# Insect Ecology & Integrated Pest Management

# INSECT ECOLOGY & INTEGRATED PEST MANAGEMENT

This eCourse Developed By

**TNAU (ICAR)**

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All About Agriculture...

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**Lecture 1**

**Principles of Applied Entomology**

The field of entomology may be divided into 2 major aspects.

1. Fundamental Entomology or General Entomology
2. Applied Entomology or Economic Entomology

Fundamental Entomology deals with the basic or academic aspects of the Science of Entomology. It includes morphology, anatomy, physiology and taxonomy of the insects. In this case we study the subject for gaining knowledge on Entomology irrespective of whether it is useful or harmful.

Applied Entomology or Economic Entomology deals with the usefulness of the Science of Entomology for the benefit of mankind. Applied entomology covers the study of insects which are either beneficial or harmful to human beings. It deals with the ways in which beneficial insects like predators, parasitoids, pollinators or productive insects like honey bees, silkworm and lac insect can be best exploited for our welfare. Applied entomology also studies the methods in which harmful insects or pests can be managed without causing significant damage or loss to us.

In fundamental entomology insects are classified based on their structure into families and orders etc. in applied entomology insects can be classified based on their economic importance i.e. whether they are useful or harmful.

Economic classification of insects

Insects can be classified as follows based on their economic importance.

**This classification us according to TVR Ayyar**.

Insects of no economic importance:-

There are many insects found in forests, and agricultural lands which neither cause harm nor benefit us. They are classified under this category. Human beings came into existence 1 million years ago. Insects which constitute 70-90% of all animals present in this world came into existence 250 - 500 million years ago.

**Insects of economic importance**

**A. Injurious insects**

**a) Pests of cultivated plants ( crop pests)**

Each cultivated plant hatbours many insects pests which feed on them reduce the yield of the3 crop. Field crops and horticultural crops are attacked by many insect species. (eg) cotton bollworm, Rice stem bores.

**b) Storage pests**

Insects feed on stored products and cause economic loss. (eg) Rice wewil, Pulse beetle.

**c) Pest attacking cattle and domestic animals**

Cattle are affected by pests like Horse fly, Fleshfly, Flese and Lice. They suck blood and sometimes eat the flash.

**d) House hold and disease carrying insects**

House hold pests include cockroach, ants, etc,. Disease carrying insects are mosquitoes, houseflies, bed bugs, fleas etc.

**B. Beneficial insects**

**a) Productive insects**

**Silk worm:-** The silk worm filament secreted from the salivary gland of the larva helps us in producing silk.

**Honey bee:-** Provides us with honey and many other byproducts like bees wax and royal jelly.

**Lac insects**:- The secretion from the body of these scale insects is called lac. Useful in making vanishes and polishes.

**Insects useful as drugs, food, ornaments** etc,

**As medicine** eg. Sting of honey bees- remedy for rhenmatism and arthritis
Eanthoridin - extracted from blister beetle –useful as hair tonic.

**As food -** for animals and human being.
For animals- aquatic insects used as fish food.
Grass hoppers, termites, pupac of moths.
They have been used as food by human beings in different parts of the world.

**Ornaments, entertainers**

-Artists and designers copy colour of butterflies.
- Beetles worm as necklace.
- Insect collection is an hobby

(d) **Scientific research**

Drosophila and mosquitoes are useful in genetic and toxicological studies respectively.

**Helpful insects**

**Parasites:** These are small insects which feed and live on harmful insects by completing their life cycle in a host and kill the host insect.
Eg egg, larval and pupal parasitoids

**Predators:** These are large insects which capture and devour harmful insects.
Eg Coccimellids, Preying matritids.

**Pollinators:** Many cross pollinated plants depend on insects for pollination and fruit set.
Eg Honey bees, aid in pollination of sunflower crop.

**Weed killers:** Insects which feed on weeds, kill them thereby killers. Eg Parthenium beetle eats on parthenium. Cochneal insect feeds in Opuntia dillenii.

**Soil builders:** soil insects such as ants, beetles, larval of cutworms, cri kets, collun bola, make tunrels in soil and facilitate aeration in soil. They become good manure after death and enrish soil.

**Scavengers:** Insects which feed on dead and decaying matter are called scavengers. They important for maintaining hygine in the surroundings.
Eg Carrion bettles, Rove beetles feed on deade animals and plants.

**House hold and disease carrying insects**

i) Pests which cause damage to belongings of human being like furniture, wool, paper etc. Eg. Cockroaches, furniture beetle, sliver fish etc.
ii) Pests which cause painful bite, inject venoms. Eg. Wasps, bees sting us. Hairy caterpillar nettling hairs are poisonous. Mosquitoes, bugs bite, piece and suck blood from us.
iii) Disease causing Mosquito - Malaria, Filariasis, dengue fever. Housefly - Typhoid, Cholera, Leprosy, Anthrax

## Lecture 2: Honey bees:- History of bee keeping

Honey bees and their usefulness are known to man from prehistoric times. Mention of bees are found in vedas, Ramayan and Quran. The modern bee keeping became possible after the discovery of movable frame hive in 1851 by Rerd. L.L.Langshoth. In India beekeeping was introduced in 1882 in Bengal. Rerd. Newton introduced beekeeping to south India in 1911. But still India is much behind USA, Canada, Europe, Australia and Newzealand in beekeeping.

**Bee species**

There are five important species of honey bees as follows.
*Apis dorsata*: The rock bee Apidae.
*Apis cerana indica:* The Indian hive bee Apidae.
*Apis florea* : The little bee Apidae.
*Apis mellifera*: The European or Italian bee Apidae.
*Melipona irridipennis*: Danner bee, Meliporidae stingless bee.

*Apis dorsata:-*

1. They construct single comb in open (About 6ft long and 3ft deep)
2. They shift the place of the colony often.
3. Rock bees are ferocious and difficult to rear.
4. They produce about 36 Kg honey /comb/year.
5. The bees are the largest among the bee described.

*Apis florea*

1. They also construct comb in open of the size of palm in branches of bushes, hedges, buildings, caves, empty cases etc.
2. They produce about 1/2Kg honey/year/hive.
3. They are not rearable as they frequently change their palce.
4. The size of the bees is smallest among 4 Apis Sp. Described. (smaller than Indian bee).
5. They distributed only in plains and not in hills above 450M.

*Apis cerana indica* (Indian bee/Asian bee)

1. They make multiple parallel combs on trees and cavities in darkness.
2. The bees are larger than Apis florae but smaller than Apis mellifera.
3. They produce about 5Kg of honey/year/hive.
4. They are more prone to swarming and absconding.
5. They are native of India/Asia.

*Apis mellifera* (Italian bee or European bee)

1. They also make multiple parallel combs in cavities in darkness.
2. They are larger than Indian bees but smaller than Rock bees.
3. They have been imported from European countries.(Italy)
4. They yield on an average 35Kg/hive/year.
5. They are less prone to swarming and absconding.

**Honey bee castes**

Every honey bee colony comprises of a single queen, a few hundred drones and several thousand worker castes of honey bees. Queen is a fertile, functional female, worker is a sterile female and the drone is a male insect.

**Duties of a queen**

1. The only individual which lays eggs in a colony .(Mother of all bees).
2. Lays upto 2000/day in Apis mellifera.
3. Five to Ten days after emergence, she mates with drones in one or more nuptial flights.
4. When her spermatheea is filled with sperms, she will start laying eggs and will not mate any more.
5. She lives for 3 years.
6. The secretion from mandibular gland of the queen is called queen's substance.
7. The queen substance if present in sufficient quantity performs following functions.

a) Prevent swarming and absconding of colonies.
b) Prevent development of ovary in workers.
c) Colony cohesion is maintained.

8. The queen can lay either fertilized or sterile eggs depending on the requirement.

**Duties of a drone**

1. Their important duty is to fertilize the queen.
2. They also help in maintenance of hive temperature.
3. They cannot collect nectar / pollen and they do not possess a sting.

**Duties of a worker**

1. Their adult life span of around 6 weeks can be divided into

a) First three weeks- house hold duty.
b) Rest of the life- out door duty.

House hold duty includes

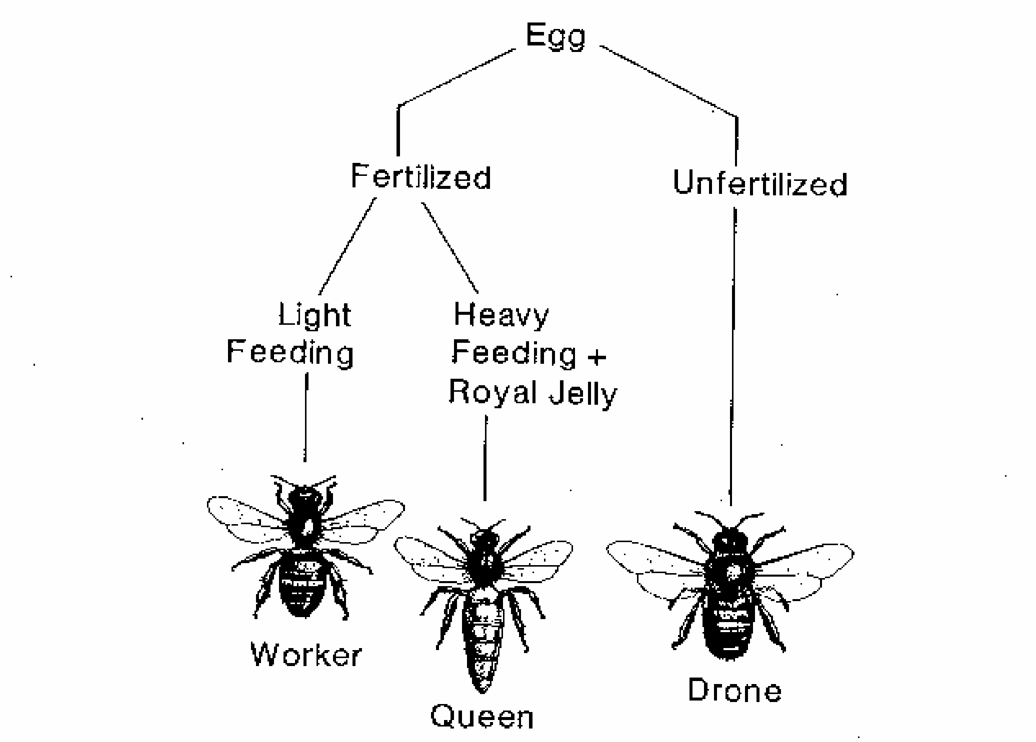
a. Build comb with wax secretion from wax glands.
b. Feed the young larvae with royal jelly secreted from hypopharyngeal gland.
c. Feed older larvae with bee-bread (pollen+ honey)

d. Feeding and attending queen.
e. Feeding drones.
f. Cleaning, ventilating and cooling the hive.
g. Guarding the hive.
h. Evaporating nectar and storing honey.

**Outdoor duties**

1. Collecting nectar, pollen, propolis and water.
2. Ripening honey in honey stomach.

**Sex differentiation in bees**




**Bee behaviour**

a) Swarming: Swarming is a natural method of colony multiplication in which a part of the colony migrates to a new site to make a new colony. Swarming occurs when a colony builts up a considerable strength or when the queen's substance secreted by queen falls below a certain level. Swarming is a potent instinct in bees for dispersal and perpetuation of the species.

**Steps involving in swarming**

1. Strong colonies develop the instinct of swarming.
2. Development of drone brood and emergence of large number of drones is first sing of swarming.
3. New queen cells are built at the bottom of comb.

4. When the queen cells are sealed after pupation the old queen along with 1/3 rd or half colony strength moves out of the hive.
5. They first settle in a nearby bush and hang in a perdant cluster.
6. The scout bees go in search of appropriate place for colonization and later the entire colony moves to the suitable site.
7. The first swarm which comes of the parent colony with the old queen is called primary swarm.
8. The new queen which emerges kills all other stages of queen present inside the queen cell.
9. Sometimes the new queen is not allowed to destroy stages of other queens.
10. In this case the new queen leaves the hive along with a group of workers. This is called after swarm or cast.

**Supersedure:**

When a old queen is unable to lay sufficient eggs, she will be replaced or superseded by supersedure queen. Or when she runs out of spermathezoa in her supermatheca, and lays many unfertilized eggs from which only drones emerge.

In this case, one or 2 queen cells are constructed in the middle of the comb and not at the bottom. At a given time both new and old queens are seen simultaneously. Later the old queen disappears.

**Emergency queen**

In the event of death of the queen the eggs (less than 2½ days old) in worker cells are selected and the cell extended like a queen cell. It is fed with abundant royal jelly and covered into queen. In this case many queen cells are built in the middle of the comb. The first queen which comes out of the emergency queen cells kills other stages of queen inside the cells and then go for mating. After mating they laying fertile eggs.

**Laying workers**

In the event of loss of a queen and in the event of absence of worker eggs less than 2½ days old the chance of producing new queen is lost. In this case, the worker status laying eggs. Since the worker cannot mate, they lay unfertilized eggs. From these eggs only drones emerge. Moreover, a worker lays more than one egg per cell and there is competition among the larva, stuited drones are produced.

**Colony odour**: Every colony has a specific odour. This is brought about by scent fanning of secretion of vasanov gland present in last abdominal segment of worker bees recognise colony odour and return to same hives.

Hive temperature maintenance: Brought about by fanning of wings in hot weather to reduce temperature. In cold weather they sit on the brood and prevent heat loss.

**Division of labour:** Each and every caste of bees have their own role to play as described earlier.

Queen controls colony with her queen's substance Guarding the hive:- The workers perform this duty by sitting at hive entrance and preventing and stinging intrudes.

**Royal fidelity or Blossom faithfulness**

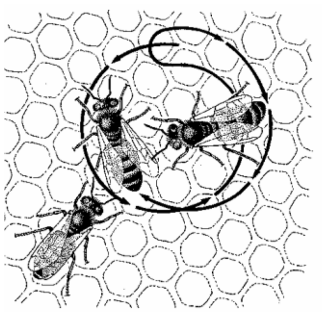
Bees restrict themselves to a single source of pollen and hectar until it is available. Only if the pollen and nectar from a plant species is exhausted they more to the next plant species.

**Communication in bees**

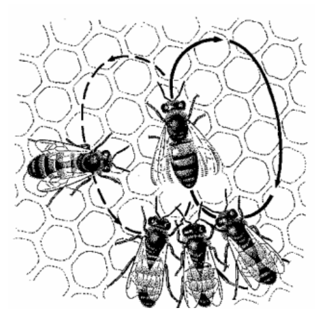
Bees communicate using various phenomones, including the queen's substance, vasanov gland secretion, alarm pheromone emitted from sting and secretion of tarsal gland. In addition the bees also communicate by performing certain dances.

When scout bees return to the box after foraging they communicate to the other forages present in the box about the direction and distance of the food source from the hive by performing dances. The important types of dances are noticed.

1. **Round dance** is used to indicate a short distance (Less than 50m in case of A.mellifera). The bee runs in circles, first in one direction and then in opposite direction, (clockwise and anticlockwise).



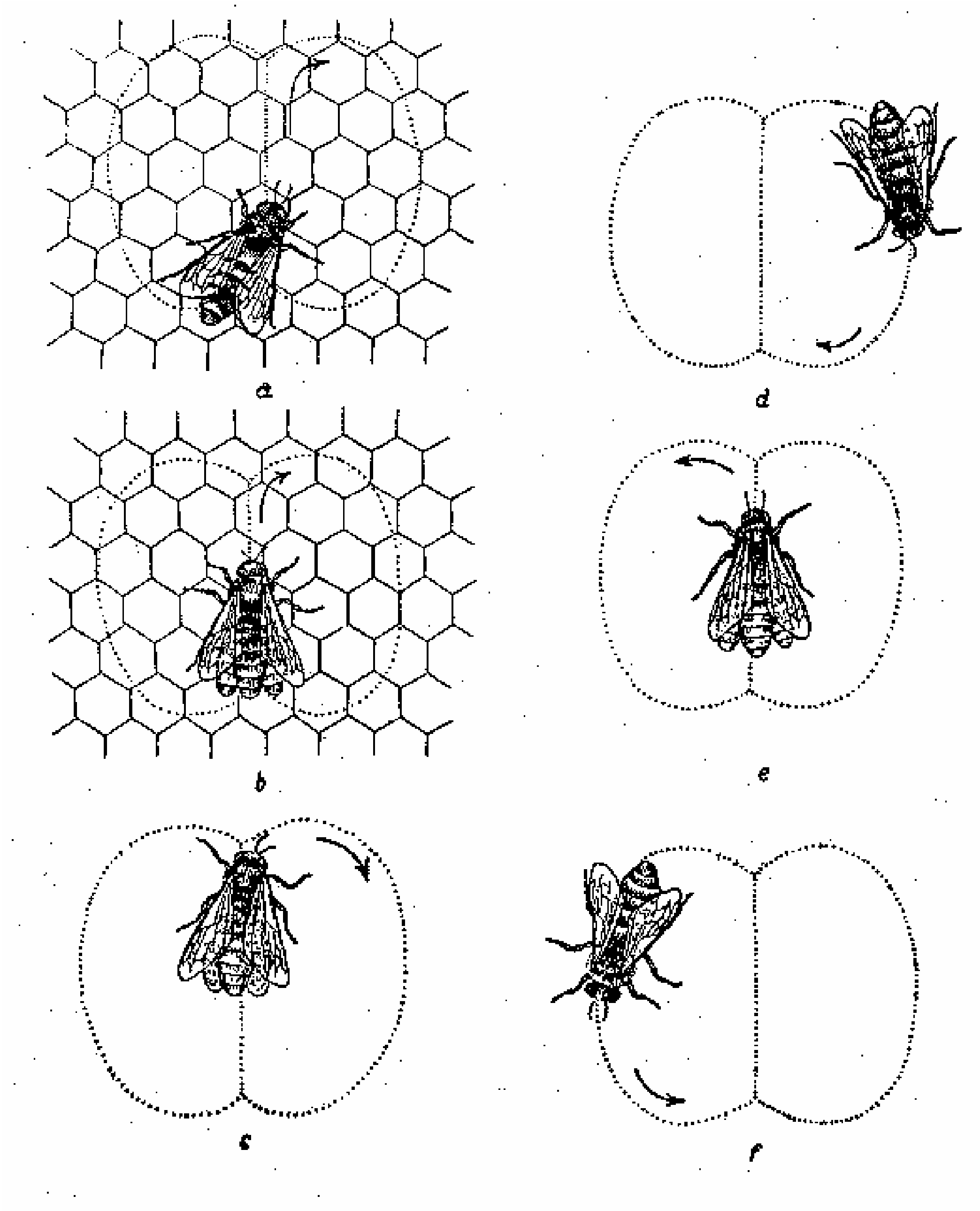
**Round dance**



**Wag tail dance**

**2. Tail wagging dance or Wag-tail dance.**

This is used to indicate long distance.(more than 50m in case of A.mellifera). Here the bee makes two half circles in opposite directions with a straight run in between. During the straight run, the bee shakes (wags) its abdomen from side to side, the number of wags per unit time inversely proportional to the distance of the food (more the wags, less the distance.). The direction of food source is conveyed by the angle that the dancing bee makes between its straight run and top of the hive which is the same as between the direction of the food and direction of the sun. The bees, can know the position of the sun even if it is cloudy.




**Wag tail dance to communicate the direction and distance of food source**

## Lecture 3: APIARY MANAGEMENT

Pre-requisites to start beekeeping

a. Knowledge/Training on beekeeping
b. Knowledge on local bee flora
c. Sufficient on local bee flora
d. If necessary practice migratory beekeeping

**Apiary site requirements**

a. The site should be dry without dampness. High RH will affect bee flight and ripening of nectar.
b. **Water -** Natural source/Artificial provision
c. **Wind breaks -** Trees serve as wind belts in cool areas
d. **Shade -** Hives can be kept under shade of trees. Artificial structures can also be constructed
e. **Bee pasturage/Florage** - Plants that yield pollen/nectar to bees are called bee pasturage/florage

**General apiary management practices**

i. **Hive inspection -** Opening the hive atleast twice a week and inspecting for following details.

- Presence of queen
- Presence of eggs and brood
- Honey and pollen storage
- Hive record to be maintained for each hive
- Presence of bee enemies like wax moth, mite, disease

**ii. Expanding brood net**

- Done by providing comb foundation sheet in empty frame during honey flow period.

