damage:

The aphids are dissiminated in the cardamom plantation mostly by crawling from plant by the contact of foliage at the top and along the soil. They feed on the leaf sheath and pseudostem. Direct damage is negligible but this is a vector of cardamom mosaic “Katte disease”, *Amomum* mosaic and “Foorky disease” of large cardamom.

Host plants:

In addition to banana it also feeds on cardamom, *Colocasia* sp. *Alocasia* sp. *Caladium* sp.

Life history:

The common mode of reproduction in aphid is agamic viviparity. Females reproduce about 30 to 50 youngone’s in a total life period of 27 to 37 days. There are 4 nymphal instars of 2 to 3 days duration each. One life cycle occupies 8 to 9 days. Pest completes as many as 30 to
40 overlapping generations during a year under south Indian conditions.

Control measures:

Foliar spraying with 0.1 per cent dimethoate at an interval of 2 weeks will give adequate protection against this aphids.

5. White flies: *Dialeurodes cardamomi*

Hemiptera; Aleurodidae

Nature of damage:

Nymphs and adults remain in colonies on lower leaf surface and suck the sap. As a result chlorotic patches appear on leaves. There is gradual yellowing and drying of leaves. Sooty mould development occurs due to honey dew secretion by the nymphs and adults.

Control measures:

Spraying with methyl demeton or dimethoate (0.05% each) on the foliage controls the pest effectively.

EXERCISE NO. 24 **DATE :**

STUDY OF PESTS OF NUTMEG AND MACE

1) Black scales: *Parasaissetia nigra*

Hemiptera: Coccidae

The black scales infests tender stems and leaves especially in the nursery and sometimes young plants in the field. The scales are clustered together and are black, oval and dome shaped. Black scales fed on plant sap and severe infestation causes the shoots to wilt and dry. They also secrete large amount of honey dew on which black sooty mould develops, results into reduction in yield.

White scales: *Pseudaulacaspis cockerelli*

The white scales are grayish white, flat and shaped like a fish scale and occurs clustered together on the lower surface of the leaves especially in nursery seedlings. The pest infestations results in yellow streaks and spots on affected leaves and in severe infestations the leaves wilt and dry.

Shield scale: *Protopulvinaria mangiferae*

The shield scale is creamy brown and oval and occurs on tender leaves and stems especially in nursery seedlings. The pest infestation results in wilting of leaves and shoots.

Green scale: *Lecanium* sp.

Vary in size and colour but are generally oval in shape. Females vary in size and colour but are generally oval in shape. Nymphs are yellow "crawlers" migrate to the leaves and settle on the

undersides along the midrib and veins. Dieback of twigs and branches and premature leaf drop are the symptoms of infestation. Secretes honey dew and sooty mould development takes place.

Control measures:

These three species can be controlled by spraying with 0.025 per cent quinalphos or 0.05 per cent dimethoate or 0.2 per cent carbaryl.

2) Leaf miner: *Phyllocnistis citrella*

Lepidoptera; Gracillaridae

Marks of identification:

Minute moths with a 4 mm wingspread, white and silvery scales on the forewings, with several black and tan markings, plus a black spot on each wingtip. Hind wings and body are white, with long fringe scales extending from the hindwing margins. Larvae are minute 3 mm in length, translucent greenish-yellow, and located inside the leaf mine. -

Nature of damage:

The larvae form serpentine mines in the leaves and fruit (rarely). These mines are filled with a central line of frass. Larvae only infest the younger, flushing foliage.

Life history:

Eggs are laid on both the upper and lower surface of the leaves. Egg period is 2 to 10 days. Larval period is 5 to 20 days and have four instars. Pupal period is 6 to 22 days. Pupation takes place in pupal cell at the leaf margin. Life cycle is completed in 13 to 52 days.

Control measures:

1. Remove infested leaves and destroy them properly.
2. Pest can be controlled effectively by spraying insecticides at 15 days interval commencing from the appearance of pest.

Monocrotophos 0.05 per cent OR Formothion 0.04 per cent OR Dimethoate 0.05 per cent OR Quinalphos 0.05 per cent OR Chlorpyriphos 0.05 per cent OR Malathion 0.07 per cent 3. Use of parasitoid *Ageniaspis citricola.*

3) Stem borer: *Sahyadrassus malabaricus*

Lepidoptera; Hepialidae

(Given under Clove)

EXERCISE NO. 25 **DATE :**

STUDY OF PESTS OF CURRY LEAF

1. Curry leaf butterfly: *Papilio demoleus*
Lepidoptera; Papilionidae

Marks of identification :
Adult is a beautiful butterfly with yellow and black markings on it's large wings. Adult has wing expanse of about 50 to 60 mm. Hind wings have a brick red oval patch near anal margin and a tail like extension behind on account of which pest is commonly known as 'Swallow tail butterfly'. Newly hatched larva is dark brown with milky white markings on it. When full-grown, it turns deep green in colour and cylindrical in form and measures about 38 mm in length. The young caterpillar is often mistaken as bird excreta. The caterpillar when disturbed, pushes out from top of it's prothorax a bifid purple or red horn like structure called "osmeterium" which emits a distinct smell. After a few seconds of its extrusion, it is withdrawn.

Nature of damage :
Damage is caused by the larvae alone by feeding on tender leaves right upto the mid-rib and thus defoliate the plants. In case of severe infestation, only midribs are left over. The tender foliage and young shoots of plant are mainly damaged. The pest is not of regular occurrence but occasionally becomes serious, particularly on young plants and seedlings.

Host plants :

All species of citrus and all other members of family Rutaceae to which citrus belongs, ber, wood apple, kadhilimb, curry leaf, ornamental and medicinal plants, bawachi, bael.

Life history :

Female deposits about 180 round, pale yellow eggs singly on the tender leaves. Hatching period is 3 to 7 days. Larval development is completed in two weeks period. Pupation takes place on leaves or on plant part itself, attached with silken girdle. Pupal period varies from 7 to 24 days. One generation is completed in 20 to 100 days depending upon climatic conditions. As many as 6 overlapping generations are completed per year.

Control measures :

1. Hand picking of larvae and their mechanical destruction.
2. Spray carbaryl 50 WP 0.1 per cent when attack is noticed.

EXERCISE NO. 26 **DATE :**

STUDY OF PESTS OF CORIANDER, CUMIN AND FENNEL

(A) PESTS OF CORIANDER:

1) Coriander white fly: *Bemisia tabaci*

Hemiptera; Aleurodidae **Marks of Identification:**

Winged nymphs are 1.0 to 1.5 mm long, and their yellowish bodies are dusted with a white waxy powder. They have two pairs of pure white wings and have prominent long white wings.

Nature of damage :

Both nymphs and adults suck the cell sap from the leaves. As a result, infested leaves become yellowish, wrinkled, curled downwards and are ultimately shed. The vitality of the crop is reduced. Insects exude honeydew which attracts sooty mould which interferes with the normal photosynthesis resulting in poor growth and yield.

Host plants:

A polyphagous pest. Tomato, cotton, tobacco, sweet potato, cabbage, cassava, cauliflower, sarson, melons, brinjal, okra, coriander and many wild and cultivated plants.

Life history :

On an average 119 eggs are laid singly on undersurface of leaves. The eggs hatch in 3-5 days in summer and 5-33 days in winter. There are three nymphal instars. Pupation takes place on leaves. One life cycle occupies 14 to 122 days. About 11 generations are completed per year.

Control measures :

Spray 0.05 per cent formothion or 0.03 per cent dimethoate or 0.03 per cent oxydemeton methyl or imidachloprid 0.08 per cent as soon as incidence is noticed.

2. Coriander aphid: *Hyadaphis coriandri* Das
Hemiptera; Aphididae

Coriander aphids are yellow-green in color, dusted with greyish wax. They have short, dusky, slightly swollen cornicles. They form dense and often damaging colonies on leaves, heads, and stems of their host plants.

The suck the cell sap from the shoots and inflorescence of coriander reducing the vitality and yield of the crop.

Control measures:

1. Spraying with deltamethrin 0.003 per cent or neem oil 2 per cent or sulphur extract of Karanj 1.0 per cent controls the pest effectively.

3. Coriander Mite : *Tetranychus* spp.
Acarina; Tetranychidae

Nymphs and adults are abundant on lower surface of tender leaves sucking cell sap. They cause devitalization of crop.

Dusting sulphur 300 mesh @ 20-25 kg per ha controls the mite infestation effectively.

(B) PESTS OF CUMIN:

1) Aphid: *Myzus persicae* Hemiptera; Aphididae

Aphid is a major pest of cumin crop, it sucks the sap of tender parts and reduces the yield. The crop growth remains stunted.

Spraying of 0.03 % solution of Dimethoate or 0.025 % solution of Methyl demeton or 0.04 % solution of Monocrotophos is recommended to control the aphid.

2) Leaf eating Caterpillar: *Spodoptera litura*
Lepidoptera; Noctuidae

Marks of identification :

Adult is medium sized moth with pale grey or dark brown forewings having weavy white markings. The hind wings are whitish. The caterpillars are pale greenish brown with dark head and prothoracic shield. The full-grown caterpillars measure about 37.5 mm in length. The pupae are dark brown and eggs are round and greenish white in colour.

Nature of damage :

Caterpillars feed gregariously on tender foliage and juicy stems at night when they are young and become isolated in their advanced stages of growth. In case of severe infestation, only mid-ribs and leafstalks are left over. The complete failure of crop has also been noticed.

Host plants :

Cumin, sorghum, maize, bajara, potato, brinjal, rice, tomato, cotton, leguminous crop, banana, tobacco, sesamum.

Life history :

Female lays about 500 to 2000 eggs in cluster in parallel rows on central leaves. The eggs hatch in about a week. Larval development is completed in 3 to 4 weeks. Full-grown larvae drop down and pupate in soil at a depth of 0.5 to 6 cm. Pupal period is 8 to 10 days. One generation completed in 5 to 6 weeks. There are several generations in one year. Pest usually hibernates as pupa in the soil.

Control measures :

(i) Hand collection and destruction of egg masses and caterpillars in early stage of infestation helps in reducing pest infestation.

ii) Deep ploughing of infested fields after harvest for exposing and killing hibernating pupae.

iii) Clean cultivation help in reducing pest infestation. iv) As soon as pest appears apply :- cypermethrin 0.006 per cent or quinalphos 0.05 per cent or carbaryl 5 D @ 25 kg/ha.

v) Light traps may be set up to destroy adult moths.

(b) *Helicoverpa armigera* (Given under Tomato)

Lepidoptera; Noctuidae

(c) *Systole albipennis* Walker

Hymenoptera; Eurytomidae

This pests causes damage to the foliage of plants reducing yield of the crop.

Control measures:

1. Hand picking of the larvae and their destruction.
2. Spraying with *B.t* formulation.
3. It can be controlled by spraying of 0.05 % quinalphos in the early stage of crop.