**iii. Sugar syrup feeding**

- Sugar dissolved in water at 1:1 dilution
- Used to feed bees during dearth period

**iv. Supering (Addition of frames in super chamber)**

- This is done when brood chamber is filled with bees on all frames are covered
- Comb foundation sheet or constructed comb provided in super chamber

**v. Honey extraction**

- **Bee escape board** - Kept between brood and super chamber
- Bees bushed away using **brush**

- Cells uncapped using uncapping knife
- Honey extracted using honey extractor
- Combs replaced in hive for reuse

**vi. Swarm management**

- Remove brood frames from strong colony and provide to weak
- Pinch off the queen cells during inspection
- Divide strong colonies into 2 or 3
- Trap and hive primary swarm

**vii. Uniting bee colonies - Done by Newspaper method**

- Bring colonies side by side by moving 30 cm/day
- Remove queen from week colony
- Keep a newspaper on top of brood chamber of queen - Right colony
- Make holes on the paper
- Keep queenless colony on top
- Close hive entrance (the smell of bees will mix)
- Unite bees to the brood chamber and make it one colony

**SEASONAL MANAGEMENT**

- Pollen and nectar available only during certain period
  Honey flow season (surplus food source) x Dearth period (Scarcity of food)
- Extremes in climate like summer, winter and monsoon - Need specific management tactics

**Honey flow season management (Coincides with spring)**

- Provide more space for honey storage by giving CFS or built combs
- Confine queen to brood chamber using queen excluder
- Prevent swarming - As explained
- Prior to honey flow - Provide sugar syrup and build sufficient population
- Divide strong colonies into 2-3 new colonies - if colony multiplication need
- Queen rearing technique may be followed to produce new queens for new colonies

**Summer management**

- Bees have to survive intense heat and dearth period
- Provide sufficient shade (under trees or artificial structure)
- To increase RH and reduce heat - Sprinkle water twice a day on gunny bag or rice straw put on hive
- Increase ventilation by introducing a splinter between brood and super chamber
- Provide sugar syrup, pollen supplement/substitute and water

**Winter management**

- Maintain strong and disease free colonies
- Provide new queen to the hives
- Winter packing in cooler areas (Hilly areas)

**Management during dearth period**

- Remove empty combs (and store in air tight container)
- Use dummy division board to confine bees to small area
- Unite weak colonies
- Provide sugar syrup, pollen supplement/substitute

**Rainy season/monsoon management**

- Avoid dampness in apiary site. Provide proper drainage
- In rain when bees are confined to the hive, provide sugar syrup feeding

**BEE PASTURAGE/BEE FORAGE**

Plants that yield pollen and nectar are collectively called bee pasturage or bee forage.

Plants which are **good source of nectar**

| | | | |
|---|---|---|---|
| 1. | Tamarind | 6. | Moringa |
| 2. | Neem | 7. | *Prosopis juliflora* |
| 3. | Soapnut tree | 8. | *Glyricidia maculata* |
| 4. | Eucalyptus | 9. | *Tribulus terrestris* |
| 5. | Pungam | | |

Plants which are **good source of pollen**

| | | | |
|---|---|---|---|
| 1. | Sorghum | 6. | Sweet potato |
| 2. | Maize | 7. | Tobacco |
| 3. | Millets like Cumbu, Tenai, Varagu, Ragi | 8. | Coconut |
| 4. | Roses | 9. | Castor |
| 5. | Pome granate | 10. | Date palm |

**Plants which are good source of Pollen and Nectar**

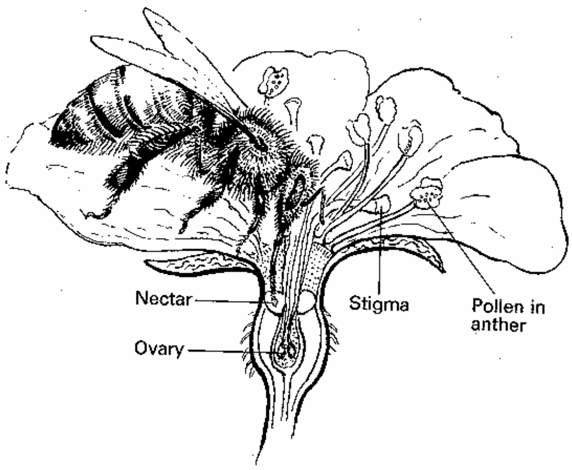
| | | | |
|---|---|---|---|
| 1. | Banana | 7. | Peach |
| 2. | Citrus | 8. | Guava |
| 3. | Apple | 9. | Sunflower |
| 4. | Berries | 10. | Safflower |
| 5. | Pear | 11. | Mango |
| 6. | Plum | | |

## FORAGING

Refers to collection of nectar and pollen by bees.

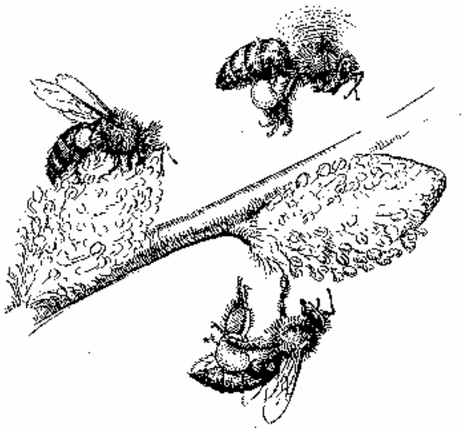
### Nectar foragers

- Collect nectar from flowers using lapping torigue
- Passes the nectar to hive bees
- Hive bees repeatedly pass the nectar between preoral cavity and tongue - to ripen honey
- Later drops into cell




### Pollen foragers

- Collects pollen by passing flower to flower. Pollen sticking to body removed - Using pollen comb
- Packed using pollen press into corbicula
- A single bee carries 10-30 mg pollen (25% of bee's wt)
- Dislodge by middle log into cell
- Mix with honey and store



### Floral fidelity

A bee visits same species of plant for pollen/nectar collection until exhausted. Bees travel 2-3 km distance to collect pollen/nectar.

**Lecture 4: ROLE OF HONEY BEES IN CROSS POLLINATION - THEIR EXPLOITATION - CASE STUDIES WITH SELECTED CROPS**

For SEXUAL reproduction in flowering plants transfer of anther to stigma is essential - Pollination

**Self pollination**

Transfer to sligma of same plant
No external agents are involved

**Cross pollination**

Transfer pollen from one plant to stigma of another plant
External agents are involved

**External agents involved in pollination**

**A. Abiotic agents**

**a. Wind (Anemophily)**

Wind carries pollen from one plant to another
Flowers are small, inconspicuous, unattractive
Pollen are dry and light in weight
Stigma feathery with large surface area
eg: Maize, barley, wheat, sugarcane

**b. Water (Hydrophily)**

Water carries pollen from one plant to other

**B. Biotic agents**

Bird, bat and insects are important biotic agents
Among insects honey bees play major role
Honey bees and flowering plants have coevolved
In insect pollinated plants, flowers are large, brightly colour, distinct fragrance, presence of nectar and sticky pollen
True honeybees (*Apis* spp.) - Most valuable pollinators of commercial crop

**Qualities of honeybees which make them good pollinators**

1. Body covered with hairs and have structural adaptation for carrying nectar and pollen.
2. Bees - Not injurious to plants
3. Adult and larva feed on nectar and pollen - Available in plenty
4. Superior pollinators - Since store pollen and nectar for future use
5. No diapause - Need pollen throughout year
6. Body size and probascis length - Suitable for many crops

7. Pollinate wide variety of crops
8. Forage in extreme conditions also (weather)

**Effect of bee pollination on crop**

- It increases yield (seed yield, fruit yield) in many crops
- It improves quality of fruits and seeds
- Bee pollination increases oil content of seeds in sunflower
- Bee pollination is a must in some self incompatible crops for seed set

**Crops benefited by bee pollination**

| Fruits and nuts | Vegetable and vegetable seed crops | Oil seed crops | Forage seed crops |
|---|---|---|---|
| Almond | Cabbage | Sunflower | Lucerve |
| Apple | Cauliflower | Niger | Clover |
| Apricot | Carrot | Rape seed | |
| Peach | Coriander | Mustard | |
| Strawberry | Cucumber, Melon | Safflower | |
| Citrus | Onion, Pumpkin | Gingelly | |
| Litchi | Radish, Turnip | | |

**Per cent increase in yield due to bee pollination**

| Crop | Botanical name | Per cent yield increase |
|---|---|---|
| Mustard | *Brasica* sp | 43 |
| Sunflower | *Helianthus annus* | 32 - 48 |
| Cotton | *Gossypium* sp. | 17-19 |
| Lucerne | *Medicago sativa* | 112 |
| Onion | *Allium cepa* | 93 |
| Apple | *Purus malus* | 44 |

**Scope of beekeeping for pollination in India**

- Total area under bee dependant crops - 50 million ha
- At the rate of 3 colonies/ha - 150 million colonies needed
- In India only 1.2 million colonies exist - There is scope

**Management of bees for pollination**

- Place hives very near the field (source) - to save bee's energy
- Migrate colonies near field at 10% flowering
- Place colonies at 3/ha - Italian bee; 5/ha - Indian honey bee
- The colonies should have 5-6 frame strength of bees, possess sealed brood, have young mated queen
- Allow sufficient space for pollen and honey storage

**Pollination by bees - Cross studies with selected crops**

**1. Sunflower**

- It is a cross-pollinated crop
- Self incompatability noticed - i.e. The pollen a plant cannot fertilize ovary of same plant
- Pollen should come from different plant
- Honey bees - Most important mode of pollination in sunflower
- Yield increase due to bee pollination - Even upto 600%
- Improves quality and quantity of seeds
- Oil content increases by 6.5% in seeds
- Requires 5 strong 4 *C. indica* colonies or 3 *A. mellifera* colonies
- Irrigated crop is preferred by bees

2. **Cucurbitaceous vegetables**

- Monoecious - Staminate and pistillate flowers in same plant
- 30-100% increase in fruit set due to bee pollination

3. **Alfalfa or Lucerne**

- Tubular flower - has 5 petals joined at base
- One large standard petal
- 2 smaller petals on sides
- 2 keel petals holding staminal column
- When bee sits on keel petal, staminal column strikes against standard petal and pollen shatters
- This is called TRIPPING
- Only if bee sits to trips the flowers seed set occurs

4. **Corinader**

- Yield increase upto 187% noted when pollinated by bees

5. **Cardamom**

- Important commercial crop depending on bee pollination. Yield increase upto 21-37%

6. **Gingelly**

- Another oilseed crop, bee pollination causes 25% increase in yield

7. **Apple**

- Only if pollinated by bees - feed set occurs
- Fruit is formed around seeds only
- If improper seed set - Fruit shape is lopsided (market value decreases)

**Migratory Vs. Stationary beekeeping**

- Migratory beekeeping - Advantageous to beekeeper and farmer

## Lecture 5 BEE PRODUCTS - THEIR PROPERTIES AND USES

1. Honey
2. Bees Wax
3. Royal Jelly
4. Bee Venom
5. Propolis
6. Pollen

### 1. Honey

- A sweet, viscous fluid - Produced by honey bees
- Collected as nectar from nectaries at base of flower
- Also collected from extra floral nectaries (nectar secreted by parts other than flowers)
- Collected also from fruit juice, cane juice

### Collection and ripening of honey

- Bee draws nectar by its tongue (proboscis)
- Regurgitated by field bees
- Collected by hive bees - Deposited in cells in comb
- Nectar contains 20-40% sucrose
- Invertase converts sucrose into dextrose (glucose) and levulose (fructose)
- Invertase is present in nectar itself and in saliva of honey
- Ripening of honey is by action of enzyme and by evaporation of water by fanning of wings

| **Composition of fully ripened honey** | **Per cent (Approx.)** |
|---|---|
| Lrvulose | 41.0 |
| Dextrose | 35.0 |
| Sucrose | 1.9 |
| Dextrins | 1.5 |
| Minerals | 2.0 |
| Water | 17.0 |
| Undetermined (Enzymes, Vitamins, Pigments, etc.) | 1.6 |

### Pigments

Carotene, Chlorophyll, Xanthophyll

**Minerals include**

Potassium, Calcium, Phosphorus, Sodium, Magnesium, Manganese, Copper, Sulphur, Silica, Iron.

**Vitamins**

Vit $B_1$ (Thiamine), $B_2$ (Riboflavin), Nicolinic acid, Vit.K, Folic acid, Ascorbic acid, Pantothenic acid.

**Physical properties of honey**

1. Honey is hygroscopic. If exposed to air it absorbs moisture
2. Honey is a viscous fluid. Heating of honey reduces viscosity
3. Specific gravity of pure honey is 1.35 - 1.44 gms/cc
4. Refractive index of honey - Helps to find moisture content measured using refractometer

**Purity test for honey**

1. Measure specific gravity of honey using hydrometer
2. If the specific gravity is between 1.25-1.44 it is pure honey

**Aroma and flavour of honey**

1. Acquired from the nectar of the flower
2. Lost if heated or exposed to air for long time

**Colour of honey**

1. Depends on the nectar of flower (plant species)
2. Darker honey has stronger flower
3. Lighter honey has more pleasant smell

**Fermentation of honey**

- Honey containing high moisture can ferment
- Sugar tolerant yeast present in honey cause fermentation
- Fermentation more at 11-21$^{o}$C
- Fermentation lends to formation of alcohol and carbondioxide
- Alcohol later converted into acetic acid
- Fermented honey sour in taste due to acidity
- Heating honey to 64$^{o}$C for 30 min destroys yeast and prevents fermentation

**Crystallization or granulation of honey**

- This is a natural property of honey (particularly at low temperature)
- Dextrose present in honey granulate and suffer down
- Levulose and water remain top - More prone to fermentation
- High ratio of Levulose/Dextose (L/D) - Less granulation
- High ratio of Dextrose/Water (D/W) - More granulation

**Lecture 6: Effect of agricultural inputs on bee activity – Pesticide poisoning**

The use of pesticides has become inevitable in modern agriculture. Most of crops are attacked by some or the other pests. The control of insect pests, diseases and weeds, in most cases is done by applying some pesticide. Pesticides used on field crops for the control op pests have their own side effects, one of which is their toxicity to honey bees. Honeybees are susceptible to many pesticides, especially insecticides. Each year honeybee colonies are damaged or destroyed by pesticides, primarily insecticides. Such losses have devastating impact on the beekeepers, who may have to relocate damaged hives or perhaps even be forced out of business. It is very difficult to assess the extent of losses of bees from pesticides. Three types of harmful effects evident in agriculture are:

1. Loss in production of honey.
2. Contamination of bee products.
3. Reduction in the yield of cross-pollinated crops.

These effects may happen as a result of the direct exposure of bee fauna to pesticides or through indirect contact with their residues. Direct exposure occurs from treatment of bee hives with pesticides for disinfestation purpose or honey bees visiting the fields at the time of spray. While the indirect exposure occurs from spray drift from nearby fields or bee foraging in sprayed crops. Honeybees may also come in contact with spray fluid spilled inadvertently or thrown in the watercourses.

**Symptom's of bee poisoning**

Dead or dying bees near the entrance of hives /colonies.

Dead bees on the top of frames or bottom board.

Lack of recognition of guard bees.

General aggressiveness.

Fighting among bees at the entrance or inside of colonies.

Paralysed or stupefied bees crawling on nearby objects of the colony and also on blades of the grass.

Sudden cessation of food storage and brood rearing.

Dead and deserted brood in the hive.

Poor recognition of pollen and nectar.

And finally a depleted population of the colony.

**Causes of poisoning**

Bee poisoning mainly occurs when pesticides are applied to crop during bloom. It may also be caused by drift of toxic chemicals onto non-target areas or bees contacting residues of pesticides on plants for pollen and nectar and also bees drinking or contacting contaminated water in watercourses or spillage. If the chemical is highly poisonous the bees may get killed in or near the field. However, if the chemical has delayed action the bees may reach their hives but die near the entrance. Some of workers may even enter the hive and store nectar and pollen inside and thus, result in exposure of the nurse bees to the contaminated pollen, carried by the foragers and stored in the comb. The resultant cumulative effect of the contaminated pollen may lead to depletion of brood, death of young ones, nurse bees and other workers. Hence, not only the population of colony decreases substantially but also results in contamination of bee products.

**Factors of bee poisoning**

Many factors involving pesticides affect the potential for honey bee poisoning. The important factors are described below.

**Plant growth stage:** Severe bee poisoning most often results from spraying insecticides directly on flowering plants, either the crop itself or flowering weeds within its margins.

**Relative toxicity of chemical**: Pesticides vary in their toxicity to honeybees. Among the pesticides, most fungicides and herbicides are relatively less toxic to honeybees. Insecticides are most toxic. Honeybees are most vulnerable to broad-spectrum insecticides. Insecticides that are highly toxic can not be applied to blooming crop when bees are present without causing serious to colonies. Insecticide like dimethoate, malathion, methyl parathion etc. carbaryl come under this category. However, insecticides like endosulfan are less toxic (Table 1).

**Choice of formulation**: different formulations even of same pesticide, often vary considerably in their toxicity to bee. Dust formulations are typically more hazardous than sprays because the are picked up on bee hairs. A wettable powder such as Sevin 80 S, would usually remain toxic in the field for a longer time than Sevin XLR Plus, an emulsifiable concentrate. Granular insecticides are less hazardous to bee. However, microencapsulated materials such as Penncap-M are particularly dangerous to use around bees because, the capsules have a tendency to adhere to bees due to their size and electrostatic charge.

**Residual action:** Residual activity of an insecticide is an important factor in determining its safety to pollinators. An insecticide that degrades rapidly can generally be applied with minimum risk when bees are not foraging.

**Drift:** Drift of spray application can cause significant bee poisoning, particularly when drift reaches colonies adjacent flowering weeds. In general sprays should not be applied when wind speed exceeds 10 km/hr.

**Temperature:** Temperature can have a substantial effect on bee poisoning hazard. If temperatures following treatment are unusually low, insecticide residues can remain toxic to bee many times longer than if normal temperature prevails.

**Distance from treated fields:** the most severally damaged colonies are usually closest to fields where insecticides are being applied. However, during periods of pollen or nectar shortage, hives within 6 – 7 km of the treated areas can be injured.

**Time of application:** evening application of a short residual insecticide can greatly reduce any potential for bee damage.

**Minimizing pesticide hazards to bees / management practices**

Proper understanding of above-mentioned principles can go a long way in reducing pesticide hazards to honey bees. The basic principle, of course, is that honey bees should not get exposed to the toxic effects of insecticides as far as possible. Reducing pesticide injury to honeybees requires communication and cooperation between beekeepers and farmers. Since both mutually benefit from honeybees, the beekeeper in terms of its products and the farmer in terms of increased production of crops. While it is unlikely that all poisoning can be avoided, a balance must be struck between the effective use of insecticides, the preservation of pollinators and the rights of all – the beekeeper, farmers and the community.

**GUIDELINES FOR BEEKEEPERS**

It is most desirable that bee colonies should be maintained where use of pesticides or drift from pesticides is minimum. For this, the beekeeper should be fully conversant with the type of pesticides used in their locality, which in turn depends upon the cropping pattern and the pest complex. He / she should also be aware of normal wind currents prevalent in that area to protect against the harmful effects from drift.

If ever disinfestation of beehives becomes necessary he / she should use only the recommended chemicals, safe to the bees, for the purpose.

During bloom if the crops in the surrounding areas are being sprayed with the insecticides, it is always advisable to confine the bee within the hives. If it is apprehended that the spray programme will continue for a longer period, it is better to move the hives away to the safe location free from the drift in advance.

Apiarists and farmers should have close cooperation so that beneficial activity of bee is not jeopardized by the irrational use of pesticides by the latter.

Feeding of colonies with sugar syrup following pesticide application to reduce bee foraging may help substantially in reducing the exposure of bees to pesticides

Bee repellent like Methyl salicylate and MGK 874 (2 – hydroxyethl – N octyl sulphide) also reduces bee foraging

Addition of (adjuvant) Sylgard 309 silicone surfactant reduced honey bee mortality for some insecticides

Carbolic acid and creosite reduced activity of bees on cotton for few hours

## GUIDELINES FOR FARMERS

The golden principle for the farmers is to use insecticides only when necessitated. For this purpose, integrated pest management approaches are available on most crops, which should be strictly practiced.

It is in the mutual interests of both that the farmer should intimate the spray programme in advance to the bee keeper.

If there is a choice for insecticides, the use should be restricted to the chemicals in the less hazardous groups.

The spray operation in the evening is always preferable as it not only gives better deposit and distribution (because of invert current) but also bee activity subsides.

Apply granules or sprays in preference to dusts. Pesticide formulation containing attractants like Sevimol, used for fruit fly control, should be discouraged as for as possible during the crop in bloom.

Examine fields and field margins before spraying to determine if bees are foraging on flowering weeds. Where feasible eliminate weeds by mowing or tillage.

Give careful consideration to position of bee colonies relative to wind speed and direction. Changing spray nozzles or reducing pressure can increase droplet size and reduce spray drift.

**Table 1 Select list of insecticides according to bee hazard categories**

| **Insecticide** | **Formulation** |
|---|---|
| *High hazard class category* | |
| Carbaryl | D, WP |
| Cypermethrin | EC |
| Deltamethrin | EC |
| Diazinon | D, EC |
| Dichlorvos | EC |
| Dimethoate | EC |
| Fenitrothion | EC |
| Fenthion | EC |
| Fenvalerate | D, EC |
| Malathion | D, ULV, EC |
| Monocrotophos | EC |
| Methyl parathion | D, EC |
| Methomyl | D, WP |
| *Low hazard category* | |
| Endosulphan | EC |

| | |
|---|---|
| Fenthion | G |
| Phorate | G |
| Aldicarb | G |
| Carbofuran | G |
| Phosalone | EC |
| Fluvalinate | EC |
| Menazon | EC |

Since pesticides are indispensable for crop protection, as an alternative scientists are continuously looking for such chemicals which are selective and repellent to bees, in addition to the development of a bee strain resistant to toxic effects of pesticides.