(C) PESTS OF FENNEL:

1) Fennel aphid: (Given under Coriander).

2) White fly: (Given under Coriander)

EXERCISE NO. 27 **DATE :**

STUDY OF PESTS OF TURMERIC AND GINGER

Sr. No.	Common Name	Scientific Name	Order	Family
1.	Rhizome fly	*Mimegralla coeruleifrons*	Diptera	Micropezidae
2.	Scale insect	*Aspidiotus hartii (Cockerell)*	Hemiptera	Diaspididae
3.	Castor capsule borer	*Dichocrocis punctiferalis*	Lepidoptera	Pyralidae
4.	Skipper butterfly	*Udaspes folus*	Lepidoptera	Hesperidae
5.	Nematodes	*Helicotylenchus* spp. *Meloidogyne* spp.	-	-

1) Rhizome fly : *Mimegralla coeruleifrons* Macq.
Diptera; Micropezidae

Marks of identification :
Adults are fairly large flies with slender body and long legs. The body is black and wings are transparent with ashy spots. Wing expanse of adult is 13 to 15 mm. Maggots are creamy white, apodous, 9.5 mm in length and 1.95 mm in breadth. Eggs are white cigar-shaped tapering at either sides.

Nature of damage :
The maggots bore into the rhizomes of ginger and turmeric and damage them. The yellowing of plants and rotting of rhizomes takes place due to severe infestation of pest. The maggots pave way for the invasion by the fungus (*Pythium* spp., *Sclerotium* spp.) and the nematodes (*Meloidogyne* spp.).

Host plants : Ginger and turmeric.

Life history :
The adult fly lays eggs in soil in the vicinity of the plants. Egg, larval and pupal periods last for 4, 17 and 14 days, respectively. The maggots pupate in rotten rhizomes. The adult has a longevity of 18 days. The fly completes its life cycle in 38 to 62 days. Pest hibernates in pupal stage. The total number of generations completed in a season are 2 to 3.

Control measures :

i) Select healthy rhizomes for planting.
ii) Treat the rhizome sets by dipping in carbaryl 50 WP (0.4 per cent) suspension for 10 minutes before planting.

iii) Apply insecticides three times at monthly interval by broadcasting them at the base of the plants followed by light irrigation.

Phorate 10 G @ 20 kg/ha

OR

Carbaryl 10 D @ 20 kg/ha

iv) Remove and destroy the rotten rhizomes from the field alongwith maggots after harvest of crop to check the breeding of the pest.

v) Destroy stray plants in off season.

2) Scale insect: *Aspidiotus hartii* (Cockerell)

Hemiptera; Diaspididae

This is a small circular hard scale which infests the rhizome in large numbers. A female lay about 180 eggs under the scale which hatch within a day. The nymph takes about 30 days for its development. The male forms a pupa before emergence as the winged adult.

The insect multiplies in large numbers on stored ginger rhizomes which shrink and dry up. Rhizomes in the field are also attacked by the scale and the infested plant look pale and dry up.

Control measures:

Spray the crop with 0.075 per cent malathion or 0.03 per cent dimethoate.

3) Castor capsule borer: (Given under Cardamom)

The caterpillars bore into the aerial stem and kills it.

EXERCISE NO. **DATE :**

28

STUDY OF PESTS OF CHILLI

Sr. No.	Common Name	Scientific Name	Order	Family
1.	Chilli thrips Onion thrips	*Scirtothrips dorsalis Thrips tabaci*	Thysanoptera	Thripidae
2.	Aphids	*Aphis gossypii Myzus persicae*	Hemiptera	Aphididae
3.	Leaf eating caterpillar	*Spodoptera exigua* *Spodoptera litura*	Lepidoptera	Noctuidae
4.	White grub	*Lachnosterna insularis*	Coleoptera	Melolonthidae
5.	Mites	*Polyphagotarsonemus latus*	Acarina	Tarsonemidae
6.	Leaf hopper	*Amrasca biguttula biguttula*	Hemiptera	Cicadellidae
7.	Cutworm	*Agrotis ypsilon*	Lepidoptera	Noctuidae

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

Marks of identification :
Adult is light yellow coloured, delicate, minute insect measuring less than 1 mm in length. Wings are fringed with hairs. Nymphs are very tiny, delicate, smaller than adults, yellowish straw in colour and wingless. Eggs are soft, minute and dirty white in colour.

Nature of damage :
Both nymphs and adults of this pest have mouth parts suitable for scrapping the epidermal tissues and sucking the oozing cell sap. The plant tissues damaged by thrips initially become

whitish but later turn brown and ultimately dry. As a result of feeding, the leaves curl, become small, undersized producing typical symptom which is locally called as **'Churda- murda'** or **'Bokadya'**. Besides causing direct damage to the plant, the pest acts as a vector transmitting leaf curl disease. Under conditions of severe infestation 30 to 50 per cent crop may be lost.

Host plants :

Chilli, Onion, Brinjal, Okra, Cashew, Mango, Guava, Bottle gourd, Ridge gourd.

Life history :

Females lay 50 to 60 fertilized or unfertilized eggs inside the leaf tissues generally on lower side of leaves. Average incubation, larval, prepupal, pupal stages last for 8 to 9, 4 to 6, 2 and 3 days, respectively. Prepupal and pupal stages are generally found in soil. One generation is completed in 2 to 2½ weeks. About 25 overlapping generations completed in a year.