Beekeepers on their own through their organizationz may approach the enforcement agency for amendments in The Insecticides Act, 1968 for getting protection to these beneficial insects which is possible by restricting use of pesticides in apiculture zones.

## Lecture 7: Role of pollinators, weed killers and other beneficial insects

I. Role of pollinators

Pollination refers to the transfer of anther to stigma in flowering plants for sexual reproduction.

Insects aid in cross pollination in fruits, vegetables, ornamentals, cotton, tobacco, sunflower and many other crops.

Insect pollination helps in uniform seed set, improvement in quality and increase in crop yield.

**Entomophily refers to cross pollination aided by insects**

| Pollination classes | Type of insects |
|---|---|
| Melitophily | Bees |
| Cantharophily | Beetles |
| Myophily | Syrphid and Bombylid flies |
| Sphigophily | Hawk moths |
| Psychophily | Butterflies |
| Phalaeophily | Small moths |

**1.Honeybees as pollinators**

All bee species aid in pollination

Value of honey bees in pollination is 15-20 times higher than that of the honey and wax it produces.

*Per cent increase in yield due to bee pollination*

| | | |
|---|---|---|
| Mustard | - | 43% |
| Sunflower | - | 32 - 48% |
| Cotton | - | 17 - 19% |
| Lucerne | - | 112% |
| Onion | - | 93% |
| Apple | - | 44% |
| Cardamom | - | 21-37% |

**2. Hoverflies *Syrphus* sp. (Syrphidae:Diptera)**

Brightly coloured flies

Body is striped or banded with yellow or blue

Resemble bees and wasps

Larval stage predatory, adults are pollinators

Crops pollinated - carrot, cotton, pulses

**3.Carpenter bee, *Xylocopa* sp. (Xylocopinae:Anthophoridae)**

Robust dark bluish bees with hairy body
Dorsum of abdomen bare, pollen basket absent
Adults are good pollinators
Construct galleries in wood and store honey and pollen

**4. Digger bees, *Anthophora* sp. (Anthophoridae:Hymenoptera)**

Stout, hairy, pollen collecting bees
Abdomen with black and blue bands

**5. Fig wasp *Blastophaga psenes* (Agaonitae:Hymenoptera)**

Fig is pollinated by fig wasp only. There is no other mode of pollination. There are two types of fig Caprifig and Symrna fig.

**(i) Caprifig**

a. It is a wild type of fig - not edible
b. Has both male and female flowers
c. Pollen is produced in plenty
d. Natural host of fig wasp

**(ii) Smyrnafig**

a. It is the cultivated type of fig - Edible
b. It has only female flowers
c. Pollen not produced
d. Not the natural host of fig wasp

Fig wasp: Male - wingless, present in caprifig
Female - winged

wasp lays eggs in caprifig, larvae develops in galls in the base of the flowers
mates with female even when the is inside gall

Mated wasp emerges out of flower (caprifig) with lot of pollen dusted around its body.

The fig wasp enters smyrna fig with lot of pollen and deposits it on the stigma
But it cannot oviposit in the ovary of symrna fig which is deep seated
It again moves to capri fig for egg laying. In this process smyrna fig is pollinated
Caprifig will be planted next to smyrna fig to aid in pollination

**6. Oil palm pollinating weevil: *Elacidobins kamerunicus* (Curculionidae : Coleoptera)**

Aid in increasing oil palm bunch weight by 35% and oil content by 20%

**7. Other pollinators**

Butterflies (eg *Deilaphila* spp.) and moths (*Acherontia* spp.)
Ants, flies, stingless bees, beetles etc.,

**II.WEED KILLERS**

Insect which help in controlling weeds by feeding on them are called weed killers.

1. *Dactylopius tomentosus* cochnieal insect to control prickly pear *Opuntia dillenii*

This insect was introduced into India in 1925. Within 5-10 years it controlled the weed.

2. Aristalochia butterfly, *Papilio aristolochiae* (Papilionidae:Lepidoptera). It feeds on Arista lochia which a weed.

3. Caotropis butterfly - *Danaus chrysippus* (Nymphalidae:Lepidoptera) - feeds on calotropis.

4. AK Grosshopper - *Poecilocerus* pictus (Actididae:Orthoptera)

Feeds on Calotropis and controls it

**5. Water hyacinth weevil *Neochetina eichhorniae* and *N. bruchi***

The larvae tunnel and feed inside the petioles. Ten pairs of adults and progeny controls plant growth in 0.58 $m^2$.

**6. Parthenium weed killer, *Zygogramma bicolorata* (Chrysomelidae:Coleoptera)**

Adults and grubs feed on leaves and flowers. 2 beetles controls and destroys one plant in 45 days.

**A successful weed killer has following qualities**

Should not be a pest of cultivated plants - at present or in future
Effective in damaging and controlling the weed
Should be a borer or internal feeder of the weed
Should not be affected by parasitoids/predators

*III. SCAVENGERS*

Insects which feed on dead and decaying plant and animal matter are called scavengers.

Remove decomposing material and prevents health hazard
Convert complex material into simple substances

a. Rove beetles (Staphylinidae:Coleoptera)
   Adults and larvae feed on decaying matter
b. Chafer beetles (Scarabaeidae:Coleoptera)
c. Darkling beetles (Tenebrionidae:Coleoptera)
d. Nitidulids (Nitidulidae:Coleoptera)
e. Water scavenger beetle (Hydrophilidae:Coleoptera)
f. Daddy long legs (Tipulidae:Diptera)
g. Muscid flies (Muscidae:Diptera)
h. Termites (Isoptera)
i. Ants (Hymenoptera)

*IV. INSECTS OF AESTHETIC VALUE*

Insects which are beautiful are admired

Jewel beetle (Buprestidae:Coleoptera)
- necklaces, bracelets and made of whole insects

Nymphs of scale insects - made as stings
Butterflies - symbol of beauty

*V. SOIL BUILDERS*

Insects which live in soil, male tunnels. During this process, the soil disintegrates, and soil aeration is facilitated. Subsoil is brought to the surface. Excreta of insects also enrich the soil.

eg. Beetles, ants, cutworms, larvae of flies, crickets, termites, wasps etc.,

*VI. INSECTS OF SCIENTIFIC VALUE*

**1. Fruitflies - *Drosophila melanogastes***

Useful in biological investigations such as cytology, and genetics for studying principles of inheritance.

These flies have short life cycle, easy to culture and multiply - They have large chromosomes and easily recognizable heritable variations.

2. Mosquitoes - Used in bioassay of insecticide residues
3. Cockroaches - Used in Zoology and Entomology courses, also used in nutritional studies

VII. INSECTS AS FOOD

Termites, grubs of beetles are being used as food
They are rich in protein

MANAGEMENT OF HOUSEHOLD PESTS, VECTORS OF HUMAN DISEASES AND PESTS OF CATTLE AND POULTRY

**Lecture 8:**

## I.HOUSEHOLD PESTS AND VECTORS OF HUMAN DISEASES

### 1. Housefly *Musca nebulo* (Muscidae:Diptera)

Biology: Larvae - feed on decaying organic matter, faeces etc.,
Adults - Frequent human dwelling and transmits diseases

*Damage*

- Source of nuisance
- Transmits many diseases in human beings such as diarrhoea, dysentry, cholera, typhoid, enteric fevers, tuberculosis, leprosy, anthrax, trachoma, gonorrhoea and many helmithic diseases.

Management

Proper disposal of manure, garbage, sewage, human excrement, dead animals etc., Covering manure pits with soil.
Inside houses, spraying with malathion/diazinon 2%, lindane 1% or tricholorphon 0.5%. The deposits are effective for long periods.
Smearing doors and windows with malathion 3% or diazinon 1.5% emulsion with a bruch.
Using fly swatters to manually kill flies.
Protecting eatables from flies to prevent transmission of diseases.
Use of poison baits such as formaline + sweetened milk (or) fermented banana + milk or cheese + sugar + insecticide

### *2.* Mosquitoes

*Culex* sp., *Anopheles* sp., and *Aedes* sp. Culicidae : Diptera

**More than 2500 sp world wide**

*Mosquitoes*

| | | |
|---|---|---|
| Biology | : | Egg, larval and pupal stages spent in water, marshy lands, stagnant ponds etc.,<br>Adults cause problem to humans and animals. |
| Damage | : | Their bile causes itching and irritation (Females only bite and suck blood) |

*Diseases transmitted*

*Anopheles* sp. transmits malaria (caused by *Plasmodium* sp.)
*Culex* sp. transmits filariasis (caused by *Wuheretia bancrofti*)
*Aedes* sp. transmits dengue fever, encephalitis and yellow fever

Management of mosquitoes

- Stagnant water should be drained (or) treated with 0.025% malathion emulsion. Kerosine oil can also be used.
- Grasses and weeds around buildings should be cut or sprayed with 1% malathion every week when mosquitoes are active.
- Mosquito nets or repellents such as citronella oil (creams).
- Adults can be killed with space sprays of propreitary products such as pyrethrins, dichlorvos, synthetic pyrethroids.
- Spray human dwellings, cattle shed with lindane 0.5 $g/m^2$ and propuxur, fenitrothion and malathion 2 $g/m^2$.

**3. Sandflies *Phlebotomus argentipes* (Psychodidae:Diptera)**

Larvae found in decaying organic matter.

**Damage**

Adults cause painfaul bite, itching and swelling
Transmits diseases in man like kala-azar, three day fever, tropical ulcer etc.,]
Transmits anthrox in cattle

**Management**

- Cleanliness in and around human inhabitations
- Surface spraying with Lindane 5% as residual spray
- Insecticides recommended for mosquito control
- Pyrethrum oinment to repel the sand flies

**4. Eye flies *Siphunculina funicola* (Chloropidae : Diptera)**

Breeds in decomposing organic matter, near latrines, stables and drains.

Damage

- Frequents the eye with buzzing sound and feeds on eye secretions
- Transmits diseases like *Conjunctivitis* and *Ophthalmia*

*Management*

- ✔ Good sanitary and hygienic condition

**5. Human lice**

| | |
|---|---|
| Head louse *Pediculus capitis*<br>Body louse *Pediculus humanus*<br>Crab louse *Phthirus pubis* | } Pediculidae:<br>Siphunculata or Phthiraptera |

*Damage*

- Biting causes cutaneous lesions, itching

- Severe infestation by lice is called pediculosis - discolouration hardening and ulceration of skin
- Transmits diseases like typhus, trenchfever, European relapsing fever

*Management*

Powder containing malathion 2% or lindane 1% is effective in delousing on clothes
On infested head/body lindane 0.2% mixed in hair oil or lotions containing 0.2% lindane
Cleanliness to have constant relief

**6. Rat fleas: *Xenopsylla cheopsis* (Pulicidae:Siphonaptera)**

*Damage*

- Painful bites - cause irritation, itching on skin

Transmits bubomic plague - caused by bacterium *Pasteurella pestes* which affects both rats and humans.

Also transmits endemic or murine typhus

*Management*

Keep houses rat free by poison baits
Cleaniless, proper ventilation and occational spraying with malathion 0.5% or lindane 1%

**7. Cockroaches**

*Periplanata americana, Blatela germanica, Blatella orientalis* Blathidae:Dictyoptera

Live in dark unclean kitchens, restaurants, filthy places

*Damage*

- Starchy material are ruined by excreta, offensive smell
- Feed on damp books and leather articles

Management

Observing cleanliness
Sealing pipelines and drains leading to basement
Spraying room with malathion / chlorpyriphos 0.5% without contaminating food material
Combined application of dichlorvos 0.5% (quick knock down) and persistent insecticide (Chlorpyriphos)

**8. Crickets *Grylloides sigillatus, Acheta domesticus* Gryllidae:Orthoptera**

Damage

- Nuisance and disturbance to humans by producing monotonous chirping sound produced at night
- Eat food and clothings

*Management*

Dusting corner and floors with malathion / carbaryl 5% dust at night (care not to contaminate food)

**9. Bed bugs**

legion

*Cimex hemipterus* (Tropical) } Cimicidae:Hemiptera
*Cimex lectularius* (Temperate)

Damage

Nymphs and adults suck blood and inject toxic saliva during night- (irritating, painful, itching) (Does not transmit any diseases)

**Management**

Exposing bed, bedsheets to hot sun will kill bed bugs
Using steel cots instead of wooden cots
Applying kerosine, turpentine or petroleum oils in furniture
Treating furniture with malathion 1% or lindane 0.1%

**10. Silverfish**

*Lepisma saccharina*, *Thermobia domestica* Lepismatidae : Thysanura

*Management*

Cleaning and ventilation.
Use of naphthalene balls in cupboards

**11. Other minor household pests**

Ants, termites, book lice, wood boring, beetles, carpet beetles, cloth moth.

***MANAGEMENT OF PESTS OF CATTLE AND POULTRY***

Farm animals are attacked by pests under following categories

1. Blood sucking flies (Adults - flies suck blood)

2. Myiasis flies (Tissues eaten by maggots of flies)
3. Lice - (a) sucking lice (b) biting lice
4. Fleas
5. Arachnids - (a) Ticks (b) Mites

*I. Blood sucking flies*

a. Sand flies: *Phlebotomus argentipes* (Psychodidae:Diptera)

**Damage**

Both male and female flies such blood from horses, dogs, man and cattle
Causes weakening and reduction of milk
Transmits anthrox in animals

b. Horseflies: *Tabanus striatus* (Tabanidae:Diptera)

Other species *Chrysopa* sp., *Hamatopota* sp.

*Damage*

- Females are blood suckers - even on running animals
- Animal weakened, loses lot of blood
- Transmits anthrox
- Attacks horse, cattle, camel, elephant, rarely man

c. Stableflies *Stomoxys calcitrans* (Muscidae:Diptera)

*Damage*

Bite causes itching, pain, restlessness in animals
Reduction in milk yield
Transmits diseases like anthrax, surra, swamp fever, *Trypanosomiasis* and *Leishmaniasis* in animals

d. Hornflies: *Haematobia irritans* (Tahinidae:Diptera)

*Damage*

- Both sexes suck blood from neck region from cattle, goats, horses, gods and sheep
- Transmits anthrax

e. Dogflies: *Hippobosca maculata* (Hippoboscidae:Diptera)

*Damage*

Permanent ectoparasites on cattle, horse, dog, goat, sheep
Painless but irritating bite cause annoyance

*Management of blood sucking flies on cattle*

- Elimination of breeding of flies through cleanliness
- Residual spray of cattle shed with lindane 5% or diazion 1%
- Draining stagnant water to prevent breeding
- Spraying 0.1% pyrethrin + 1% piperonyl butoxide at 1-2 lit/animal, twice or thrice a week
- Cover or dry the fresh dung as it attracts egg laying by hornflies
- To manage dog flies, apply malathion 5% dust on neck, back and flanks of animal every 10-14 days

*II. MYIASIS FLIES*

Myiasis refers to an infestation of living organs or tissues of man and other mammals by maggots (larvae) of flies (order Diptera) and disturbances resulting therefrom

caused by insects belonging to *Calliphoridae* (Blousflies)
*Oestridae* (Botflies, warble flies), *Sarcophagidae* (Flesh flies)

| Types of myasis | | | |
|---|---|---|---|
| → | **Atrial myiasis** | - | Cavities on body |
| → | **Cutaneous myasis** | - | Skin |
| → | **Intestinal myasis** | - | Intestine |
| → | **Enter through wounds** | - | Wound |

Botflies

1. Horse botfly - *Gastrophilus intestinalis, G. nasalis* (Oestridae:Diptera)

*Damage*

- Eggs laid on body of animal - while licking gets into intestine - larva develops inside intestine
- Maggots injure tongue, stomach and intestine
- Animal dies if not treated

*Management*

If larva detected in faeces - give 25 ml tolerance or 1.5 g carbon disulphide / 100 kg body weight in gelatin capsule to horse.

2. *Oestrus ovis* Sheep bot fly (Oestridae:Diptera)

**Maggots attacks nasal passage of sheep - discharge of mucus, distress to the sheep.**

*Management*

Irrigating the sheep's nostrils with 3% lysol
Carbondsulphide + Paraffin injection into nostrils

3. Warble fly/Heal fly: *Hypoderma lineatum* (Oestridae:Diptera)

Cutaneous/subcutaneous myiasis caused
Causes holes in skin - less value
Even causes eye myiasis

*Management*

- During monsoon, hair close to loof may be cut to prevent egg laying
- Treating animal with 1% trichlorphon or 0.05% rotenone every 45 days when warbles appear on skin

Blowflies

*Chrysomyia bezziana* (Calliphoridae:Diptea)
*Cochliomyia hominivorax, Calliphora, Lucilia, Phormia* sp.

Also called screw worms
Cause cutaneous myiasis by entering through wound/sores

*Management of blowflies*

- Disposal of carcasses to prevent egg laying
- Removing maggots with forceps after spraying with 5% chloroform
- Dressing wounds with pine oil which is a repellent

*III. LICE*

a. Sucking lice: Has sucking mouth parts

1. Cattle louse: *Haematopinus eurystermus* (Haematopinidae:Siphunculata)

Ectoparasites on cattle, cling, bite and irritate

*Management (Delousing) DELOUSNG CATTLE*

- Applying linseed oil all over the body could kill lice
- Malathion 5% dust or 0.5% suspension spray/dip of animal

b. Biting lice: Has biting and chewing MP

*Bevicola caprae* (on goat) *B. ovis* (on sheep); *B. bovis* (on cattle)
(*Trichodectidae*:Mallophaga)

*Menopon gallinae* (Menoponidae:Mallophaga)

Shaft louse of focol (on birds)

Feed on feathers of birds and cause annoyance

*Menacanthus stramineus* (Chicken body louse)

Prefers skin to feathers

**Management of biting lice on birds (Delousing birds)**

Spray individual chicken or in groups with 0.5% carbaryl or malathion (5 lit/100 birds)

Apply 5% Malathion / Carbaryl dust on individual birds @ 500 g/100 birds

On walls and ceiling spray 3% malathion

Delousing birds not only removes the lice but also poultry tick and fleas.

IV. FLEAS

a. Poultry stick fast fleas *Echidnophaga gallinacea* (Hectosyllidae : Siphonaptera)

Attack comb, wattle, around eyes, beaks

Birds become anaemic and egg production reduced

V. ARACHNIDS

Ticks (1) *Boophilus microplus* cattle tick

Cause inflammation and haemarrhage

Produce tick paralysis

Transmits tick fever, texas fever, tulanemia

Management

Careful removal with hand/forceps along with capitulum

Use 1% lindane dust or 5% malathion dust

2. Poultry tick: *Argas persicus* (Fowl tick)

Suck blood, causes weakness, annoyance

Transmits fowl diseases

Mites: *Sarcoptes scabiei* called mange mite

Mite damages or eats the skin

Ecto parasite on horse, cattle, mule, sheep, goat

Management

Repeated application of powdered sulphur in vegetable oil

## Lecture 8 Insect ecology and balance of life

**Ecology**:

The term ecology is derived from the Greek term "oikos" meaning "house" combined with "logy" meaning "the science of" or "the study of". Thus literally ecology is the study of earth's household comprising of the plants, animals, microorganisms and people that live together as interdependent components. The term ecology was coined by a German biologist Ernst Haekel (1869).

**Definition of Ecology**

Ecology can be defined as the science of plants and animals in relation to their environment.

Webster's dictionary defines ecology as "totality of pattern of relation between organisms and their environment."

Eugene P. Odum defined ecology as "the study of organisms at home"

Insect Ecology may be defined as the understanding of physiology and behaviour of insects as affected by their environment.

Ecology related terminology

i. **Habitat** is the place where the organism lives.

ii. **Population** denotes groups of individuals of any kind of organism. Insect populations are groups of individuals set in a frame that is limited in time and space.

iii. **Community** in the ecological sense includes all the populations of a given area. Community can also be defined as interacting 'web' of populations where individuals in a population feed upon and in turn are fed upon by individuals of other populations (Fig. 1)

iv. **Ecosystem**

Ecosystem or ecological system is the functioning together of community and the nonliving environment where continuous exchange of matter and energy takes place.

In other words ecosystem is the assemblage of elements, communities and physical environment.

Ecosystem is the ultimate unit for study in ecology as they are composed of living organisms and the nonliving environment.

Examples of natural ecosystem: Ponds, lakes and forests ecosystem (Fig.2)

v. **Biosphere** is the term used for all of the earth's ecosystems functioning together on the global scale.