Control measures :

A) Nursery treatment :

Apply phorate 10G @ 10kg /ha or 70gm/m^2 area in the seed bed before sowing the seed in line.

If phorate is not available then give two sprayings of dimethoate 0.03 per cent at 15^{th} and 30^{th} days after seed germination in nursery.

B) Field treatment :

Apply phorate 10G @ 10kg/ha –10 days after transplanting OR

If phorate is not applied, give 3 sprays of following insecticides at 10 to 15 days interval starting from 10 days after transplanting.

Dimethoate 30 EC 0.03 per cent

OR

Thiometon 25 EC 0.02 per cent

2) White fly : *Bemisia tabaci* (Given under Tomato)

3) Aphid : *Aphis gossypii*, *Myzus persicae* (Given under Brinjal)

4) Fruit borer : *Helicoverpa armigera* (Given under Tomato)

5) Mite : (Given under Bell pepper)

EXERCISE NO. **DATE :**

29

STUDY OF PESTS OF ONION AND GARLIC

1) Onion thrips : *Thrips tabaci* Lind.
Thysanoptera; Thripidae

Marks of identification:

The nymphs are slender, yellowish brown and look like adults but are wingless and smaller than the adults. The adults are slender, yellowish brown and measures about 1 mm in length. The males are wingless whereas the females have long, narrow, strap like wings, which are furnished with long hairs along the hind margins.

Nature of damage :

Nymphs and adults cause damage by scrapping epidermal tissues of leaves and sucking oozing cell sap. As a result, whitish patches are seen on the leaves. In case of severe infestation, it gives whitish appearance to the whole plant. If attack appears during later stage of crop, the bulbs remain undersized and get distorted in shape and there is no seed setting in the flowers. It is a major pest of onion and garlic from November to May.

Host plants:

Onion, tobacco, tomato, cotton, pineapple, peas, beet, garlic, cabbage, cauliflower, potato, cucumber and many other plants.

Life History:

The female lives for 30-40 days and lays 50-60 kidney shaped eggs singly in slits which are made in leaf tissue with its sharp ovipositor. The incubation period is 4-9 days. Nymphal period is 4-6 days having four instars. Pupation takes place in soil and pupal period is 2-4 days. Several generations are completed in a year.

Control measures:

A) "**Spanish white**" is tolerant to attack of onion thrips while "**Puna red**" is highly susceptible. Grow least affected varieties of onion. B) Nursery treatment :

Apply dimethoate 0.03 per cent two weeks after germination. C)

Field treatment :

Apply following insecticides at 3 to 4 weeks interval starting from 2 to 3 weeks after transplanting.

Fenthion – 0.05 per cent OR
Fenitrothion – 0.05 per cent OR
Quinalphos – 0.05 per cent
OR
Malathion – 0.05 per cent

2) Onion fly or Onion maggot: *Hylemya antiqua*

Diptera; Anthomyiidae

Marks of identification:

The maggots are small, white and measures about 8 mm in length. The flies are slender, grayish, large winged and 6 mm in length.

Nature of damage :

The maggots bore into the bulbs, leaving only outer sheath. At times, it destroys 8 to 9 per cent of the plants. The attacked plants become flabby and yellowish. Several maggots at a time attack larger bulbs making cavities. The infestation is not completely destructive to the bulbs but it leads subsequent rotting in the storage. The initial damage caused by this pest leads to development of soft rot on onion caused by *Bacillus carotovorus.*

Host plants: Onion

EXERCISE NO. **DATE :**

Life History:

White and elongated eggs are laid by female flies near the base of the plant, in cracks in the soil. The incubation period is 2-7 days. After hatching the maggots crawl upto the plant, and enter inside the leaf sheath and reach the bulb. The maggot is full grown in 14-21 days. Pupation takes place in soil and pupal period varies from 14 to 21 days. three generations are completed in a single season.

Control measures:

Apply Carbaryl 4 G @ 10 kg/ha or Phorate 10 G @ 10 kg per hac in the soil followed by a light irrigation.

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INTEGRATED PEST MANAGEMENT IN PROTECTED CULTIVATION

The warm, humid conditions and abundant food under protected conditions provide an excellent, stable environment for pest development. Often, the natural enemies that keep pests under control outside are not present under protected environment. For these reasons, pest situations often develop in the indoor environment more rapidly and with greater severity than outdoors. The damage inflicted by arthropod pests on greenhouse crops varies with the pest and

season. The level of damage that can be tolerated is greatly dependent on the type of crop. Producers of vegetable crops generally can accept a higher level of damage than those of ornamental crops that are produced for their aesthetic value.

Integrated pest management (IPM) is a systematic approach to manage pests that combines a variety of techniques and strategies to either reduce pest populations or lessen their economic impact. It is a site-specific strategy for managing pests that relies on correct pest identification and understanding the pest biology. With a long-term perspective it is easier to see that an investment in IPM can pay for itself in a higher-quality crop and a cleaner environment.

Insects and Mite Pests under Protected Environment

The growing conditions within the protected environment of greenhouse/ polyhouse are highly favourable to arthropod pests. In India, about twenty insect and mite species have been recorded to be associated with the crops under protected environment. Some of the important pest groups are aphids *(Myzus persicae, Aphis gossypii)*, caterpillars (*Spodoptera* spp*., Helicoverpa armigera),* leafminer *(Liriomyza trifoli*), mites *(Tetranychus urticae* and *Polyphagotarsonemus latus),* thrips (*Thrips tabaci* and *Scritothrips dorsalis)* and whiteflies *(Trialeurodes vaporariorum* and *Bemisia tabaci).* The detailed account of the insect-pests associated with crops under protected environment is being presented in Table 1.