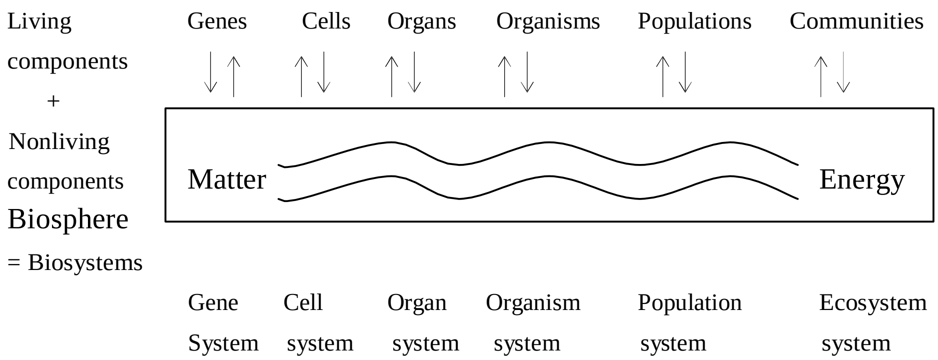



**Figure 3. Flow of matter and energy in an ecosystem**

**Agroecosystem** is largely created and maintained to satisfy human wants or needs. It is not a natural ecosystem but is man made. Agroecosystem is the basic unit of pest management - a branch of applied ecology.

A typical agroecosysyetm (Fig. 4) is composed of

i. more or less uniform crop-plant population
ii. weed communities
iii. animal communities (including insects)
iv. microbiotic communities
v. and the physical environment the react with.

Unique features of Agroecosystem

Dominated by plants selected by man

No species diversity and no intraspecific diversity. Genetically uniform

Phenological events like germination, flowering occur simultaneously

Lack of temporal continuity - due to various agricultural operations carried out by man like ploughing, weeding, pesticide application etc.

Plants contain imported genetic material

Nutrients are added

Outbreak of pests, weeds and diseases occur frequently

## Balance of Nature

**Balance of Nature** is defined as the natural tendency of plant and animal population resulting from natural regulative processes in an undisturbed ecosystem (environment) to neither decline in numbers to extinction nor increase to indefinite density.

In unmanaged ecosystems, a state of balance exists or will be reached, that is species interact with each other and with their physical environment in such a way that on average, individuals are able only to replace themselves. Each species in the community achieves a certain status that becomes fixed for a period of time and is resistant to change which is termed as the balance of nature.

When man begins to manage creating new ecosystem (agroecosystem) where natural ecosystem existed previously, the balance is altered. The exceptionally strong forces react in opposition to our imposed change toward a return to the original system (e.g. outbreak of a pest is one of the forces). So insect pests are not ecological aberrations. Their activities counter wants and needs of human populations.

## Factors that determine insect abundance

### i) **Biotic potential**

It is the innate ability of the population to reproduce and survive. It depends on the inherited properties of the insect i.e., reproduction and survival. **Potential natality** is the reproductive rate of the individuals in an optimal environment. Survival rate depends on the feeding habits and protection to young ones (eg. Viviparity). Generally insects with high reproductive rate tend to have low survival rate and vice versa.

Insect pests with high reproductive rate and low survival rate are called **r strategists** named after the statistical parameter r, the symbol for growth rate coefficient. Such pests succeed because of sheer numbers. E.g. Aphids.

K strategists reproduce slowly but effectively compete for environmental resources and so their survival rate is high. (K letter denotes flattened portion of growth curve) eg. Codling moth of apple.

Birth rate or natality is measured as the total number of eggs laid per female per unit time. Factors determining birth rate are fecundity, fertility and sex ratio.

Death rate or mortality denotes the number of insects dying over a period.

Example of High reproductive rate

A single moth of *Earias vitella* (Bhendi fruit borer) lays about 200 eggs per female. Life cycle is completed in 1 month

After 1 month → 200 adults

↓

100 male+ 100 female

100 x 200 = 20,000 eggs

After 2nd month → 10,000 x 200 = 2,000,000 eggs

After 1 year adults → 2,000,000,000,000,000,000,000,000

(i.e., 2 followed by 24 zeroes)

If a single moth can produce this much, they will cover 24.32 above earth surface in 1 year. But in reality only a fraction of progeny completes life cycle due to environmental resistance.

**Environmental resistance** is the physical and biological restraints that prevent a species from realizing its Biotic potential. Environmental resistance may be of 2 types.

1. Biotic factors - includes
   a) Competition (interspecific and intraspecific)
   b) Natural enemies (predators, parasites and pathogens)

.

2. Abiotic factors -
   a) Temperature
   b) Light
   c) Moisture and water
   d) Substratum and medium

**BIORESOURCES IN ECOSYSTEM**

Ecosystem comprises of biological communities and non-living environment. e.g. Agro ecosystem, pond ecosystem, etc.). **Bioresources refers to the biodiversity of various organisms living in that ecosystem.**

e.g. The different pests of cotton, its natural enemies, hyperparasitoids, microbes, etc. are referred to the bioresources in cotton ecosystem.

**The ecosystem should have more bioresources**. Such ecosystem will be more stable. Insecticides will deplete the bioresources in ecosystem and make it less stable and prone to pest outbreak.

**Natural control will be high when bioresources** (e.g. Parasitoids and Predators) are more.

# Lecture 9 : Population dynamics and role of biotic factors

## Attributes of a population

i. **Density** : Population size per unit area
ii. **Birth rate (Natality)** : Rate at which new individuals are added to the population by reproduction
iii. **Death rate (Mortality)** : The rate at which individuals are lost by death.
iv. **Dispersal** : The rate at which individuals immigrate into and emigrate out of the population.
v. **Dispersion:** the way in which individuals are distributed in space. It may be of 3 types.
   a) Random distribution
   b) Uniform distribution
   c) Clumped distribution

vi. **Age distribution**: the population of individuals of different ages in the group.
vii. **Genetic characteristics** : adaptiveness, reproductive fitness, persistence.
viii. **Population growth form**: the way in which population changes / grows as a result of natality, mortality, and dispersal.

## Population dynamics.

Populations grow in two contrasting ways. They are

i. J- shaped growth form (Fig 1a)
ii. S- Shaped or sigmoid growth form (Fig 1b)

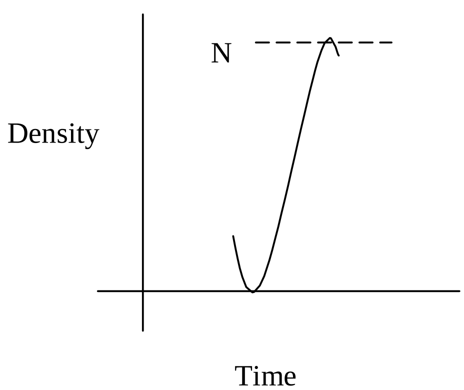



Fig. 1a. J- shaped growth form

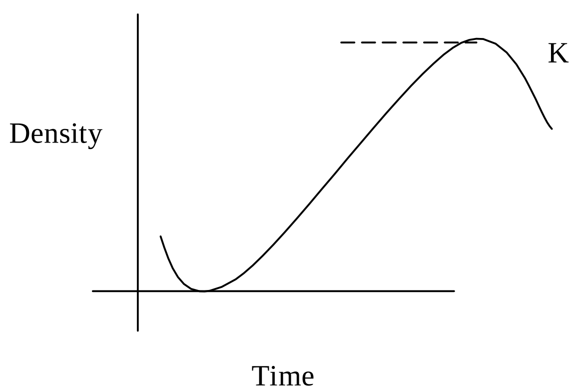



Fig. 1b. S - shaped growth form.

In the J - shaped growth form, the population density increases in exponential or geometric fashion; for example 2,4,8,16,32 … and so on until the population runs out of some resource or encounters some limitation (limit N, Fig 1a). Growth then comes to a more or less abrupt halt and density declines rapidly. Populations with this kind of growth form are unstable. Their reproductive rate is high and survival rate is less and so they are r strategists. Factors other than density regulates the population.(eg; Aphids).

In the S-shaped growth pattern (Fig 2) the rate of increase of density decreases as the population increases and levels off at an upper asymptote level K, called the carrying capacity, or maximum sustainable density. Their reproductive rate is less and survival rate is more. So they are K strategists. This pattern has more stability since the population regulates itself.(eg Hymenopterans).

The population growth rate or change is worked out using the formula,

$$N_t = N_0e^{(b-d)t} - E_t + I_t$$

Where $N_t$ = number at the end of a short time period

$N_0$ = number at the beginning of a short time period

e = base of natural logarithm = 2.7183

b= birth rate

d= death rate

t= time period

E= emigration

I = immigration.

**Life table**: Life tables are tabular statements showing the number of insects dying over a period of time and accounting for their deaths.

**Example of a life table for a lepidoperan insect**

| Stage | Number living beginning of stage | Number dying by end of stage | Cause of death | Percent reduction during stage |
|---|---|---|---|---|
| Egg | 200 | 10.0 | Parasites | |
| | | 20.0 | Other | 15 |
| Early larva | 170 | 136.0 | Dispersal | 80 |
| Late larva | 34 | 13.6 | Parasites | |
| | | 6.8 | Disease | |
| | | 10.2 | Other | 90 |
| Pupa | 3.4 | 0.3 | Parasites | |
| | | 0.5 | Other | 25 |
| Adult | 2.5 | 0.5 | Miscellaneous | 20 |

**Factors influencing population growth.**

a) Biotic factors or density dependent factors.
b) Abiotic factors or density independent factors.

**Biotic factors**

1) **Competition** : For at least part of the lifetime the members of an insect species are likely to be competing with one another or with members of another species for limited resources like food, mates, suitable site for oviposition or pupation. Such competition operates whenever the population is increasing and the resources are limited.

**a) Intraspecific competition**: When members of population of the same species compete for resources we call it intraspecific competition. Examples are as follows

- Cannibalism in American bollworm larvae
- Cannibalism in later stage grubs of Chrysopid
- Crowding in aphids result in alate (winged) form for migration
- Reduction in fecundity (egg laying) in rice weevil, *Sitophilus oryzae* during overcrowding
- Crowding in honeybees leads to swarming

b) **Interspecific competition**. This is the competition occurring between members of two or more species. Two or more competing species with identical requirements cannot coexist in a same place for a long time. The elimination of one species by another as a result of interspecific competition has come to be known as the **competitive exclusion principle or Gause's principle**.

- For example when flour beetles *Tribolium castaneum* and *Tribolium confusum* were grown in the same jar of flour, one species eliminates the other. Under high temperature and RH conditions T. castaneum eliminates T.confusum and vice versa under low temperature and RH conditions.
- Accidental introduction of oriental fruit fly *Dacus dorsalis* into Hawai eliminated Mediterranean fruit fly *Ceratitis capitata.*

2) **Predators and Parasites**

**Predators :** Predators are free living organisms that feed on other animals, their prey, devouring them completely and rapidly.

- Predators may attack immatures and adults.
- More than one individual of prey required for predator to reach maturity

- Major insect predators are birds, fish, amphibians, reptiles, mammals and arthropods

**Parasites:** An organism that is dependent for some essential metabolic factor on another throughout its all life stages, which is always larger than itself

- A parasite weakens or kills the host while feeding
- Many parasites on asingle host
- Requires only one part of one host to reach maturity

Eg. Virus, fungi, bacteria, protozoa, nematodes and other arthropods.

**Parasitoid**: An insect parasite of an arthropod that is parasitic in its immature stage killing the host in the process of development and adults are free living.

Interactions between predator and prey are different from the parasite host relationship in that the predator and prey maintain equilibrium more dynamically than the parasite and its host. The parasites I n general when the rate of parasitism is high, cause death and result in elimination of hosts. But the predator never eliminates the prey completely.

**Lecture 10 Abiotic factors on insect population**

- Physical factors
- Nutritional factors
- Host associated factors

**Physical factors**

- Temperature, light, wind, soil conditions influence development, longevity, reproduction and fecundity of insects
- Population density fluctuates depending on weather
- Extreme weather causes mortality of pests

**Temperature**

- Insects are poikilothermic - do not have mechanism to regulate body temperature
- Body temperature depends on environmental conditions

- Preferred or Optimum temperature is the temperature at which normal physiological activities take place - insects survive at this temperature.
- Upper lethal limit - 40-50$^{o}$C (even upto 60$^{o}$C survival in some stored product insects)
- Lower lethal limit - Below freezing point e.g. snow fleas
- The total heat required for completion of physiological processes in life - history is a constant - thermal constant.
- At low temperature (winter) insect takes more days to complete a stage (larval or pupal stage)
- At high temperature (summer) it takes less than to complete a stage.
- Some insects when exposed to extremes of temperature
- Undergo - Aestivation (during summer) or Hibernation (during winter)
- During this period, there is a temporary developmental arrest, metabolic activities suspended. When temperature is favourable, they resume activity.
- Eggs undergo aestivation in summer
- Larva, pupa commonly undergo hibernation in winter

**Influence of temperature on fecundity (egg laying)**

Grasshopper lays 20-30 times more eggs at 32$^{o}$C compared to 22$^{o}$C

Oviposition of bed bug inhibited at 8-10$^{o}$C

Other effects of temperature

- **Early shoot borer of sugarcane attacks more high temp.**
- Larval period of sugarcane internode borer
  very short 16-24 days in summer
  prolonged 141-171 days in winter
- Swarm migration of locust occurs at 17-20$^{o}$C

MOISTURE/HUMIDITY

- Moisture required for metabolic reactions and transportation of salts in insects
- War layer of cuticle prevents water loss
- Other adaptations - Morphological, physiological prevent moisture loss in insects
- Moisture scarcity leads to dehydration and death of insects - but very rare
- Excessive moisture can be harmful in following ways
  i. Affects normal development and activity of insects
  ii. Encourages disease causing pathogens on insects

Examples

- White halo fungus *Verticillium lecanii* on coffee green scale *Coccus viridis* requires high RH for multiplication and spread
- High RH induces BPH in rice and aphids in other crops
- Termites prefer high humidity 90-95% RH
- Low RH in rainfed groundnut crop induces leaf mines incidence

**Light**

The following properties of light influence insect life

i. Intensity and illumination
ii. Quality or wavelength
iii. Duration or Photo period

**Photoperiodism**

The response of organisms to environmental rhythms of light and darkness

**Photo period**

Each daily cycle inclusive of a period of illumination followed by a period of darkness

- Photo period influences induction of diapause (a resting stage) in most of the insects e.g. Long day during embryonic development causes adult to lay diapausing eggs in *Bombyx mori*.
- Seasonal dimorphism occurs in aphids due to change in photo period
  - Short day - Sexual forms
  - Long day - Asexual - Parthenogenetic forms
- Some insects are active in night - Nocturnal
  Some are active during the day - diurnal
  Some active during dawn and dusk - Crepuscular
- Fruit flies lays eggs in dark
- Lepidopterans like cotton bollworm, Red hairy caterpillar (RHC) oviposit in **dark**

**Rainfall**

- Rainfall is essential for adult emergence of cutworms and RHC
- Heavy rain washes aphids, diamond back moth (DBM)

- Intermittent low rain increases BPH and thrips

**Wind**

- Interferes with feeding, mating, oviposition
- Wind aids in dispersal of insects
- Aphids, mites (Eriophyid mites also) disperse through wind
- Helicoverpa flies upto 90 km with the aid of winds

**Topgraphy**

Mountains, lakes, sea, etc. act as physical barrier for spread of insects

**Soil Type**

Wire worm, multiplies in clay soil with poor drainage
White grubs and cut worm - multiply in loose soil with good drainage

**Water Current**

Standing water aids in multiplication of mosquitoes
Running water is preferred by Odonata and Caddis flies

NUTRITIONAL FACTORS

Insects heterotrophic - cannot synthesize their own food
- depend on plants for food

The quantity and quality of food/nutrition plays important role in survival, longevity, distribution, reproduction and speed of development

**a. Quantity of food**

- Short supply of food causes intranspecific and interspecific competition
- Also affects parasitoids and predators of insects hosts whose food is of short supply

**b. Quality of food**

- This depends on nutritional availability of plants
- Crop varieties/species differ in nutritional status which affects insects

Host plant associated factors

Antixenosis or non preference

Host plant **not preferred** by insects for feeding, oviposition or shelter due to morphological characters like thorns, wax, hairyness, etc. or done to presence of some chemicals (called allelochemicals)

Antibiosis

This refers to adverse effect of the host plant on biology (survival, dept, reprdn.) of insects and their progeny due to

- Presence of toxic substance in plant
- Absence of essential substances
- Presence of enzymes which affect digestion of insects

Example

DIMBOA in corn leaves affects European corn borer *Ostrinia nubilalis*

Gossypol in cotton affects *H. armigera* and *S. litura*

**Tolerance**

Ability of host plant to withstand insect population sufficient to damage susceptible plants

- No adverse effect on insect infestation
- Tolerance by plant vigour, regrowth of damaged tissues, etc.

## Lecture 11: PEST - DEFINITION, CATEGORIES, CAUSES FOR OUTBREAK, LOSSES CAUSED BY PESTS

PEST - Derived from French word 'Peste' and Latin term 'Pestis' meaning plague or contagious disease

- Pest is any animal which is noxious, destructive or troublesome to man or his interests
- A pest is any organism which occurs in large numbers and conflict with man's welfare, convenience and profit
- A pest is an organism which harms man or his property significantly or is likely to do so (Woods, 1976)
- Insects are pests when they are sufficiently numerous to cause economic damage (Debacli, 1964)
- Pests are organisms which impose burdens on human population by causing
  - (i) Injury to crop plants, forests and ornamentals
  - (ii) Annoyance, injury and death to humans and domesticated animals
  - (iii) Destruction or value depreciation of stored products.
- Pests include insects, nematodes, mites, snails, slugs, etc. and vertebrates like rats, birds, etc.

Depending upon the importance, pests may be agricultural forest, household, medical, aesthetic and veterinary pests.

### CATEGORIES OF PESTS

Based on occurrence following are pest categories

**Regular pest**: Frequently occurs on crop - Close association e.g. Rice slem borer, Brinjal fruit borer

**Occasional pest:** Infrequently occurs, no close association e.g. Caseworm on rice, Mango stem borer

**Seasonal pest:** Occurs during a particular season every year e.g. Red hairy caterpillar on groundnut, Mango hoppers

**Persistent pests**: Occurs on the crop throughout the year and is difficult to control e.g. Chilli thrips, mealy bug on guava

**Sporadic pests**: Pest occurs in isolated localities during some period. e.g. Coconut slug caterpillar

### Based on level of infestation

**Pest epidemic**: Sudden outbreak of a pest in a severe form in a region at a particular time e.g**.** BPH in Tanjore, RHC in Madurai, Pollachi

**Endemic pest**: Occurrence of the pest in a low level in few pockets, regularly and confined to particular area e.g. Rice gall midge in Madurai, Mango hoppers in Periyakulam

**Parameters of insect population levels**

**General equilibrium position (GEP)**

The average density of a population over a long period of time, around which the pest population over a long period of time, around which the pest population tends to fluctuate due to biotic and abiotic factors and in the absence of permanent environmental changes.

**Economic threshold level (ETL)**

Population density at which control measure should be implemented to prevent an increasing pest population from reaching the ETL.

**Economic injury level (EIL)**

The lowest population density that will cause economic damage

**Damage boundary (DB)**

The lowest level of damage which can be measured. ETL is always less than EIL. Provides sufficient time for control measures.

**PEST CATEGORIES ACCORDING TO EIL, GEP AND DB**

**(i) Key pest**

- Most severe and damaging pests
- GEP lies above EIL always
- Spray temporarily bring population below EIL
- These are persistent pests
- The environment must be changed to bring GEP below EIL

  e.g. Cotton bollworm, Diamond backmoth

**(ii) Major pest**

- GEP lies very close to EIL or coincides with EIL
- Economic damage can be prevented by timely and repeated sprays e.g. Cotton jassid, Rice stem borer

**(iii) Minor pest/Occasional pest**

- GEP is below the EIL usually
- Rarely they cross EIL
- Can be controlled by spraying e.g. Cotton stainers, Rice hispa, Ash weevils

**(iv) Sporadic pests**

- GEP generally below EIL
- Sometimes it crosses EIL and cause severe loss in some places/periods e.g. Sugarcane pyrilla, White grub, Hairy caterpillar

**(v) Potential pests**

- They are not pests at present
- GEP always less than EIL
- If environment changed may cause economic loss e.g. *S. litura* is potentia pest in North India

## CAUSES OF PEST OUTBREAK

Activity of human beings which upsets the biotic balance of ecosystem is the prime cause for pest outbreak. The following are some human interventions - Reason fro outbreak

**i. Deforestation an bringing under cultivation**

- Pest feeding on forest trees are forced to feed on cropped
- Biomass/unit area more in forests than agricultural land
- Weather factors also altered - Affects insect development

**ii. Destruction of natural enemies**

- Due to excess use of insecticides, natural enemies are killed
- This affects the natural control mechanism and pest outbreak occurs, e.g. Synthetic pyrethroid insecticides kill NE.

**iii. Intensive and Extensive cultivation**

Monoculture (Intensive) leads to multiplication of pests

Extensive cultivation of susceptible variety in large area - No competition for food - multiplication increases

e.g. Stem borers in rice and sugarcane

**iv. Introduction of new varieties and crops.**

Varieties with favourable physiological and morphological factors cause multiplication of insects. e.g.

Succulent, dwarf rice varieties favour leaf folder

Combodia cotton favours stem weevil and spotted bollworm

Hybrid sorghum (CSH 1), cumbu (HB1) favour shoot flies and gall midges

**v. Improved agronomic practices**

Increased N fertilizer - High leaf folder incidence on rice
Closer planting - BPH and leaf folder increases
Granular insecticides - Possess phytotonic effect on rice

**vi. Introduction of new pest in new environment**

Pest multiplies due to absence of natural enemies in new area
Apple wooly aphid *Eriosoma lanigerum* multiplied fast due to absence of *Aphelinus mali* (Parasit)

**vii. Accidental introduction of pests from foreign countries (through air/sea ports) e.g.**

a. Diamondback moth on cauliflower (*Plutella xylostella*)
b. Potato tuber moth *Phthorimaea operculella*
c. Cottony cushion scale *Icerya purchasi* on wattle tree
d. Wooly aphid - *Eriosoma lanigerum* on apple
e. Psyllid - *Heteropsylla cubana* on subabul
f. Spiralling whitefly - *Adeyrodichus dispersus* on most of horticultural crops

**viii. Large scale storage of food grains** Serve as reservoir for stored grain pests
Urbanisation - changes ecological balance
Rats found in underground drainage

**Resurgence**

Tremendous increase in pest population brought about by insecticides despite good initial reduction in pest population at the time of treatment.

Deltamethrin, Quinalphos, Phorate - Resurgence of BPH in rice
Synthetic pyrethroids - Whitefly in cotton
Carbofuran - Leaf folder in rice

Losses caused by pests
Crop loss from all factors - 500 billion US $ annually world wide
Insect pests - 15.6% loss of production
Plant pathogens - 13.3%
Weeds - 13.2%

**Estimated crop loss in various crops in India**

| | **Crop** | Loss in yield % |
|---|---|---|
| 1. | Wheat | 3.0 |
| 2. | Rice | 10.0 |
| 3. | **Maize** | 5.0 |
| 4. | Sorghum | 5.0 |
| 5. | Cotton | 18.0 |
| 6. | Pulses, groundnut | 5.0 |
| 7. | Sugarcane | 10.0 |
| 8. | Coffee | 8.0 |
| 9. | Fruits | 25.0 |
| 10. | Coconut | 5.0 |

Source: (Pradhan (1964)

**Estimated annual crop loss in India by insect pests = Rs.29,240 crores**

(Dhaliwal and Arora, 1996)

**Lecture 12**: **PEST MONITORING - PEST SURVEILLANCE AND FORECASTING - OBJECTIVES, SURVEY, SAMPLING, TECHNIQUES AND DECISION MAKING - ETL AND EIL. FACTORS INFLUENCING EIL AND ETL.**

**Pest Monitoring**

Monitoring phytophagous insects and their natural enemies is a fundamental tool in IPM - for taking management decision

Monitoring - estimation of changes in insect distribution and abundance

- information about insects, life history
- influence of biotic and abiotic factors on pest population

**Pest Surveillance**

Refers to the constant watch on the population dynamics of pests, its incidence and damage on each crop at fixed intervals to forewarn the farmers to take up timely crop protection measures.

**Three basic components of pest surveillance**

**Determination of**

a. the level of incidence of the pest species
b. the loss caused by the incidence
c. the economic benefits, the control will provide

**Pest Forecasting**

Forecasting of pest incidence or outbreak based on information obtained from pest surveillance.

**Uses**

- Predicting pest outbreak which needs control measure
- Suitable stage at which control measure gives maximum protection

**Two types of pest forecasting**

a. Short term forecasting - Based on 1 or 2 seasons
b. Long term forecasting - Based on affect of weather parameters on pest

**Objectives of Pest Surveillance**

to know existing and new pest species
to assess pest population and damage at different growth stage of crop
to study the influence of weather parameters on pest
to study changing pest status (Minor to major)
to assess natural enemies and their influence on pests
effect of new cropping pattern and varieties on pest

**Survey**

Conducted to study the abundance of a pest species

**Two types of survey - Roving survey and fixed plot survey**

**Roving survey**

- Assessment of pest population/damage from randomly selected spots representing larger area
- Large area surveyed in short period
- Provides information on pest level over large area

**Fixed plot survey**

Assessment of pest population/damage from a fixed plot selected in a field. The data on pest population/damage recorded periodic from sowing till harvest. e.g. 1 sq.m. plots randomly selected from 5 spots in one acre of crop area in case of rice. From each plot 10 plant selected at random. Total tillers and tillers affected by stem borer in these 10 plants counted. Total leaves and number affected by leaf folder observed. Damage expressed as per cent damaged tillers or leaves. Population of BPH from all tillers in 10 plants observed and expressed as number/tiller.

*Qualitative survey - Useful for detection of pest*

Quantitative survey - Useful for enumeration of pest

**Sampling Techniques**

*Absolute sampling - To count all the pests occurring in a plot*

*Relative sampling - To measure pest in terms of some values which can be compared* over time and space e.g. Light trap catch, Pheromone trap

**Methods of sampling**

a. *In situ* counts - Visual observation on number of insects on plant canopy (either entire plot or randomly selected plot)

b. Knock down (Sudden trap) - Collecting insects from an area by removing from crop and counting (Jarring)

c. Netting - Use of sweep net for hoppers, odonates, grasshopper

d. Norcotised collection - Quick moving insects anaesthesised and counter

e. Trapping - Light trap - Phototropic insects

*Pheromone trap - Species specific*

*Sticky trap - Sucking insects*

*Bait trap - Sorghum shootfly - Fishmeal trap*

Emergence trap - For soil insects

f. Crop samples

*Plant parts removed and pest counted e.g. Bollworms*

**Stage of Sampling**

- Usually most injurious stage counted
- Sometimes egg masses counted - Practical considerations
- Hoppers - Nymphs and adult counted

**Sample Size**

- Differs with nature of pest and crop
- Parger sample size gives accurate results

**Decision Making**

- Population or damage assessed from the crop
- Compared with ETL and EIL
- When pest level crosses ETL, control measure has to be taken to prevent pest from reducing EIL.

**Economic Injury Level**

- Defined as the lowest population density that will cause economic damage (Stern *et al*., 1959)
- Also defined as a critical density where the loss caused by the pest equals the cost of control measure

EIL can be calculated using following formula

$$EIL = \frac{\mathbf{C}}{V \times I \times D \times K} \quad \text{(or)} \quad \frac{\mathbf{C}}{VIDK}$$

where,

EIL = Economic injury level in insects/production (or) insects/ha

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

V = Market value per unit of yield or product (Rs./tonne)

I = Crop injury per insect (Per cent defoliation/insect)

D = Damage or yield loss per unit of injury (Tonne loss/% defoliation)

K = Proportionate reduction in injury from pesticide use

Worked examples of EIL

Calculate EIL in terms of pest population/ha with following figures

C = Management cost per unit area = Rs.3,000/- per ha

V = Market value in Rs./unit product = Rs.1,000/tonne

I = Crop injury/pest density = 1% defoliation/100 insects

D = Loss caused by unit injury = 0.05 tonne loss/1% defoliation

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

$$EIL = \frac{C}{VIDK} = \frac{3000}{1000 \times 0.01 \times 0.05 \times 0.8}$$

EIL = 7500 insects/ha

**Economic threshold level (ETL) or Action threshold**

- ETL is defined as the pest density at which control measures should be applied to prevent an increasing pest population from reaching Economic Injury Level (EIL)
- ETL represents pest density lower than EIL to allow time for initiation of control measure

**Factors Influencing ETL and EIL**

| | | |
|---|---|---|
| a. Market value of crop | } | Primary factors |
| b. Management costs | | |
| c. Degree of injury per insect | } | Secondary factors |
| d. Crop susceptibility to injury | | |

a. Market value of crop

*When crop value increases, EIL decreases and vice-versa*

b. Management of injury per insect

*When management costs increase, EIL also increases*

c. Degree of injury per insect

- Insects damaging leaves or reproductive parts have different EIL (Lower EIL for Rep. part damages)
- If insects are vectors of disease EIL is very low even 1 or 2 insects if found - management to be taken
- If insects found on fruits - Marketability reduced - EIL very low e.

Crop susceptibility to injury

- If crop can tolerate the injury and give good yield. EIL can be fixed at a higher value
- When crop is older, it can withstand high pest population - EIL can be high

Tertiary factors

Weather, soil factors, biotic factors and human social environment

These tertiary factors cause change in secondary factors thereby affect the ETL and EIL.

## Lecture 13: PEST MANAGEMENT - DEFINITION - NEED - OBJECTIVES - REQUIREMENTS FOR SUCCESSFUL PEST MANAGEMENT PROGRAMME - COMPONENTS OF PEST MANAGEMENT

**Pest Management (or) Integrated Pest Management –**
**Definition IPM definition by FAO (1967)**

Integrated Pest Management (IPM) is a system that, in the context of associated environment and population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economic injury.

**IPM definition by Luckmann and Metcalf (1994)**

IPM is defined as the intelligent selection and use of pest control tactics that will ensure favourable economical, ecological and sociological consequences.

**Need for Pest Management (or) Why Pest Management**

1. Development of resistance in insects against insecticides e.g. OP and synthetic pyrethroid resistance in *Helicoverpa armigera*.
2. Out break of secondary pests e.g. Whiteflies emerged as major pest when spraying insecticide against *H. armigera*.
3. Resurgence of target pests e.g. BPH of rice increased when some OP chemicals are applied.
4. When number of application increases, profit decreases.
5. Environmental contamination and reduction in its quality.
6. Killing of non-target animals and natural enemies.
7. Human and animal health hazards.

**Stages in crop protection leading to IPM**

| | | | |
|---|---|---|---|
| 1. | Subsistence phase | : | Only natural control, no insecticide use |
| 2. | Exploitation phase | : | Applying more pesticides, growing HY varieties and get more yield and returns |
| 3. | Crisis phase | : | Due over use pesticides, problem of resurgence, resistance, secondary pest out break, increase in production cost |
| 4. | Disaster phase | : | Due to increased pesticide use - No profit, high residue in soil - Collapse of control system |
| 5. | Integrated Management Phase | : | IPM integrates ecofriendly methods to optimize control rather than maximise it. |

**Objectives of pest management**

1. To reduce pest status below economic injury level. Complete elimination of pest is not the objective.
2. To manage insects by not only killing them but by preventing feeding, multiplication and dispersal.
3. To use ecofriendly methods, which will maintain quality of environment (air, water, wild life and plant life)
4. To make maximum use of natural mortality factors, apply control measures only when needed.
5. To use component in sustainable crop production.

**Requirements for successful pest management programme**

1. Correct identification of insect pests
2. Life history and behaviour of the pest
3. Natural enemies and weather factors affecting pest population
4. Pest surveillance will provide above data
5. Pest forecasting and predicting pest outbreak
6. Finding out ETL for each pest in a crop
7. Need and timing of control measure - Decision
8. Selection of suitable methods of control
9. Analysis of cost/benefit and benefit/risk of each control measure
10. Farmer's awareness and participation
11. Government support
12. Consumer awareness on use of pesticides free products

**TOOLS OR COMPONENTS OF INTEGRATED PEST MANAGEMENT (Arranged in increasing order of complexity)**

i. Cultural method or use of agronomic practices

1. Crop rotation
2. Crop refuse destruction
3. Tillage of soil
4. Variation in time of planting or harvesting
5. Pruning or thinning
6. Fertilizer management
7. Water management
8. Intercropping
9. Trap crop

ii. Host plant resistance - Antixenosis, antibiosis, tolerance

iii. Mechanical methods of pest control

1. Hand destruction
2. Exclusion by screens, barriers
3. Trapping, suction devices, collecting machine
4. Crushing and grinding

iv. Physical methods

1. Heat
2. Cold
3. Energy - light trap, irradiation, light regulation
4. Sound

v. Biological methods

1. Protection and encouragement of NE
2. Introduction, artificial increase and colonizing specific parasitoids and predators
3. Pathogens on insects like virus, bacteria, fungi and protozoa
4. Use of botanicals like neem, pongam, etc.

vi. Chemical methods

1. Attractants
2. Repellents
3. Insecticides - OC, OP, carbamates, pyrethroids, etc.
4. Insect growth inhibitors
5. Chemosterilants

vii.Behavioural methods

1. Pheromones
2. Allelochemics

viii. Genetic/biotechnology method

- Release of genetically incompatible/sterile pests
- Transgenic plant

ix. Regulatory/legal method

- Plant/animal quarantine
- Eradication and suppression programme

## Lecture 14: TRADITIONAL METHODS OF PEST CONTROL

### CULTURAL CONTROL

**Definition** : Manipulation of cultural practices to the disadvantage of pests.

**I. Farm level pratices**

| S.No. | Cropping Techniques | Pest Checked |
|---|---|---|
| 1. | Ploughing | Red hairy caterpillar |
| 2. | Puddling | Rice mealy bug |
| 3. | Trimming and plastering | Rice grass hopper |
| 4. | Pest free seed material | Potato tuber moth |
| 5. | High seed rate | Sorghum shootfly |
| 6. | Rogue space planting | Rice brown planthopper |
| 7. | Plant density | Rice brown planthopper |
| 8. | Earthing up | Sugarcane whitefly |
| 9. | Detrashing | Sugarcane whitefly |
| 10. | Destruction of weed hosts | Citrus fruit sucking moth |
| 11. | Destruction of alternate host | Cotton whitefly |
| 12. | Flooding | Rice armyworm |
| 13. | Trash mulching | Sugarcane early shoot borer |
| 14. | Pruning / topping | Rice stem borer |
| 15. | Intercropping | Sorghum stem borer |
| 16. | Trap cropping | Diamond back moth |
| 17. | Water management | Brown planthopper |
| 18. | Judicious application of fertilizers | Rice leaf folder |
| 19. | Timely harvesting | Sweet potato weevil |

**II. Community level practices**

1. Synchronized sowing : Dilution of pest infestation (eg) Rice, Cotton
2. Crop rotation : Breaks insect life cycle
3. Crop sanitation
   a) Destruction of insect infested parts (eg.) Mealy bug in brinjal
   b) Removal of fallen plant parts (eg.) Cotton squares
   c) Crop residue destruction (eg.) Cotton stem weevil

| Advantages | | Disadvantages | |
|---|---|---|---|
| 1. | No extra skill | 1. | No complete control |
| 2. | No costly inputs | 2. | Prophylactic nature |
| 3. | No special equipments | 3. | Timing decides success |
| 4. | Minimal cost | | |
| 5. | Good component in IPM | | |
| 6. | Ecologically sound | | |

## PHYSICAL CONTROL

Modification of physical factors in the environment to minimise (or) prevent pest problems. Use of physical forces like temperature, moisture, etc. in managing the insect pests.

### A. Manipulation of temperature

1. Sun drying the seeds to kill the eggs of stored product pests.
2. Hot water treatment (50 - 55$^{o}$C for 15 min) against rice white tip nematode.
3. Flame throwers against locusts.
4. Burning torch against hairy caterpillars.
5. Cold storage of fruits and vegetables to kill fruitflies (1 - 2$^{o}$C for 12 - 20 days).

### B. Manipulation of moisture

1. Alternate drying and wetting rice fields against BPH.
2. Drying seeds (below 10% moisture level) affects insect development.
3. Flooding the field for the control of cutworms.

### C. Manipulation of light

1. Treating the grains for storage using IR light to kill all stages of insects (eg.) Infra-red seed treatment unit (Fig.1).
2. Providing light in storage go downs as the lighting reduces the fertility of Indian meal moth, *Plodia.*
3. Light trapping.

### D. Manipulation of air

1. Increasing the $CO_2$ concentration in controlled atmosphere of stored grains to cause asphyxiation in stored product pests.

### E. Use of irradiation

Gamma irradiation from $Co^{60}$ is used to sterilize the insects in laboratory which compete with the fertile males for mating when released in natural condition. (eg.) cattle screw worm fly, *Cochliomyia hominivorax* control in Curacao Island by E.F.Knipling.

**F. Use of greasing material**

Treating the stored grains particularly pulses with vegetable oils to prevent the oviposition and the egg hatching. eg., bruchid adults.

**G. Use of visible radiation :** Yellow colour preferred by aphids, cotton whitefly : yellow sticky traps.

**H. Use of Abrasive dusts**

1. Red earth treatment to red gram : Injury to the insect wax layer.
2. Activated clay : Injury to the wax layer resulting in loss of moisture leading to death. It is used against stored product pests.
3. Drie-Die : This is a porous finely divided silica gel used against storage insects.

**Preparation of activated clay :**

Kaolinite clay

↓

POWDERING

↓

ACID ACTIVATION

In $H_2SO_4$ 10 N

↓

DIGESTION (Autoclave - 1 hr in 15 lb)

↓

WASHING

↓

DRYING

↓

POWDERING AND SIEVING IN 100 MESH HEAT

↓

ACTIVATION (Muffle furnace - 4hrs at $400^oC$)

↓

ACTIVATED CLAY

**MECHANICAL CONTROL**

Use of mechanical devices or manual forces for destruction or exclusion of pests.

**A. Mechanical destruction :** Life stages are killed by manual (or) mechanical force.

**Manual Force**

1. Hand picking the caterpillars
2. Beating : Swatting housefly and mosquito
3. Sieving and winnowing : Red flour beetle (sieving) rice weevil (winnowing)
4. Shaking the plants : Passing rope across rice field to dislodge caseworm and shaking neem tree to dislodge June beetles
5. Hooking : Iron hook is used against adult rhinoceros beetle
6. Crushing : Bed bugs and lice
7. Combing : Delousing method for Head louse
8. Brushing : Woolen fabrics for clothes moth, carper beetle.

**Mechanical force**

1. **Entoletter :** Centrifugal force - breaks infested kernels - kill insect stages - whole grains unaffected - storage pests.
2. Hopper dozer : Kill nymphs of locusts by hording into trenches and filled with soil.
3. Tillage implements : Soil borne insects, red hairy caterpillar.
4. Mechnical traps : Rat traps of various shapes like box trap, back break trap, wonder trap, Tanjore bow trap.

**B. Mechanical exclusion**

Mechanical barriers prevent access of pests to hosts.

1. Wrapping the fruits : Covering with polythene bag against pomegrante fruit borer.
2. Banding : Banding with grease or polythene sheets - Mango mealybug.
3. Netting : Mosquitoes, vector control in green house.
4. Trenching : Trapping marching larvae of red hairy catepiller.
5. Sand barrier : Protecting stored grains with a layer of sand on the top.
6. Water barrier : Ant pans for ant control.
7. Tin barrier : Coconut trees protected with tin band to prevent rat damage.
8. Electric fencing : Low voltage electric fences against rats.

| **Advantage of mechanical control** | **Disadvantages** |
|---|---|
| 1. Home labour utilization | 1. Limited application |
| 2. Low equipment cost | 2. Rarely highly effective |
| 3. Ecologically safe | 3. Labour intensive |
| 4. High technical skill not required in adopting. | |

**Appliances in controlling the pests**

1. Light traps : Most adult insects are attracted towards light in night. This principle is used to attract the insect and trapped in a mechanical device.

a) Incandescent light trap : They produce radiation by heating a tungsten filament. The spectrum of lamp include a small amount of ultraviolet, considerable visible especially rich in yellow and red. (eg.) Simple incandescent light trap (Fig. 2), portable incandescent electric (Fig.3). Place a pan of kerosenated water below the light source.

b) Mercury vapour lamp light trap : They produce primarily ultraviolet, blue and green radiation with little red. (eg.) Robinson trap (Fig.4). This trap is the basic model designed by Robinson in 1952. This is currently used towards a wide range of Noctuids and other nocturnal flying insects. A mercury lamp (125 W) is fixed at the top of a funnel shaped (or) trapezoid galvanized iron cone terminating in a collection jar containing dichlorvos soaked in cotton as insecticide to kill the insect.

c) Black light trap : Black light (Fig.5) is popular name for ultraviolet radiant energy with the range of wavelengths from 320-380 nm. Some commercial type like Pest-O-Flash, Keet-O-Flash are available in market. Flying insects are usually attracted and when they come in contact with electric grids, they become elctrocuted and killed.

2. Pheromone trap : Synthetic sex pheromones are placed in traps to attract males. The rubberised septa, containing the pheromone lure are kept in traps designed specially for this purpose and used in insect monitoring / mass trapping programmes. Sticky trap (Fig.6), water pan trap (Fig.7) and funnel type (Fig.8) models are available for use in pheromone based insect control programmes.

3. Yellow sticky trap : Cotton whitefly, aphids, thrips prefer yellow colour. Yellow colour is painted on tin boxes and sticky material like castor oil / vaseline is smeared on the surface (Fig.9). These insects are attracted to yellow colour and trapped on the sticky material.

4. Bait trap : Attractants placed in traps are used to attract the insect and kill them. (eg.) Fishmeal trap: This trap is used against sorghum shootfly. Moistened fish meal is kept in polythene bag or plastic container inside the tin along with cotton soaked with insecticide (DDVP) to kill the attracted flies (Fig.10&11).