Table 1. Insect-pests Scenario under Protected Environment in India

Group	Insect and mite pests	Host	Distribution
Aphids	*Aphis gossypii*	Capsicum	Punjab, Delhi
	Macrosiphoniella sanborni	Chrysanthemum	Karnataka, HP
	Macrosiphum luteum	Orchid	Sikkim
	Myzus escalonicus	Strawberry	New Delhi
	Myzus persicae	Capsicum, Gerbera,	Punjab, Maharashtra
	Toxoptera aurantii	Orchid	Sikkim
Caterpillars	*Helicoverpa armigera*	Capsicum, tomato, carnation	Punjab, Uttrakhand, H.P.

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	Spodoptera litura	Rose, tomato, capsicum, cucumber	Karnataka, Punjab, HP
Leaf-miner	*Liriomyza trifolii*	Tomato, cucumber, chrysanthemum, gerbera, and many ornamentals	Karnataka, H.P.
Mites	*Polyphagotarsonemus latus* (yellow mite)	Capsicum	Karnataka, Punjab, Delhi, H.P.
	Stenotarsonemus fragariae	Strawberry	New Delhi
	Tetranychus cinnabarinus	Carnation	Maharashtra
	Tetranychus neocalidonicus	Cucumber	New Delhi
	Tetranychus urticae (Spider mite)	Tomato, capsicum, cucumber, carnation, gerbera	H.P., Maharashtra
Thrips	*Scritothrips dorsalis*	Rose	Karnataka
	Thrips palmi	Gerbera	Karnataka
	Thrips tabaci	Gerbera	Maharashtra
Whiteflies	*Bemisia tabaci*	Gerbera, capsicum	Karnataka, Pumjab
	Trialeurodes vaporariorum	Tomato, cucumber, capsicum, beans, gerbera, and more than 30 hosts	H.P.and Nilgiri hills (TN)

1. AVOIDANCE:

1.1 Use of Physical Barriers:

1.1.1 Use of Insect-proof screens

One strategy particularly suited to greenhouse IPM programmes is the use of physical barriers to exclude insect-pests. Screening removes an important variable from a grower's pest management program - the movement of pests into the greenhouse from outside. This includes common greenhouse pests such as thrips, aphids, leafminers and whiteflies, but also some less common pests such as fruit borers. Screening vents and doorways can greatly limit the movement of insect pests into the greenhouse. However, selection of proper screen size mesh and assuring adequate airflow are more important.

Mesh size depends upon the targeted insect (Table 2). Mesh with holes less than 200 micrometers is required for complete exclusion of thrips; however, screening with holes as large as 600 micrometers is sufficient for excluding leaf miners.

1.1.2 Provision of double door

Limited access to screened areas is beneficial since insects may come in the protected structure on clothing or be swept in with the wind. Building a screened foyer to create a double-door entry partially solve the problem of wind-carried insects. Special efforts must be put in for repairing holes or tears immediately, and cleaning the screens to maintain airflow.

1.1.3 Ultra-violet radiation absorbing sheets

Altering the visual behaviour of insects has been used successfully as a tool in IPM programmes directed to protect crops from insects and insect-borne viral diseases.

Insects perceive light signals through their compound eyes. The anatomy and physiology of the compound eye is adapted to sense UV wavelengths alone or a mixture of UV and visible radiation. The UV part of the solar spectrum plays an important role in the ecological behavior of insects, including orientation, navigation, feeding and interaction between the sexes.

The manipulation of the UV vision of insects by using UV-blocking greenhouse cladding materials has been shown to be effective in preventing the immigration of a wide range of insect-pests (whiteflies, aphids, thrips and leafminers) from the external environment into the protected crop.

1.2 Sanitation and Cultural Practices:

1.2.1 Pre-season cleanup

Before introducing a new crop into the greenhouse, it is extremely important to eliminate pests from the previous crop. Remove all plant debris and weeds from the greenhouse. A fallow period of two to four weeks reduces the pest load considerably.

1.2.2 Inspection upon arrival

One of the most important points in protected cultivation is to begin with insect-free planting material. When new plants arrive at the greenhouse, examine them closely for signs of pest infestation. If necessary, remove lower or damaged leaves to avoid spread of pests.

1.2.3 Balanced use of fertilizer

Fertilization schedules based on balanced use of nutrients should be followed. Nitrogen should be applied only as needed for optimal growth. Periodic heavy applications set up nitrogen surpluses that cause excessive growth, which favour the population growth of aphids, and other pests.

1.2.4 Pinching and Pruning

Pinching-off damaged plant parts, flowers, and spotted leaves (and those with insect larvae or egg deposits) can be a very effective way of reducing the spread of pests in the greenhouse. The plant debris should be placed immediately in a covered container before being disposed-off.

1.2.5 Plant Quarantine

Workers in the greenhouse are frequently the mechanism for dispersal of insects and mite pests. One should try to avoid moving plants with mites or thrips and they should not be touched or moved immediately before handling clean, healthy plants.

1.2.6 Trap crop/Indicator plants

For early detection and trapping of the target pests, some of the preferred hosts of the target pests can be used. Planting border rows of *Portulaca oleracea* in rose can be used as a trap crop for tobacco caterpillar under protected environment.