5. Pitfall trap helps to trap insects moving about on the soil surface, such as ground beetles, collembola, spiders. These can be made by sinking glass jars

(or) metal cans into the soil. It consists of a plastic funnel, opening into a plastic beaker containing kerosene supported inside a plastic jar (Fig. 12).

6. Probe trap : Probe trap is used by keeping them under grain surface to trap stored product insect (Fig.13).

7. Emergence trap : The adults of many insects which pupate in the soil can be trapped by using suitable covers over the ground. A wooden frame covered with wire mesh covering and shaped like a house roof is placed on soil surface. Emerging insects are collected in a plastic beaker fixed at the top of the frame (Fig.14).

8. Indicator device for pulse beetle detection : A new cup shaped indicator device has been recently designed to predict timely occurrence of pulse beetle *Callosobruchus spp.* This will help the farmers to know the correct time of emergence of pulse beetle. This will help them in timely sun drying which can bill all the eggs.

TAMIL NADU AGRICULTURAL UNIVERSITY
CENTRE FOR PLANT PROTECTION STUDIES
DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

**MID-SEMESTER EXAMINATION – MODEL QUESTION PAPER**

AEN 201. Principles of Applied Entomology (2+1)

Date : 14-6-2002
Time : 1hr.
Marks : 20

**PART- A**

Match the following (any eight) 8 x 0.5 = 4

| | | | |
|---|---|---|---|
| A1. | Drones | - | Pollination by honeybees |
| A2. | Sun drying of foodgrains | - | Transmits bubonic plague |
| A3. | Sudden outbreak of pest | - | Inactivity of insects in winter |
| A4. | Gause's principle | - | Emerge from unfertilized eggs |
| A5. | Myiasis | - | Communication in bees |
| A6. | Newspaper method | - | Pest epidemic |
| A7. | Mellitophily | - | Competitive exclusion |
| A8. | Rat flea | - | Infestation of tissues by maggots |
| A9. | Karl von Frisch | - | Kills stored product insects |
| A10. | Hibernation | - | Uniting bee colonies |

**PART - B**

Answer any six 6 x 1 = 6

B1. Wagtail dance

B2. Supercedure

B3. Management of mosquitoes

B4. Key pest and potential pest

B5. ETL and EIL

B6. Roving survey and fixed plot survey

B7. Delousing cattle and birds

B8. Ripening of honey

**PART - C**

Answer any five 5 x 2 = 10

C1. Draw a flow chart to show economic classification of insects

C2. List 5 major differences between rock bee (*Apis dorsata*) and Indian bee (*Apis cerana indica)*

C3. Discuss the ways to reduce pesticidal poisoning to bees.

C4. Write in brief the causes for pest outbreak

C5. Discuss pollination in fig by fig wasp

C6. Define IPM. Give a diagrammatic representation of various components of IPM

C7. Define cultural method of pest control. Mention any eight farm level cultural practices with examples

WISH YOU ALL THE BEST

**Lecture 15 LEGAL CONTROL METHODS - DEFINITION - PEST INTRODUCTIONS - QUARANTINE - PHYTOSANITARY CERTIFICATE PEST LEGISLATION LEGAL CONTROL/LEGISLATIVE CONTROL/REGULATORY CONTROL**

Definition: Preventing the entry and establishment of foreign plant and animal pest in a country or area and eradication or suppression of the pests established in a limited area through compulsory legislation or enactment

**Pests Accidentally Introduced Into India**

1. Pink bollworm - *Pectinophora gossypiella*
2. Cotton cushion scale - *Icerya purchasi*
3. Wooly aphid of apple - *Aphelinus mali*
4. SanJose scale - *Quadraspidiotus perniciosus*
5. Potato tuber moth - *Gnorimoschima operculella*
6. Cyst (Golden) nematode of potato - *Globodera* sp.
7. Giant african snail - *Acatina fullica*
8. Subabul psyllid - *Heteropsylla cubana*
9. Bunchytop disease of banana
10. Spinalling whitefly - *Aleyrodicus dispersus*

**Foreign Pests From Which India Is Free**

Mediterranean fruitfly - *Ceratitis capitata*
Grapeavine phylloxera
Cotton boll weevil - *Anthonomos grandis*
Codling moth of apple - *Lasperysia pomonella*

**Quarantine**

Isolation to prevent spreading of infection

**Plant Quarantine**

Legal restriction of movement of plant materials between countries and between states within the country to prevent or limit introduction and spread of pests and diseases in areas where they do not exist.

PEST LEGISLATIONS

1905 - 'Federal Insect Pest Act' - first Quarantine act against SanJose scale
1912 - 'US Plant Quarantine Act'
1914 - 'Destructive Insects and Pests Act' of India (DIPA)
1919 - 'Madras Agricultural Pests and Diseases Act'
1968 - 'The Insecticides Act'

DIFFERENT CLASSES OF QUARANTINE

**Foreign Quarantine (Legislation to prevent the introduction of new pests, diseases and weeds from foreign countries)**

Plant quarantine inspection and treatments at sea ports of Mumbai, Kolkata, Cochin, Chennai and Visakapattinam and airports of Amritsar, Mumbai, Kolkata, Chennai and New Delhi

Import by post parcel prohibited except by scientists

Import of plant materials prohibited or restricted

Import permits required for importation of plant material

Phytosanitary certificate from the country of origin is required

**Phytosanitary certificate** is issued by State Entomologist and Pathologists to the effect that the plant or seed material is free from any pest or disease

a. Fumigation of imported plant material based on need
b. Taking care of pests of quarantine concern in India

**Restriction imposed on the importation of**

i. Sugarcane setts - to prevent West Indies sugar weevil
ii. Coffee seeds - to prevent coffee berry borer
iii.Cotton seeds - to prevent cotton boll weevil

a. Export of pepper, cardamom and tamarind restricted
b. In 1946, Directorate of Plant Protection, Quarantine and Storage, Government of India established - for inspection of export and import of agricultural commodities.

2. **Domestic quarantine** (within different parts of country)

- Flutted scale *Icerya puchasi* noticed in Nilgiris and Kodaikanal in 1943 in Wattle trees. Quarantine stations at Mettupalayam and Gudalur for Nilgiris and Shenbaganur for Kodaikanal to prevent spread of flutted scale in TN.
- Preventing movement of Banana from Palani hills to prevent Bunchy top spread

3. **Legislation to take up effective measures to prevent spread of established pests** Example: Cotton stem weevil, Groundnut RHC, Coffee stem borer, Coconut black headed caterpillar (BHC), Sugarcane top borer.

**i. Stem weevil of cotton (Combodia cotton, 1913)**

Previous crop to be removed before Aug.1

Next crop to be sown not before Sep. 1 to keep land free of cotton for sometime

**ii. RHC of groundnut (1930)**

- Collection of pupae in summer ploughing
- Putting light traps and bonfires
- Hand picking of egg and larvae
- Spread leaves in field, trench, collect and destroy

**iii. Stem borer of coffee** (1946)

This act is still in force in Salem, Coimbatore, Madurai and Nilgiris

- All infested plants to be removed and destroyed by 15th December every year
- Swabbing with wettable powder (Carbaryl) on stem and branch

**Legislation to prevent the adulteration and misbranding of insecticides and to determine the permissible residues in food stuff.**

**Legislation to regulate the activities of men engaged in pest control**

**THE INSECTICIDES ACT, 1968**

- Implemented in 1971 (Insecticides Rule, 1971)
- Safety oriented legislation
- Regulates import, manufacture, storage, transport, sale, distribution and use of insecticides with a view to prevent risk to human beings and animals
- Regulatory provision - compulsory registration, licensing, inspection, drawal and analysis of samples, detention, seizure and confiscation of stocks, suspension and cancellation of licences, etc.
- Enforcement of the act is joint responsibility of central and state governments.
- Statutory bodies
- (i) Central Insecticides Board (CIB) (28 members)
  Chairman (CIB) - Director General of Health Services
  (ii) Registration Committee (RC) (5 members)
  Chairman (RC) - Deputy Director General, Crop Sciences, ICAR

Salient features of the insecticides act (1968)

- Compulsory registration with CIB (Central level)
- Licence for manufacture, formulation and sale at state level
- Inter departmental/Ministerial/Organisational co-ordination achieved by high level Advisory Board "Central Insecticides Board" with 28 members form various fields
- RC to lookafter registration aspects of insecticides
- Enforcement by Insecticide inspectors at state/central level
- Power to prohibit the import, manufacture and sale of insecticides and also confiscate stocks. Guilty are punishable.

**Role of Plant Quarantine in the Export of Agricultural Commodities**

International Plant Protection Convention (1951) of FAO, UN.

Article V of the convention makes it mandatory for member countries to issue Phytosanitory certificate (PSC)

PSC should be conformity with Plant Quarantine Regulations of importing country.

Agricultural commodities during export should be accompanied by PSC.

**General requirement of PSC**

- Inspected agrl. commodities should be free from pest/diseases
- Takes time for inspection - seek prior guidance from plant quarantine authorities in India

**Special requirements of PSC**

- Additional declarations required from importing country for freedom of commodities from specific pests/diseases
- Obtain complete details of requirements of importing country

**Technical limitations**

- Rules not relaxable. No compromise with principles of Plant Quarantine.

**Procedure for getting PSC**

- Application to be submitted to Plant Quarantine and Fumigation station
- Will be scrutinised, samples drawn and examined for pest, diseases, weeds
- If free PSC issued
- If found infested - rejected, PSC not issued
- Sometimes treatment (fumigation) given and PSC issued

**Authority to issue PSC**

Union Govt. of Agrl. has authorised officers in Central and State Govt. and UT
PPA to Govt. of India - Heads of Unit

| Airports | Seaports | Land frontiers |
|---|---|---|
| Amristar | Bombay | Amristar Rail |
| Bombay | Tuticorin | Attari Rail |
| Calcutta | Bhavnagar | Attari Road |
| Hyderabad | Calcutta | Bongaon |
| Chennai | Cochin | Gede |
| New Delhi | Chennai | Kalimpong |
| Patna | Nagapattinam | Panitanki |
| Varanasi | Rameswaram | |
| Tiruchirapalli | Visakhapatnam | |
| Trivandrum | | |

**Lecture 16** : **HOST PLANT RESISTANCE - DEFINITION - TYPES AND MECHANISMS ECOLOGICAL AND GENETIC RESISTANCE**

**Host Plant Resistance (HPR)**

**Definition**

"Those characters that enable a plant to avoid, tolerate or recover from attacks of insects under conditions that would cause greater injury to other plants of the same species" (Painter, R.H., 1951).

"Those heritable characteristics possessed by the plant which influence the ultimate degree of damage done by the insect" (Maxwell, F.G., 1972).

**Types of Resistance**

**Ecological Resistance or Pseudo resistance**

Apparent resistance resulting from transitory characters in potentially susceptible host plants due to environmental conditions.

Pseudoresistance may be classified into 3 categories

a**. Host evasion**

Host may pass through the most susceptible stage quickly or at a time when insects are less or evade injury by early maturing. This pertains to the whole population of host plant.

**b. Induced Resistance**

Increase in resistance temporarily as a result of some changed conditions of plants or environment such as change in the amount of water or nutrient status of soil

**c. Escape**

Absence of infestation or injury to host plant due to transitory process like incomplete infestation. This pertains to few individuals of host.

**Genetic Resistance**

**A. Based on number of genes**

- Monogenic resistance: Controlled by single gene
  Easy to incorporate into plants by breeding
  Easy to break also
- Oligogenic resistance: Controlled by few genes
- Polygenic resistance: Controlled by many genes
- Major gene resistance: Controlled by one or few major genes (vertical resistance)
- Minor gene resistance: Controlled by many minor genes. The cumulative effect of minor genes is called adult resistance or mature resistance or field resistance. Also called horizontal resistance

B. **Based on biotype reaction**

- Vertical resistance: Effective against specific biotypes (specific resistance)
- Horizontal resistance: Effective against all the known biotypes
  (Non specific resistance)

**C. Based on population/Line concept**

- Pureline resistance: Exhibited by liens which are phenotypically and genetically similar
- Multiline resistance: Exhibited by lines which are phenotypically similar but genotypically dissimilar

**D. Miscellaneous categories**

- Cross resistance: Variety with resistance incorporated against a primary pest, confers resistance to another insect.
- Multiple resistance: Resistance incorporated in a variety against different environmental stresses like insects, diseases, nematodes, heat, drought, cold, etc.

**E. Based on evolutionary concept**

- Sympatric resistance: Acquired by coevolution of plant and insect (gene for gene) Governed by major genes
- Allopatric resistance: Not by co-evolution of plant and insect. Governed by many genes

**Mechanisms of Resistance**

The three important mechanisms of resistance are

- Antixenosis (Non preference)
- Antibiosis
- Tolerance

**Antixenosis:** Host plant characters responsible for non-preference of the insects for shelter, oviposition, feeding, etc. It denotes presence of morphological or chemcial factor which alter insect behaviour resulting in poor establishment of the insect. e.g.

Trichomes in cotton - resistant to whitefly

Wax bloom on carucifer leaves - deter feeding by DBM

Plant shape and colour also play a role in non preference

Open panicle of sorghum - Supports less Helicoverpa

**Antibiosis**

Adverse effect of the host plant on the biology (survival, development and reproduction) of the insects and their progeny due to the biochemical and biophysical factors present in it.

Manifested by larval death, abnormal larval growth, etc.

Antibiosis may be due to

- Presence of toxic substances
- Absence of sufficient amount of essential nutrients
- Nutrient imbalance/improper utilization of nutrients

Chemical factors in Antibiosis - Examples

| | Chemicals present in plants | Imparts resistance against |
|---|---|---|
| 1. | DIMBOA (Dihydroxy methyl benzoxazin) | Against European corn borer, *Ostrinia nubilalis* |
| 2. | Gossypol (Polyphenol) | *Helicoverpa armigera* (American bollworm) |
| 3. | Sinigrin | Aphids, *Myzus persicae* |
| 4. | Cucurbitacin | Cucurbit fruit flies |
| 5. | Salicylic acid | Rice stem borer |

Physical factors in antibiosis
Thick cuticle, glandular hairs, silica deposits, tight leaf sheath, etc.

**c. Tolerance**
Ability to grow and yield despite pest attack. It is generally attributable to plant vigour, regrowth of damaged tissue, to produce additional branches, compensation by growth of neighbouring plants.

**Use of tolerance in IPM**
- Tolerant varieties have high ETL - require less insecticide
- Apply less selection pressure on pests. Biotype development is less

**HPR in IPM**
- HPR is a very important component of IPM
- Selection and growing of a resistant variety minimise cost on all other pest management activities

**Compatibility of HPR in IPM**

**a. Compatability with chemical control**
- HPR enhances efficacy of insecticides
- Higher mortality of leaf hoppers and plant hoppers in resistant variety compared to susceptible variety
- Lower concentration of insecticide is sufficient to control insects on resistant variety

**b. Compatibility with biological control**
- Resistant varieties reduce pest numbers - thus shifting pest: Predatory (or parasitoid) ratio favourable for biological control. e.g. Predatory activity of mirid bug *Cyrtorhinus lividipennis* on BPH was more on a resistant rice variety IR 36 than susceptible variety IR 8
- Insects feeding on resistant varieties are more susceptible to virus disease (NPV)

**c. Compatibility with cultural method**
- Cultural practices can help in better utilization of resistant varieties. e.g. Use of short duration, pest resistant plants effective against cotton boll weevil in USA.

**Examples of resistant varieties in major crops**

| | Pest | Resistant varieties |
|---|---|---|
| Rice | Yellow stem borer | TKN 6, Paiyur 1 |
| | Brown planthopper (BPH) | CO 42, IR 36, IR 64 |
| | Green leaf hopper (GLH) | IR 50, Ptb 2, CO 46 |
| Sugarcane | Early shoot borer (ESB) | CO 312, CO 421, CO 661, |
| | Internode borer | CO 975, CO 7304 |
| | Top shoot borer | CO 745, CO 6515 |
| Cotton | American bollworm | Abhadita |
| | Spotted bollworm | Deltapine |
| | Stem weevil | MCU 3, Supriya |
| | Leaf hopper | MCU 5, K 7, K 8 |
| Sorghum | Earhead bug | K tall |
| Jasmine | Eriophyid mite | Pari Mullai |

**Advantages of HPR as a component in IPM**

Specificity: Specific to the target pest. Natural enemies unaffected

Cumulative effect: Lasts for many successive generations

Eco-friendly: No pollution. No effect on man and animals

Easily adoptable: High yielding insect resistant variety easily accepted and adopted by farmers. Less cost.

Effectiveness: Res. variety increases efficacy of insecticides and natural enemies

Compatability: HPR can be combined with all other components of IPM

Decreased pesticide application: Resistant varieties requires less frequent and low doses of insecticides

Persistence: Some varieties have durable resistance for long periods

Unique situations: HPR effective where other control measures are less effective

e.g. a. When timing of application is critical

b. Crop of low economic value

c. Pest is continuously present and is a single limiting factor

**Disadvantages of HPR**

Time consuming: Requires from 3-10 years by traditional breeding programmes to develop a res. variety.

Biotype development: A biotype is a new population capable of damaging and surviving on plants previously resistant to other population of same species.

Genetic limiation: Absence of resistance genes among available germination

**Lecture 17: BIOLOGICAL CONTROL - DEFINITION - HISTORY AND DEVELOPMENT - CLASSICAL EXAMPLES - FACTORS GOVERNING BIOLOGICAL CONTROL**

**Biological control**

**Definition**

The study and utilization of parasitoids, predators and pathogens for the regulation of pest population densities.

Biological control can also be defined as the utilization of natural enemies to reduce the damage caused by noxious organisms to tolerable levels.

Biological control is often shortened to biocontrol.

History and development of biological control and classical examples of biological control

**Antient times** - In China Pharoah's ant *Monomorium pharaonis* was used to control stored grain pest. Red ant *Oecophylla* spp. used to control foliage feeding caterpillar.

**Year 1762** - 'Mynah' bird imported from India to Mauritius to control locust.

**1770** - Bamboo runways between citrus trees for ants to control caterpillars.

**1888** - **First well planned and successful biological control attempt made**

- During 1888 citrus industry in California (USA) seriously threatened by cottony cushion scale, *Icerya purdian*
- Chemical treatments not known at that time
- Mr. C.V. Riley, a prominent entomologist suggested that the scale inset originated from Australia and natural enemy for the scale from Australia should be introduced into USA
- Mr. Albert Koebele was sent to Australia
- He found a beetle called Vedalia (*Rodolia cardinalis*) attacking and feeding on seeds
- Vedalia beetle (*Rodolia cardinalis*) was imported in November 1888 into USA and allowed on scale infested trees
- Within a year spectacular control of scale insect achieved
- Even till date this beetle controls the scale insect
- After this successful attempt of biological control many such introduction of natural enemies were tried.

**1898 - First introduction of natural enemy into India**

1898 - A coccinellid beetle, *Cryptolaemus montrouzieri* was imported into India from Australia and released against coffee green scale, *Cocus viridis*. Even today it is effective against mealybugs in South India.

1920 - A parasitoid *Aphelinus mali* introduced from England into India to control Woolly aphid on Apple, *Eriosoma lanigerum*.

1929-31 - *Fodolia cardinalis* imported into India (from USA) to control cottony cushion scale *Icerya purchasi* on Wattle trees.

1958-60 - Parasitoid *Prospatella perniciosus* imported from China

1960 - Parasitoid *Aphytis diaspidis* imported from USA

Both parasitoids used to control Apple Sanjose scale *Quadraspidiotus perniciosus*

1964 - Egg parasitoid *Telenomus* sp. imported from New Guinea to control Castor semilooper *Achaea janata*

1965 - Predator *Platymeris laevicollis* introduced from Zanzibar to control coconut Rhinoceros beetle, *Oryctes rhinoceros*

**History, development, classical examples of biocontrol**
**Till 1988**

At global level 384 importations made against 416 species of insect pests. Out of them

| | | |
|---|---|---|
| 164 species (39.4%) | - | Completely controlled |
| 75 species | - | Substantially controlled |
| 15 species | - | Partially controlled |

- Regional Station of Commonwealth Institute of Biological Control (CIBC) established at Bangalore in 1957
- Presently Project Directorate of Biological Control (PDBC) Bangalore looks after Biocontrol in India.

Factors affecting biological control

1. Tolerance limit of crop to insect injury - Successful in crops with high tolerance limit
2. Crop value - Successful in crops with high economic value
3. Crop duration - Long duration crops highly suitable
4. Indigenous or Exotic pest - Imported NE more effective against introduced pest
5. If alternate host available for NE, control of target pest is less
6. If unfavourable season occurs, reintroduction of NE required
7. Presence of hyperparasites reduces effectiveness of biocontrol

8. Tritrophic interaction of Plant-Pest-Natural enemy affects success of biocontrol, e.g. *Helicoverpa* parasitization by Trichogramma more in timato than corn
9. Use of pesticides affect natural enemies
10. Selective insecticides (less toxic to NE required)
11. Identical situation for successful control does not occur

Qualities of an effective natural enemy

1. Adaptable to the environmental condition
2. Host specific (or narrow host range)
3. Multiply faster than the host (with high fecundity)
4. Short life cycle and high female : male ratio
5. High host searching capacity
6. Amenable for easy culturing in laboratory
7. Dispersal capacity
8. Free from hyper parasites
9. Synchronise life cycle with host

Three major techniques of biological control

**1. Conservation and encouragement of indigenous NE**

Defined as actions that preserve and increase NE by environmental manipulation. e.g. Use of selective insecticides, provide alternate host and refugia for NE.