2. EARLY DETECTION:

Scouting and early detection are critical to manage the insect infestation successfully. Monitoring or scouting is the regular, systematic inspection of the plants and exteriors to identify and assess pest problems. It includes inspection of foliage and flowers; and the use of insect traps.

3. CURATIVE MEASURES:

3.1 Biological Control:

Practically every crop pest has its natural enemies in the form of parasitoids or predators. The biological control involves a large scale multiplication and liberation of such agents, or creating conditions under which the naturally occurring agents can act effectively.

Use of specific predators and parasitoids in greenhouse ecosystem to manage pests forms the basics of biological control. But to be effective, biological control must be well planned and begun when the target populations are low. In Western Europe and North America, the bioagents are commercially available and being used successfully for the management of pest problems under protected situations

Registered natural enemies for pest management in protected cultivation

Target pest	**Biocontrol agent**	**Scientific name**
Whiteflies	Parasitic wasps	*Encarsia Formosa*
Serpentine leaf miner	Leafminer parasitoid	*Dacnusca sibiriica Diglyphus isaea*
Spider mites	Predatory mites	*Amblyseius californicus* *Phytoseiulus longipes* *Phytoseiulus persimilis*
Thrips	Predatory mites	*Amblyseius cucumeris* *Amblyseius mckenziei*
Various soft-bodied insects and eggs	Lady beetles	*Hippodamia convergens* *Cryptolaemus montrouzeri*
Various soft-bodied insects and eggs	Green lacewings	*Chrysoperla carnea*

3.2 Chemical Control:

The insecticides are curative in action and are one of the important tools to check the flaring pest populations. Insecticides belonging to different groups namely, botanicals pesticides, microbial pesticides, Insect Growth Regulators (IGR), synthetic chemical pesticides etc. are in use. Some of the serious limitations of the insecticides have been highlighted in recent years. Out of these, the problems of insecticides residues on crops have been agitating the minds of people in

developed and developing countries of the world due to indiscriminate use of pesticides. However, the sensible approach suggested and generally accepted is for need based judicious and safe use of insecticides.

Under protected environment, in order to avoid the contamination of produce from pesticide residues, use of pesticides having less persistence and adopting suggested waiting period between last insecticidal application and harvesting can be followed.

EXERCISE NO. 31 **DATE :**

INSECT PESTS OF STORAGE AND PROCESSED VEGETABLE, ORNAMENTAL AND SPICE CROPS AND THEIR MANAGEMENT

1) Cigarette beetle : *Lasioderma serricorne*
Coleoptera; Anobiidae

Marks of identification :

Adult beetles are stout, oval, 2.0- 2.5 mm, light brown. The elytra are smooth with very short hairs. The antennae are about half the length of body with fourth to tenth segments as serrate. When disturbed the adults conceals its head under the large pronotum. The grubs are white and scarabaeiform.

Nature of damage :

Grubs are damaging. The grubs are very active and move and bore into the commodity. They make small cylindrical galleries. The products are contaminated by the presence of the beetles, larvae, pupae, cocoons, frass (fecal matter) and insect parts. Adults eat very little. Causes commercial value loss and nutritional value loss of the commodities.

Hosts :

Cocoa, tobacco, dried cassava, black and red pepper, ginger, turmeric, dried fruits and vegetables, chilli powder, spices (fennel, cumin, coriander, ajowan) etc.

Life history:

Each female lay 100-110 eggs. Generally there are 4-6 larval instars. Larval period is 3035 days. Pupation takes place in fragments of attacked commodity and waste material by making pupal cells. Adults live for 2-4 weeks. Adults are active fliers and fly freely in the evening and night. Adults do not feed.

2) Drug store beetle : *Stegobium paniceum*
Coleoptera; Anobiidae

Marks of identification :

It is similar to cigarette beetle in appearance but can be distinguished by its antennae. In *Stegobium* the last three segments form a large loosely segmented club. The elytra have longitudinal striae which are also present in *Lasioderma.*

Nature of damage :

Grubs damage by making small cylindrical galleries through the commodities. Grubs are quite active and move around and bore into the commodity. Adults feed very little. They contaminate food by leaving insect fragments, exoskeletons and fecal matter. The food stuffs or commodities may cause off flavours. **Hosts :**

Chocolate, confectionery, biscuits, dried fruits, vegetables and spices, stored grains and seeds, animal and plant derived products, drugs in pharmacies, leather, wool, hair, books, paper, cardboard etc.

Life history:

The biology of this pest is similar to *Lasioderma* except that *Lasioderma serricorne* performs better at higher temperature and grows more rapidly than does *S. paniceum*.

3) Fig or Almond moth : *Cadra (Epesthia) cautella* (Walker)
Lepidoptera; Phycitidae

Marks of identification : The moth is 12 mm in wing expanse, grayish in colourwith transverse stripes on grey colour wings. The full grown larva is white with pinkish tinge and measures about 15 mm in length.

Nature of damage :

The damage is done by the caterpillars which tunnel into food material and feed on the internal contents. The food material is made unfit for human consumption due to the activity of the larvae. The number of silken tubes is sometimes extremely high and these clog the mill machinery where the infested grains have been sent for milling.

Hosts :

Cereals, dry fruits like currants, dates, berries, figs, almonds, walnut, tamarind seed, even mango pulp and dry garlic bulbs.

Life history:

The female lays whitish eggs indiscriminately in cracks and crevices of the recepticles or on the food stuff. While feeding the larvae spin tubes in the food material and are full grown in 40-50 days. The larvae pupates inside the cocoons and pupal stage lasts for about 12 days. The life cycle is completed in about two months and there are 5- 6 generations in a year.

4) Indian meal moth : *Plodia interpunctella* (Hubner)
Lepidoptera; Phycitidae

Marks of identification :

Adults are reddish brown moths. The forewings of adult are lustrous brown with yellowish or whitish bands across the basal half. The wing expanse of adult is 12 to 18 mm. The larva is grey white in colour tinged with green or pink and about 8-13 mm long when matures. Its body is covered with hairs and the skin is granular.

Nature of damage :

It is a major pest of imported wheat on whose germ portion the larva feeds. During that process, tubular webbing is formed by it either on bags or on the bulk of the food material. In serious cases, the bags or flooring is completely covered with silken sheets. The adults fly about From one bin to another spreading the infestation.

Hosts :

Dried fruits and vegetables, Grains, meals, soybean, herbs, nuts, dead insects etc. Important pest of dried and stored commodities in the pantry.

Life history:

Breeding continues throughout the year under favourable warm conditions, however in cold weather or in unheated buildings, the insect overwinters in the larval stage. The female moth lays 300-500 minute whitish ovate eggs, singly or in clusters on or near the appropriate foodstuff. The incubation period is 2-14 days. The larvae feed upon the grains and become full grown in 30-35 days. Pupal stage lasts for 4-35 days. In summer the life cycle is completed in 56 weeks and there are 4-6 generations in a year.

Management of stored pests :

i) Sun drying :

This was the only technique followed in the country till recently and is still followed in respect of large quantities of grain. Moist grains are spread in the open exposed to the sun for varying periods depending upon the initial moisture and intensity of heat. Floors used for drying are either plastered with mud or bitumen or in some cases cemented. One tonne of grain takes about 10 sq.m. of space. The requirements of labour and the duration of operation depend on the moisture content of grains meant for storage. Recently, heated as well as unheated air and some chemicals are also used for drying grain.

ii) Surface treatments :

The simple steps that can help to maintain grain in storage for long durations are – a) Thorough cleaning of the facility.

b) White washing where necessary before use.

c) Placing dunnage between the grain and the floor.

d) Building uniform sized rectangular stacks when grain is in sacks.

e) Filling the facility to capacity when grain is in bulk.

f) Regular inspections.

g) Maintaining hygienic conditions during storage.

iii) Improved storage receptacles :

The grains can be best protected by using improved insect proof receptacles. The metal bins are now available for storing small quantities of grain ranging from 1 to 6 tonnes. The grains stored in bins can be easily fumigated. For storing larger quantities, it is advisable to construct improved godowns.

iv) Fumigation :

Most practicable and useful curative method is the fumigation. Fumigation may be defined as the treatment of commodity or a space with a gaseous material to kill the insect pest present. They are highly volatile and able to penetrate deep and kill insect within a large mass of food stuff. In case of small scale storage, first sieve the grains and remove different stages of pests. But in large scale storage, it is not possible to sieve and clean the grains and hence direct fumigation has to be carried out. Fumigation is possible only under air tight conditions. For small scale fumigation, metal bins or 'kothis' can be made air-tight. For large scale fumigation, however, the dump method is used.

Dump method of fumigation :

The grains are enveloped in air proof cover. The covers for dump method are prepared from balloon fabrics or rubberized cloth or polythene sheet of varying sizes. The standard size of cover being 20' x 15' x 15' which can accommodate about 500 bags at a time. Put the cover over the grains to be fumigated and the sides touching the ground are covered with dry earth to prevent the leakage. The fumigant should be introduced (poured) from the opening at the top which should subsequently be closed. After the expiry of exposure time, the cover should be gradually opened from the sides so that the operator will not be exposed to the fumes for a longer period. The bags should not be disturbed for at least 24 hours after removing covers to allow the enclosed gases to escape. After this, the grains can safely be used. The commonly used fumigants for grain storage are given in the table along with the rate, time of exposure and the precautions to be taken while using particular fumigant.

Optimum Doses of Pesticides Recommended by the Storage and Research Division of Ministry of Food.

Sr. No.	Name of pesticide	Dose of pesticide	Method of application	Against	Remarks

1.	Malathion 50 % EC	In ratio of 1:100 with water at the rate of 3 litres/100 sq.m. For flying insects at the rate of 1 litre/300 cu.m.	Spray on grain bags, walls, floors *etc*. Should not be sprayed on foodgrains directly.	As prophylactic treatment against insect pests	Fortnightly spraying
2.	Ethylene Dibromide (EDB)	3 ml/quintal for small storage 22 gms/cu.m. for large storage.	The ampules are inserted in storage structures after breaking and making the structure airtight.	As fumigant against insect pests (except for oilseeds/flour)	7 days exposure period
3.	ED/CT mixture	30 to 40 kg/100 cu.m. in large scale storage. For small storage 55 ml. per qtl.	Fumigation in airtight condition on bags/in bulk.	As fumigant against insect pests (except for oilseeds/flour)	7 days exposure period

EXERCISE NO. 32 **DATE :**

INSECTICIDAL RESIDUE PROBLEMS IN VEGETABLE AND ORNAMENTAL CROPS

Terminology :

Deposit :

The amount of pesticide initially laid down on the surface of the commodity is called as the deposit.

Residue :

Pesticide residue means any specified substances in food, agricultural commodities, or animal feed resulting from the use of a pesticide. The term includes any derivative of a pesticide, such as conversion products, metabolites, reaction products, and impurities considered to be of toxicological significance. The term pesticide residue includes residues both from known as well as unknowns sources.