**2. Importation or Introduction**

Importing or introducing NE into a new locality (mainly to control introduced pests).

**3. Augmentation**

Propagation (mass culturing) and release of NE to increase its population. Two types,

**(i)** **Inoculative release**: Control expected from the progeny and subsequent generations only.

**(ii)** **Inundative release**: NE mass cultured and released to suppress pest directly e.g. *Trichogramma* sp. egg parasitoid, *Chrysoperla carnia* predator

**ROLE OF PARASITOIDS AND PREDATORS IN IPM**

- Parasitoids and predators may be used in Agriculture and IPM in three ways. They are
  - i) Conservation
  - ii) Introduction
  - iii) Augmentation - (a) Inoculative release, (b) Inundative release

- Since biological control is safe to environment, it should be adopted as an important component of IPM.
- Biological control method can be integrated well with other methods namely cultural, chemical methods and host plant resistance (except use of broad spectrum insecticides)
- Biological control is self propagating and self perpetuating
- Pest resistance to NE is not known
- No harmful effects on humans, livestock and other organisms
- Biological control is virtually permanent
- Biological agents search and kills the target pest

**MICROBIAL CONTROL**

- It is a branch of biological control
- Defined as control of pests by use of microorganisms like viruses, bacteria, protozoa, fungi, rickettsia and nematodes.

**I. VIRUSES**

Viruses coming under family *Baculoviridae* cause disease in lepidoptera larvae. Two types of viruses are common.

**NPV** (Nucleopolyhedro virus) e.g. HaNPV, SlNPV

**GV** (Granulovirus) e.g. CiGV

**Symptoms**

Lepidopteran larva become sluggish, pinkish in colour, lose appetite, body becomes fragile and rupture to release polyhedra (virus occlusion bodies). Dead larva hang from top of plant with prolegs attached (Tree top disease or “Wipfelkrankeit”)

**II. BACTERIA**

2 types of bacteria
- Spore forming (Facultative - Crystalliferous)
- Spore forming (Obligate)
- Non spore forming

**i. Spore forming (Facultative, Crystelliferous)**

The produce spores and also toxin (endotoxin). The endotoxin paralyses gut when ingested e.g. *Bacillus thuringiensis* effective against lepidopteran. Commercial products - Delfin, Dipel, Thuricide

**ii. Spore-forming (Obligate)**

e.g. *Bacillus popilliae* attacking beetles, produce **‘milky disease’**

Commercial product - ‘Doom’ against ‘white grubs’

**iii. Non-spore forming**

e.g. *Serratia entomophila* on grubs

**III. FUNGI**

i. Green muscardine fungus - *Metarhizium anisopliae* attack coconut rhinoceros beetle

ii. White muscardine fungus - *Beaveria bassiana* against lepidopteran larvae iii. White halo fungus - *Verticillium lecanii* on coffee green scale.

**Other Microbs: Protoza, Nematodes**

**Limitations of biocontrol technique**

- Complete control not achieved - Slow process
- Subsequent pesticide use restricted
- Expensive to culture many NE
- Requires trained man power

**Lecture 18 CHEMICAL CONTROL - DEFINITION - HISTORY AND DEVELOPMENT - TOXICITY PARAMETERS - IDEAL QUALITIES OF AN INSECTICIDE**

**Chemical Control**: Management of insect pests using chemical pesticides is termed as chemical control.

**Pesticides**: Chemicals which are used to kill pests

History of insecticide development

| Year | | *Chemicals* |
|---|---|---|
| **900** | **-** | Arsenites in China (Inorganic compound) |
| **1690** | **-** | Tobacco used in Europe (Plant/natural product) |
| **1787** | **-** | Soaps used in Europe |
| **1867** | **-** | Paris Green in US |
| **1874** | **-** | DDT synthezized by Zeidler |
| **1883** | **-** | Bordeau in France |
| **1925** | **-** | Dinitro compounds (First synthetic organic insecticide) |
| **1932** | **-** | Thiocyanates |
| **1939** | **-** | DDT insecticidal property discovered by **Paul Muller of Switzerland**. Paul Muller awarded Nobel Prize in 1948 for discovering insecticidal property of DDT |
| **1941** | **-** | **BHC** in France and UK (in 1942) (BHC is presently called as HCH) |
| **1944** | **-** | Parathion (**Organo phosphate**) discovered by **Gerhard Schrader** in Germany |
| **1945** | **-** | **Chlordane (Cyclodian compound)** in Germany |
| **1947** | **-** | **Carbamate insecticides** in Switzerland |
| **1962** | **-** | Rachel Carson’s Silent Spring appears (US) (This is not a chemical. The book ‘ Silent Spring’ created awareness about ill effects of pesticides) |
| **1967** | **-** | First JH mimic (Juvenile Hormone mimic) used in US (Insect growth regulator) |
| **1970** | **-** | Development of synthetic pyrethroids (UK) (Fast degradation) (Effective at very low doses) |
| **1980** | **-** | Discovery of avermectins (derived from bacteria). Effective at low dose. Fast degradation. |
| **1990** | **-** | Discovery of newer groups like (1) **Neonicotinoids** (Imidacloprid), similar to natural nicotin, (2) **Spinosyns** (e.g. Spinosad) derived from actinomycet |

TOXICITY PARAMETERS

Toxicity of a given chemical to an organism can be measured using various parameters as listed below.

**1) $LD_{50}$ or Median lethal dose**

$LD_{50}$ is defined as the amount of insecticide per unit weight which will kill 505 of the particular organism or insect. $LD_{50}$ usually expressed as mg/kg body weight or g/larva or adult insect.

**2) $LC_{50}$ or Median lethal concentration**

Defined as the concentration of insecticide required to kill 50% of the given organism or insect. This is used when the exact dose per insect is not known, but the concentration is known.

$LC_{50}$ is expressed in PPM (1/1,000,000) or Percentage (1/100)

**3) $LT_{50}$ (Median lethal time)**

$LT_{50}$ is defined as the time required to kill 50% of the population at a certain dose or concentration.

$LT_{50}$ expressed in hours or minutes. $LT_{50}$ is used in field studies and also for testing insect viruses (NPV).

**4. $KD_{50}$: Median knockdown dose**
**5. $KT_{50}$: Median knockdown time**
} Dose of insecticide or time required to knockdown 50% of the insects

$KD_{50}$ and $KT_{50}$ are used for evaluating synthetic pyrethroids against insects.

**6. $ED_{50}$: Median effectivedose**
**7. $EC_{50}$: Median effective concentration**
} These terms are used to express the effectiveness of insect growth regulators (IGR)

$ED_{50}$ and $EC_{50}$ are defined as the dose or concentration of the chemical (IGR) required to affect 50% of population and produce desired symptoms in them.

Toxicity terms used to express the effect on mammals

| | | | |
|---|---|---|---|
| 1. | Acute toxicity | : | Toxic effect produced by a single dose of a toxicant |
| 2. | Chronic toxicity | : | Toxic effects produced by the accumulation of small amounts of the toxicant over a long period of time |
| 3. | Oral toxicity | : | Toxic effect produced by consumption of pesticide orally |
| 4. | Dermal toxicity | : | Toxic effect produced when insecticide enters through skin |
| 5. | Inhalation toxicity | : | Toxic effect produced when poisonous fumes of insecticide are inhaled (fumigants) |

Other terms : Acute oral, Acute dermal, Acute inhalation toxicity, etc.

**Ideal Qualities of an Insecticide**

An ideal insecticide should posses the following qualities

Kill the target insect effectively and quickly

Be less toxic to natural enemies

Be less toxic to honey bees, soil microorganisms

Be less toxic to fishes and mammals

Less hazardous and less toxic during handling or accidental consumption by human beings

Quickly degradable in environment and should be less persistent (Residues should be very less)

Should not cause resurgence of the target insect (i.e. Increase in population of target insect) e.g. Chlorpyriphos causes resurgence of BPH on rice.

Should not cause outbreak of secondary pest on a minor pest by killing the natural enemies

Should have a complex mode of action against which resistance development will take more time. e.g. Azadirachtin from neem tree has complex action

Should have a longer storage life or shelf life

It is advantageous to select an insecticide which can kill a relatively broad spectrum of target pests

It should be cost effective (High benefit/Cost ratio) and safe to use (High benefit/Risk ratio)

Various generations of insecticides

| | Generation | Year | Compounds |
|---|---|---|---|
| 1. | First generation insecticide | 1939-1942 | BHC and DDT |
| 2. | Second generation insecticide | 1944-1947 | Organophosphates and Carbamate |
| 3. | **Third generation insecticide** | 1967 | Hormonal insecticides, JH mimic insect growth regulators |
| 4. | Fourth generation insecticide | 1970s | Synthetic pyrethroids |

## Lecture 19 PESTICIDES GROUPS

Groups of pesticides : The pesticides are generally classified into various groups based on pest organism against which the compounds are used, their chemical nature, mode of entry and mode of action.

**1. Based on organisms**

a) Insecticides : Chemicals used to kill or control insects (eg.) endosulfan, malathion

b) Rodenticides : Chemicals exclusively used to control rats (eg.) Zinc phosphide

c) Acaricides : Chemicals used to control mites on crops / animals (eg.) Dicofol

d) Avicides : Chemicals used to repel the birds (eg.) Anthraquionone

e) Molluscicides : Chemicals used to kill the snails and slugs (eg.) Metaldehyde

f) Nematicides : Chemicals used to control nematodes (eg.) Ethylene dibromide

g) Fungicides : Chemicals used to control plant diseases caused by fungi (eg.) Copper oxy cholirde

h) Bactericide : Chemicals used to control the plant diseases caused by bacteria (eg.) Streptomycin sulphate

i) Herbicide : Chemicals used to control weeds (eg.) 2,4, - D

**2. Based on mode of entry**

a) Stomach poison : The insecticide applied in the leaves and other parts of the plant when ingested, act in the digestive system of the insect and bring about kill (eg.) Malathion.

b) Contact Poison : The toxicant which brings about death of the pest species by means of contact (eg.) Fenvalerate.

c) Fumigant : Toxicant enter in vapour form into the tracheal system (respiratory poison) through spiracles (eg.) Aluminium phosphide

d) Systemic poison : Chemicals when applied to plant or soil are absorbed by foliage (or) roots and translocated through vascular system and cause death of insect feeding on plant. (eg.) Dimethoate.

**3. Based on mode of action**

a) Physical poison : Toxicant which brings about kill of one insect by exerting a physical effect (eg.) Activated clay.

b) Protoplasmic poison : Toxicant responsible for precipitation of protein (eg.) Arsenicals.

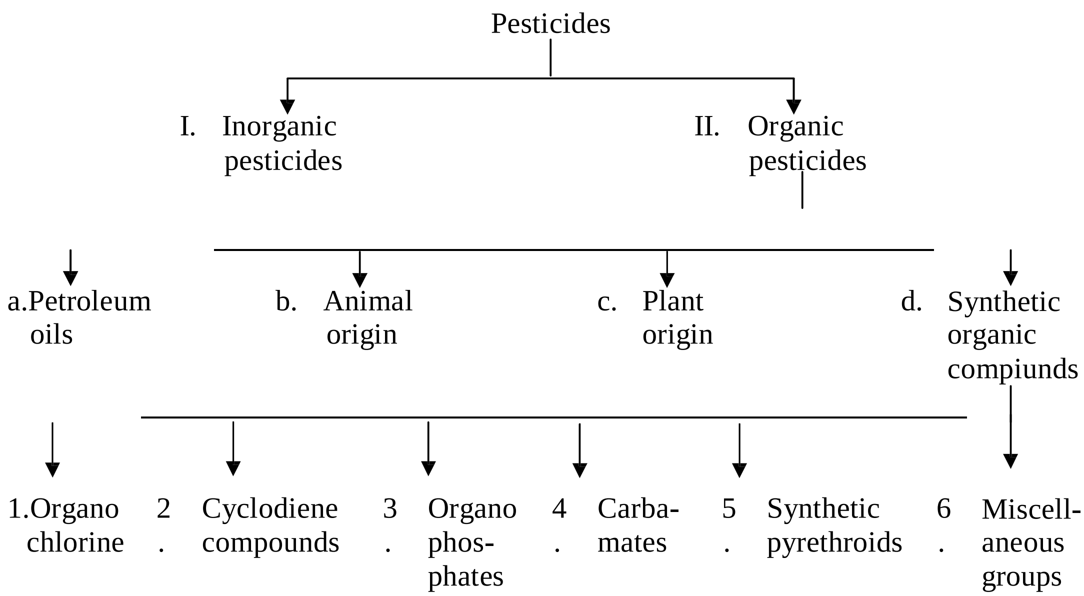
c) Respiratory poison : Chemicals which inactivate respiratory enzymes (eg.) hydrogen cyanide.

d) Nerve poison : Chemicals inhibit impulse conduction (eg.) Malathion.

e) Chitin inhibition : Chemicals inhibit chitin synthesis (eg.) Diflubenzuron.

**4. Based on chemical nature**

**Classification based on chemical nature of insecticides**




I.Inorganic pesticides

Inorganic chemicals used as insecticides

Eg. Arsenic, Fluorine, Sulphur, lime sulphur (Insecticides) zinc phosphide (Rodenticide)

II.Organic pesticides

Organic compounds (constituted by C, H, O and N mainly)

Hydrocarbon oil (or) Petroleum oil – eg. Coal tar oil, kerosine etc.,

Animal origin insecticides – eg. Nereistoxin extracted from marine annelids – commercially available as cartap, padan.

Plant origin insecticides : Nicotine from tobacco plants, pyrethrum from *Chrysanthemum* flowers, Rotenoids from roots of *Derris* and *Lonchocarpus*
Neem – *azadirachtin*, *Pongamia glabra*, Garlic etc.,

Synthetic organic compounds : These organic chemicals are synthetically produced in laboratory.

i. Chlorinated hydrocarbon (or) organochlorines
Eg. DDT, HCH, Endosulfan, Lindane, Dicofol (DDT, HCH banned)

ii. Cyclodienes
Eg. Chlordane, Heptachlor (Banned chemicals)

iii Organophosphates : (Esters of phosphoric acid)

.

Eg. Dichlorvos, Monocrotophos, Phospamidon, Methyl parathion, Fenthion, Dimethoate, Malathion, Acephate, Chlorpyriphos

iv. Carbamates: (Derivatives of carbamic acid)
Eg. Carbaryl, Carbofuran, Carbosulfan

v. Synthetic pyrethroids ; (Synthetic analogues of pyrethrum)
Eg. Allethrin, Cypermethrin, Fenvalerate

vi. Miscellaneous compounds
Neonicotinoids (Analogues of nicotine) eg. Imidacloprid Spinosyns (Isolated from actinomycetes) eg. Spinosad Avermectins (Isolated from bacteria) eg. Avermectin, Vertimec Fumigants : Eg. Aluminium phosphide, Hydrogen cyanide, EDCT

## Lecture 20 THE INSECTICIDES ACT, 1968

An act to regulate the import, manufacture, sale, transport, distribution and use of insecticides with a view to prevent risk to human beings on animals and for matters connected therewith.

### Salient features of the Insecticides Act

**Compulsory registration** of the product at the Central level and licenses for manufacture, formulation and sale at state level.

Inter – departmental / ministerial / organizational co-ordination is achieved by a high level advisory board **"Central Insecticides Board"** with 24 members (to be raised to 29 by an amendment) drawn from various fields having expert knowledge of the subject.

**"Registration Committee**" to look after the registration aspects of all Insecticides.

Establishment of enforcement machinery like Insecticide Analysts and **Insecticide Inspectors** by the Central or State Government.

Establishment of **Central Laboratory**

**Power to prohibit** the import, manufacture, and sale of pesticides and also **confiscate** the stocks. The offences are punishable and size and other penalties are prescribed.

Both the Central and State Governments are empowered to make rules, prescribe forms and fees.

#### The Central Insecticides Board (CIB)

The Central Insecticides Board advices on matters relating to:

The risk to human beings or animals involved in the use of insecticides and the safety measures necessary to prevent such risk.

The manufacture, sale, storage, transport, distribution of insecticides with a view to ensure safety to human beings and animals.

Board members

The Director General Health Services ➜ Chairman
The Drugs Controller, India
The Plant Protection Adviser to the Government of India
The Director General, ICAR
The Director General, ICMR

Totally 24 members – others from various other fields such as BIS, Animal husbandry, Pharmacology, Fisheries, Wild life etc.,

#### The Registration Committee (RC)

RC comprises a Chairman and five members. Among them are:

1. Deputy Director General, Crop Sciences, ICAR-Chairman
2. Drugs Controller, India
3. Plant Protection Adviser to the Government of India

### Role of RC

To register insecticides after scrutinizing them with regard to efficacy and safety.

## Registration of Insecticides

When applied for registration, the RC allots a registration number within a period of 12 months.

When pesticide registered for first time in India, provisional registration for two years given initially. After data generation full registration allowed.

### The Central Insecticides Laboratory (CIL)

CIL carrys out the analysis relating to insecticide registration and other matters.

## Insecticide Inspectors

Central or State Government appoints person called Insecticide Inspector who is empowered.

a. To enter and search premises
b. To stop the distribution or sale or use of insecticide
c. Take samples of insecticide and send for analysis

## The Insecticides Rules, 1971

There are nine chapters in the insecticide rule, 1971 relating to the functions of CIB, RC, CIL, grant of licenses, packing, labelling, first aid, antidate protective clothings etc.,

## Insecticide residues and waiting period

## Residues

The toxicant that remains in the environment (like soil, water, plant harvested produce, etc.) after the application of insecticides. The duration of retension is called persistence.

- Only 1% of the pesticide applied to crop reaches the target. The remaining 99% contaminate soil, water, air, food, forage, etc.
- When surveyed in India 20% of market samples of food commodities were having residues above legal MRL (maximum residue limits).
- 37% of milk samples contaminated with DDT above MRL (0.05 mg/kg)
- Due to contamination the dietary intake of DDT and HCH are above ADI (acceptable daily intake) in India.
- Waiting period must be observed which is the minimum period allowed between time of application of pesticide and harvest of commodities in order to allow the toxicant residue level to come below MRL.

The following are some examples of waiting period of some chemicals in a few important crops

| | Crop | **Insecticide and Dose** | **Waiting period (days)** |
|---|---|---|---|
| 1. | Chillies | Dicofol 0.05% | 1 |
| | | Quinalphos 0.05% | 8 |

| | | | |
|---|---|---|---|
| 2. | Tomato | Phosalone 0.05% | 3 |
| | | Quinalphos 0.05% | 5 |
| 3. | Brinjal | Phosalone 0.05% | 2 |
| | | Endosulfan 0.07% | 3 |
| | | Aldicarb 1 kg a.i./ha | 60 |

**Role of pesticides in IPM**

1. Pesticide should be applied only based on the need, i.e. if pest reaches ETL.
2. It should be judiciously combined with other components of IPM and pesticides should be used as last resort.
3. When pest population approaches ETL, insecticides are the only means of preventing economic damage.
4. Insecticides are available in easy and ready to use packings.
5. Easy to apply and large area can be covered.
6. A range of insecticides are available depending on crop, insect and nature of damage.
7. Pesticides which are cost effective (High benefic/cost ratio) and safe (High benefit/risk ratio) should be used in IPM.

## Lecture 21: PHEROMONES

Semiochemicals are chemical substances that mediate communication between organisms. Semiochemicals maybe classified into Pheromones (intraspecific semiochemicals) and Allelochemics (interspecific semiochemicals).

Pheromones are chemicals secreted into the external environment by an animal which elicit a specific reaction in a receiving individual of the same species. Pheromones are volatile in nature and they aid in communication among insects.

Pheromones are exocrine in origin (i.e. secreted outside the body). Hence they were earlier called as ectohormones. In 1959, German chemists Karlson and Butenandt isolated and identified the first pheromone, a sex attractant from silkworm moths. They coined the term pheromone. Since this first report, hundreds of pheromones have been identified in many organisms. The advancement made in analytical chemistry aided pheromone research.

Based on the responses elicited pheromones can be classified into 2 groups

a) **Primer pheromones:** They trigger off a chain of physiological changes in the recipient without any immediate change in the behaviour. They act through gustatory (taste) sensilla. (eg.) Caste determination and reproduction in social insects like ants, bees, wasps, and termites are mediated by primer pheromones. These pheromones are not of much practical value in IPM.

b) **Releaser pheromones:** These pheromones produce an immediate change in the behaviour of the recipient. Releaser pheromones may be further subdivided based on their biological activity into

Sex pheromones
Aggregation pheromones
Alarm pheromones
Trail pheromones

Releaser pheromones act through olfactory (smell) sensilla and directly act on the central nervous system of the recipient and modify their behaviour. They can be successfully used in pest management programmes.