Dissipation and persistence:

In nature disappearance of residues takes place in two steps. The first step is initial phase in which the disappearance of residue is fast. This phase is called as dissipation. The second phase, in which there is slow decrease in the amount of residue, is known as persistence. The main difference in the two is that the dissipation follows the law of “first order kinetics”, whereas, the persistence does not follow this law.

Acceptable daily intake (ADI):

Acceptable daily intake is a measure of the amount of a specific substance in food or drinking water that can be ingested (orally) on a daily basis over a lifetime without an appreciable health risk. ADIs are expressed usually in milligrams (of the substance) per kilograms of body weight per day. It is applied to food additives, residue of pesticides and residues of veterinary drugs in food.

Maximum residual limits (MRL):

The maximum residue limit (also maximum residue level, MRL), is the maximum amount of pesticide residue that is expected to remain on food products when a pesticide is used according to label directions, that will not be a concern to human health.

Waiting period:

It is the time interval (days) between final spray and harvest of the crop. It is the time which is required for initial deposits to dissipate below MRL.

LD_{50} (Median lethal dose):

The name LD_{50} is an abbreviation for "Lethal Dose, 50%" or median lethal dose. It is the amount of the substance required (usually per body weight) to kill 50% of the test population. It is usually expressed in milligrams of chemical per kilogram of body weight (mg/kg). OR

The median lethal dose (or LD_{50}) is defined as the dose of a test substance that is lethal for 50% of the animals in a dose group (Food and Drug Administration, USA).

OR

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

LC_{50} (Median lethal concentration):

LC_{50} is defined as the lethal concentration required to kill 50% of the test population. LC_{50} is measured as micrograms or milligrams of the material per liter or parts per million (ppm), of air or water.

Toxicity and its types:

Definition :

Toxicity is the degree to which a chemical substance or a particular mixture of substances can damage an organism (humans or animals).

Types :

1. Acute toxicity involves harmful effects in an organism through a single or short-term exposure.

- Eyes: tearing, irritation, conjunctivitis.
- Skin: rash, blistering, burns, sweating, contact dermatitis, jaundice.
- Nervous system: headache, dizziness, mood disturbances, depression, stupor, muscle twitching, lack of coordination, seizures, paralysis, loss of consciousness, coma.
- Respiratory system: throat pain, rhinorrhea, cough, pulmonary edema, difficulty in breathing, respiratory failure.
- Cardiovascular system: cardiac arrhythmias.
- Gastrointestinal tract: nausea, vomiting, diarrhea, abdominal pain.

2. Subchronic toxicity is the ability of a toxic substance to cause effects for more than one year but less than the lifetime of the exposed organism.

3. Chronic toxicity is the ability of a substance or mixture of substances to cause harmful effects over an extended period, usually upon repeated or continuous exposure, sometimes lasting for the entire life of the exposed organism.

- Increased risk of cancer.
- Neurological impairment (e.g. Parkinson's disease).
- Developmental effects.
- Reproductive effects.
- Organ damage.
- Intrusion with the human hormone system.

List of instruments for detection of pesticide residues:

1. Electrochemical Sensors based on nanomaterials.
2. Optical Sensors based on nanomaterials.
3. Piezoelectric Sensors based on nanomaterials.
4. Biosensors based on Acetylcholinesterase inhibition by different pesticides.

Techniques in pesticide Residue Analysis: It includes three methods – 1. Bioassay method
2. Enzymatic method
3. Chemical method

The chemical methods include chromatography, spectrophotometry, fluorometry, radioisotope techniques and mass spectrometry.

Most commonly used chromatographic methods are of the following types:

(i) Paper chromatography.
(ii) Thin layer chromatography.
(iii) Gas-liquid chromatography.

MRL values of some common insecticides on some vegetables :

Insecticide	**Commodity**	**MRL (mg/kg)**
Carbaryl	Okra and leafy vegetables Other vegetables	10 5
Diazinon	Vegetables	0.5
Dichlorvos	Vegetables	0.15
Dicofol	Fruits and Vegetables Chillies	5.0 1.0
Dimethoate	Fruits and Vegetables Chillies	2.0 0.5
Endosulfan	Fruits and Vegetables Chillies	2.0 1.0
Malathion	Vegetables	3.0
Lindane	Fruits and Vegetables	1.0
Methyl parathion	Vegetables	1.0
Chlorfenvinphos	Vegetables	0.05
Chlorpyriphos	Potato and onion Cauliflower and cabbage Other vegetables	0.01 0.01 0.2
Ethion	Cucumber and squash	0.2
Formathion	Vegetables Peppers and tomato	2.0 1.0
Phosalon	Potato Other vegetables	0.1 1.0
Trichlorfon	Fruits and Vegetables	0.1
Thiometon	Potato Other vegetables	0.05 2.5
Carbofuran	Fruits and Vegetables	0.1
Cypermethrin	Egg plant Cabbage Okra	0.2 2.0 0.2
Fenvalerate	Cauliflower Egg plant Okra	2.0 2.0 2.0

Phorate	Tomato Other vegetables	0.1 0.05
Permethrin	Cucumber Soybean	0.5 0.5
Quinalphos	Cardamom	0.01
Triazophos	Chillies	0.2
Fenpyroximate	Vegetables	0.02
Spiromesifen	Tomato Cucurbits	0.45 0.1
Dicofol	Fruits and Vegetables	5.0 (PFA)

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