1) **Sex pheromones** are released by one sex only and trigger behaviour patterns in the other sex that facilitate in mating. They are most commonly released by females but may be released by males also. In over 150 species of insects, females have been found to release sex pheromones and about 50 species males produce.

**Aphrodisiacs** are substances that aid in courtship of the insects after the two sexes are brought together. In many cases males produce aphrodisiacs.

Major differences between male and female produced pheromones are listed below.

| Sl. No | Properies | Female sex pheromone | Male sex pheromone |
|---|---|---|---|
| 1. | Range | Acts at a long range. Attracts males from long distance | Acts at a short distance |
| 2 | Role of other stimuli | Play less role | Visual and auduitory stimuli play major role |
| 3. | Action elicited in the other sex | Atrracts and excites males to copulate | Lowers females resistance to mating |
| 4. | Importance in IPM | More important | Less important |

**Insect orders producing sex pheromones**

Lepidoptera, Orthoptera, Dictyoptera, Diptera, Coleoptera, Hymenoptera, Hemiptera, Neuroptera and mecoptera. In Lepidoptera, sex pheromonal system is highly evolved.

**Pheromone producing glands**:

In Lepidoptera they are produced by **eversible glands** at the tip of the abdomen of the females. The posture shown during pheromone release is called 'calling position'. Aphrodisiac glands of male insects are present as **scent brushes** (or hair pencils) at the tip of the abdomen (eg. Male butterfly of *Danaus sp.*). **Andraconia** are glandular scales on wings of male moths producing aphrodisiacs.

**Pheromone reception:**

Female sex pheromones are usually received by olfactory sensillae on male antennae and males search upwind, following the odour corridor of the females. In pheromone perceiving insects, the antennae of male moths are larger and greatly branched than female moths to accommodate numerous olfactory sensilla.

**Chemical nature of sex pheromones**

In general pheromones have a large number of carbon atoms (10-20) and high molecular weight (180 – 300 daltons). Narrow specificity and high potency are two attributes which depend on long chain carbon atoms and high molecular weight. But since pheromones are volatile their molecular weights cannot be very high as they cannot be carried by wind.

Butenandt and his coworkers in 1959 isolated 12mg of pheromone from the abdomen of half a million virgin females of silkworm. They named the pheromene as Bombykol. The chemical name is 10,12 – hexadeca dienol. It is a primary alcohol.

The following are some of the female sex pheromones identified in insects

| Sl. No. | Name of the Insect | Pheromone |
|---|---|---|
| 1. | Silkworm, *Bombyx mori* | Bombykol |
| 2. | Gypsy moth, *Porthesia dispar* | Gyplure, disparlure |
| 3. | Pink bollworm ,*Pectinophora gossypiella* | Gossyplure |
| 4. | Cabbage looper, *Trichoplusia ni* | Looplure |
| 5. | Tobacco cutworm, *Spodoptera litura* | Spodolure, litlure |
| 6. | Gram pod borer, *Helicoverpa armigera* | Helilure |
| 7. | Honey bee queen, *Apis sp.* | Queen's substance |

Examples of male sex pheromones

Cotton boll weevil, *Anthonomas grandis*, Coleoptera
Cabbage looper, *Trichoplusia ni*, Lepidoptera
Mediterranean fruitfly, *Ceratitis capitata*, Diptera.

**Multi-component pheromone system :** If the pheromone of an insect is composed of only one chemical compound we call it monocomponent pheromone system. Pheromones of some insects contain more than one chemical compound. In this case we call it as multi-component pheromone system. The sex pheromone of two different species may contain same chemical compounds but the ratio of the compounds may vary. This brings about species specificity.

**Pest Management With Sex Pheromones**

Synthetic analogues of sex pheromones of quite large No. of pests are now available for use in Pest management. Sex pheromones are being used in pest management in three different ways.

a) In sampling and detection (Monitoring)
b) To attract and kill (Mass trapping)
c) To disrupt mating (Confusion or Decoy method)

**a) In sampling and detection (Monitoring) :**

Pheromones can be used for monitoring pest incidence/ outbreak in the following ways.

**Lecture 22 : STERIITY METHODS - DEFINITON - PRINCIPLES - METHODS - REQUIREMENTS AND LIMITATIONS**

**Sterility method - Definition**

Control of pest population achieved by releasing large number of sterilised male insects, which will compete with the normal males and reduce the insect population in subsequent generation.

It is usually referred as SIT (Sterile insect technique) or SIRM (Sterile insect release method)

Sterile insect release method is a genetic control method. This is also called Autocidal control since insects are used against members of their own species.

E.F. Knipling in 1937 in South East USA used the SIRM technique to control the screw wormfly (*Cochliomyia nominivorax*) a serious livestock pest.

The sterile to fertile male ratio, called S:F ratio is important, as the reduction in reproductive potential of natural population depends on S:F ratio.

The mating with the sterile males will produce inviable or sterile eggs.

Trend of hypothetical population subjected to SIRM

Assumption

1. Female:Male ratio 1:1
2. 1 female produces 5 females as off spring in one generation

| *Generation* | **No.of females without releases** | **No.of sterile males released** | **No.of females releases(9:1)** | **Ratio sterile to normal males** | **No. of fertile females** |
|---|---|---|---|---|---|
| 1. | 1,000,000 | 9,000,000 | 1,000,000 | 9:1 | 100,000 |
| 2. | 5,000,000 | 9,000,000 | 500,000 | 18:1 | 26,316 |
| 3. | 25,000,000 | 9,000,000 | 131,579 | 68:1 | 1,907 |
| 4. | 125,000,000 | 9,000,000 | 9,535 | 944:1 | 10 |
| 5. | 625,000,000 | 9,000,000 | 50 | 180,000:1 | 0 |

In suitable circumstances sterile male release method (SIRM) can be more effective, compared to insecticide application.

Comparison of SIRM with insecticide - Trend of hypothetical population

| Generation | **No. of females with no treatment** | **No. of females with sterile release (9:1)** | **No. of females with insecticide (90% kill)** |
|---|---|---|---|
| 1. | 1,000,000 | 1,000,000 | 1,000,000 |
| 2. | 5,000,000 | 500,000 | 500,000 |
| 3. | 25,000,000 | 131,579 | 250,000 |
| 4. | 125,000,000 | 9,535 | 125,000 |
| 5. | 625,000,000 | 50 | 62,500 |
| 6. | 3,125,000,000 | 0 | 31,250 |

SIRM technique can also be used after insecticide application which will be more effective.

Circumstances for using this method

1. Against well established pest when their population density is low
2. Against newly introduced pest
3. Against isolated population as in island
4. Combined with cultural and chemical methods

Methods of sterilizatoin

**1. Chemosterilants:** Any chemical which interfere with the reproductive capacity of an insect.

**a. Alkylating agents**

They inhibit nucleic acid synthesis
inhibit gonad development
produce mutagenic effect
(e.g.) TEPA, Chloro ethylamine

**b. Antimetabolites**

Chemicals having structural similarity to biologically active substances. They interfere with nucleic acid synthesis. e.g. 5-Fluororacil, Amithopterin

Methods of sterilization - continued

II. Irradiation

Irradiation done by exposing insects to , , radiations, X rays and neutrons. Of these, -radiation by $^{60}$CO (cobalt) with its half-life of 60 years is the most common method.

Irradiation causes following sterility effects in insects
Infecundity Aspermia
Inability to male
Dominant lethal mutation

Radiation dose required for different species and stages for sterilization (expressed as rads - radiation absorbed dose).

| **Insect** | Stage | **Dose** |
|---|---|---|
| Housefly | 2-3 day pupae | 3000 rads |
| Screw worm | 5 day pupae | 2500 rads |
| | 1 day adult | 5000 rads |

**Sterilizing natural population**

In this method, instead of releasing sterilised males into the field, a chemosterilant is sprayed in field like insecticide. The chemosterilant sterilizes both male and female. These do not produce offspring-equivalent to killing them.

Bonus effect: The bonus effect of this method is that the sterilized males mate with normal females and reduce their reproductive capacity.

Chemosterilants used are TEPA, HEMPA, BISULFAN, etc.

**Requirements for SIRM**

1. A method inducing sterility without impairing sexual behaviour of insects.
2. Mass rearing of the insects
3. Information on population density and its rate of increase
4. The released insects must not cause damage to the crops, livestock or human beings
5. Good intermingling of released and natural population
6. Releasing sterilized insects when the wild population is abundant
7. This method is effective against newly introduced pest or isolated insect population as in island.
8. There should be high sterile to fertile (S:F) ratio for quicker control.

**Limitations of SIRM**

1. Not effective against insects which are prolific breeders
2. Sterilizing and mutagenic effect of chemosterilants and irradiation cause problem in higher animals and man (Carcinogenic and mutagenic)

**Lecture 23: INSECT GROWTH REGULATORS**

Insect Growth Regulators (IGRs) are compounds which interfere with the growth, development and metamorphosis of insects. IGRs include synthetic analogues of insect hormones such as ecdysoids and juvenoids and non-hormonal compounds such as precocenes (Anti JH) and chitin synthesis inhibitors.

Natural hormones of insects which play a role in growth and development are

1. **Brain hormone**: The are also called activation hormone(AH). AH is secreted by neuro secretory cells (NSC) which are neurons of central nervous system (CNS). It's role is to activate the corpora allata to produce juvenile hormone (JH).
2. **Juvenile hormone (JH):** Also called neotinin. It is secreted by corpora allata which are paired glands present behind insect brain. Their role is to keep the larva in juvenile condition. JH I, JH II, JH III and JH IV have been identified in different groups of insects. The concentration of JH decreases as the larva grows and reaches pupal stage. JH I, II and IV are found in larva while JH III is found in adult insects and are important for development of ovary in adult females.
3. **Ecdysone:** Also called Moulting hormone (MH). Ecdysone is a steroid and is secreted by Prothoracic Glands (PTG) present near prothoracic spiracles. Moulting in insects is brought about only in the presence of ecdysone. Ecdysone level decreases and is altogether absent in adult insects.

**IGRs used in Pest management**

a) **Ecdysoids**: These compunds are synthetic analogues of natural ecdysone. When applied in insects, kill them by formation of defective cuticle. The development processes are accelerated bypassing several normal events resulting in integument lacking scales or wax layer.

b) **Juvenoids (JH mimics)** : They are synthetic analogues of Juvenile Hormone (JH). They are most promising as hormonal insecticides. JH mimics were first identified by **Williams and Slama** in the year 1966. They found that the paper towel kept in a glass jar used for rearing a *Pyrrhocoris* bug caused the bug to die before reaching adult stage. They named the factor from the paper as **'paper factor'** or **'juvabione'**. They found that the paper was manufactured from the wood pulp of **balsam fir tree** (*Abies balsamea*) which contained the JH mimic.

Juvenoids have **anti-metamorphic effect** on immature stages of insect. They retain *status quo* in insects (larva remains larva) and extra (super numerary) moultings take place producing super larva, larval-pupal and pupal-adult intermediates which cause death of insects. Juvenoids are **larvicidal** and **ovicidal** in action and they **disrupt diapause** and **inhibit embryogenesis** in insects.

Methoprene is a JH mimic and is useful in the control of larva of hornfly, stored tobacco pests, green house homopterans, red ants, leaf mining flies of vegetables and flowers

c) **Anti JH or Precocenes**: they act by destroying corpora allata and preventing JH synthesis. When treated on immature stages of insect, they skip one or two larval instars and turn into tiny precocious adults. They can neither mate, nor oviposit and die soon. Eg. EMD, FMev, and PB (Piperonyl Butoxide)

d) **Chitin Synthesis inhibitors:** Benzoyl phenyl ureas have been found to have the ability of inhibiting chitin synthesis in vivo by blocking the activity of the enzyme chitin synthetase. Two important compounds in this category are Diflubenzuron (Dimilin) and Penfluron. The effects they produce on insects include

Disruption of moulting
Displacement of mandibles and labrum
Adult fails to escape from pupal skin and dies
Ovicidal effect.

Chitin sysnthesis inhibitors have been registered for use in many countries and used successfully against pests of soybean, cotton, apple, fruits, vegetables, forest trees and mosquitoes and pests of stored grain

**IGRS from Neem :** Leaf and seed extracts of neem which contains azadirachtin as the active ingredient, when applied topically causes growth inhibition, malformation, mortality and reduced fecundity in insects.

**Hormone mimics from other living organisms**: Ecdysoids from plants (Phytoecdysones) have been reported from plants like mulberry, ferns and conifers. Juvenoids have been reported from yeast, fungi, bacteria, protozoans, higher animals and plants.

**Advantages of Using IGRs**

Effective in minute quantities and so are economical
Target specific and so safe to natural enemies
Bio-degradable, non-persistent and non-polluting
Non-toxic to humans, animals and plants

**Disadvantages**

Kills only certain stages of pest
Slow mode of action
Since they are chemicals possibility of build-up of resistance
Unstable in the environment

**ANTIFEEDANTS**

Antifeedants are chemicals that inhibit feeding in insects when applied on the foliage (food) without impairing their appetite and gustatory receptors or driving (repelling) them away from the food. They are also called gustatory repellents, feeding deterrents and rejectants. Since do not feed on trated surface they die due to starvation.

Groups of antifeedants

**Triazenes:** AC 24055 has been the most widely used triazene which is a oduorless, tasteless, non-toxic chemical which inhibit feeding in chewing insects like caterpillars, cockroaches and beetles.

**Organotins.** They are compounds containing tin. Triphenyl tin acetate is an important antifeedants in this group effective against cotton leaf worm, Colarado potato beetle, caterpillars and grass hoppers

**Carbamates:** At sublethal doses thiocarbamates and phenyl carbamates act as antifeedants of leaf feeding insects like caterpillars and Colarado potato beetle. Baygon is a systemic antifeedants against cotton boll weevil.

**Botanicals:** Antifeedants from non-host plants of the pest can be used for their control The following antifeedants are produced from plants.

**Pyrethrum:** Extracted from flowers of *Chrysanthemum cinerarifolium* acts as antifeedants at low doses against biting fly, Glossina sp.

**Neem:** Extracted from leaves and fruits of neem (*Azadirachta indica*) is an antifeedant against many chewing pests and desert locust in particular

**Apple factor:** Phlorizin is extracted from apple which is effective against non-apple feeding aphids**.**

**Solanum alkaloids: Leptine, tomatine and solanine are alkaloids extracted from Solanum plants and are antifeedants to leaf hoppers.**

**Miscellaneous compounds:** Compounds like copper stearate, copper resinate, mercuric chloride and Phosphon are good antifeedants.

**Mode of action:** Antifeedants inhibit the gustatory (taste) receptors of the mouth region. Lacking the right gustatory stimulus the insect fails to recognize the trated leaf as food. The insect slowly dies due to starvation.

**Advantages:**

Affect plant feeders, but safe to natural enemies
Pest not immediately killed, so natural enemies can feed on them
No phytotoxicity or pollution

Disadvantages

Only chewing insects killed and not sucking insects
Not effective as sole control measure, can be included in IPM

**INSECT ATTRACTANTS**

Chemicals that cause insects to make oriented movements towards their source are called insect attractants. They influence both gustatory (taste) and olfactory (smell) receptors.

**Types of Attractants:**

1. **Pheromones**: Pheromones are chemicals secreted into the external environment by an animal which elicit a specific reaction in a receiving individual of the same species.
2. **Food lures :** Chemical present in plants that attract insect for feeding. They stimulate olfactory receptors.

List of natural and synthetic food lures

| Insects | Lure |
|---|---|
| | **Natural** |
| Pests of cruciferae | Isothiocyanates from seeds of cruciferae |
| Onion fly (Hylemya antiqua) | Propylmercaptan from onions |
| Bark beetle | Terpenes from barks |
| Housefly | Sugar and molasses |
| | **Synthetic** |
| Oriental fruitfly (Dacus dorsalis) | Methyl eugenol |
| Melon fruitfly (Dacus cucurbitae) | Cuelure |
| Mediterranean fruitfly (Ceratitis capitata) | Trimedlure |

3. **Oviposition lures**: These are chemicals that govern the selection of suitable sites for oviposition by insects. For example extracts of corn attracts *Helicoverpa armigera* for egg laying on any treated surface.

*Use of Attractants in IPM*

Insect attractants are used in 3 ways in pest management

a) Sampling and monitoring pest population
b) Luring pests to insecticide coated traps or poison baits

Examples of poison baits

For biting insects: Moistened Bran + molasses) + insecticides
For sucking insects : Sugar solution + insecticide
For fruitflies: Trimedlure/ Cuelure/ Methyl eugenol + insecticides
For cockroaches: Sweet syrup + white or yellow phosphorus
For sweet-loving ants : Thallous sulphste + sugar + honey + glycerine + water
For meat loving ants : Thallous sulphate + peanut butter

c) in distracting insects from normal mating, aggregation, feeding or oviposition

The female insects if lured to wrong plants for egg laying, the emerging larva will starve to death

Advantage of using attractants is that they are specific to target insects and NE not affected. But they cannot be relied as the sole method of control and can only be included in IPM as a component.

**INSECT REPELLENTS**

Chemicals that induce avoiding (oriented) movements in insects away from their source are called repellents. They prevent insect damage to plants or animals by rendering them unattractive, unpalatable or offensive.

*Types of repellents*

**1. Physical repellents :** Produce repellence by physical means

a) Contact stimuli repellents: Substances like wax or oil when applied on leaf surface changes physical texture of leaf which are disagreeable to insects
b) Auditory repellents: Amplified sound is helpful in repelling mosquitoes.
c) Barrier repellents: Tar bands on trees and mosquito nets are examples.
d) Visual repellents: Yellow light acts as visual repellents to some insects.
e) Feeding repellents: Antifeedants are feeding repellents. They inhibit feeding.

**2. Chemical repellents:**

a) **Repellents of Plant origin:** Essentials oils of Citronella, Camphor and cedarwood act as repellents. Commercial mosquito repellent 'Odomos' uses citronella oil extracted from lemongrass, Andrpogon pardus as repellent.

Pyrethrum extracted form Chrysanthemum is a good repellent and has been used against tsetse fly, *Glossina morsitans.*

**b)** Synthetic repellents: **Repellents synthetically produced.**

*List of important synthetic repellents*

| Insects | Repellents |
|---|---|
| Mosquito, blood suckers | Dimethyl pthalate |
| Mites (chiggers) | Benzyl benzoate |
| Crawling insects | Trichlorobenzene |
| Phytophagous insects | Bordeaux mixture |
| Wood feeders | Pentachlorophenol |
| Fabric eaters | Naphthalene or mothballs |
| Bees | Smoke |

*Uses of repellents:*

They can be applied on body to ward off insects
Used as fumigants in enclosed area.
Used as sprays on domestic animals
To drive away insects from their breeding place.

**BIORATIONAL CONTROL**

Controlling insects using chemicals that affect insect behaviour, growth or reproduction, is called biorational control.

Insect Growth Regulator,
Chitin synthesis inhibitor,
JH analogues, Anti JH,
Moulting hormone,
Pheromones
Allelochemics
Attractant, Repellent,
Antifeedant,
Chemosterilant,
Sterile male release

} All these methods are included in **Biorational method** of control

They are called biorational agents in pest control, because of their selective nature in killing only the target insects without affecting non target organisms.

**Lecture 24 PESTICIDE APPLICATION METHODS**

The desired effect of a pesticide can be obtained only if it si applied by an appropriate method in appropriate time. The method of application depends on nature of pesticide, formulation, pests to be managed, site of application, availability of water etc.

1. **Dusting :** Dusting is carried out in the morning hours and during very light air stream. It can be done manually or by using dusters. Some times dust can be applied in soil for the control of soil insects. Dusting is cheaper and suited for dry land crop pest control.

2. **Spraying :** Spraying is normally carried out by mixing EC (or) WP formulations in water. There are three types of spraying.

| | **Spray fluid (litre per acre)** | **Droplet size** | **Area covered per day** | **Equipment used** |
|---|---|---|---|---|
| a) High volume spraying | 200-400 | 150 | 2.5 ac | Knapsack, Rocker sprayers |
| b) Low volume spraying | 40-60 | 70-150 | 5.6 ac | Power sprayer, Mist blower |
| c) Ultra low volume spraying | 2-4 lit. | 20-70 | 20 ac | ULV sprayer, Electrodyn sprayer |

3. **Granular application :** Highly toxic pesticides are handled safely in the form of granules. Granules can be applied directly on the soil or in the plant parts. The methods of application are

a) **Broadcasting :** Granules are mixed with equal quantity of sand and broadcasted directly on the soil or in thin film of standing water. (eg.) Carbofuran 3G applied @ 1.45 kg/8 cent rice nursery in a thin film of water and impound water for 3 days.

b) **Infurrow application :** Granules are applied at the time of sowing in furrows in beds and covered with soil before irrigation. (eg.) Carbofuran 3G applied @ 3 g per meter row for the control of sorghum shootfly.

c) **Side dressing :** After the establishment of the plants, the granules are applied a little away from the plant (10-15 cm) in a furrow.

d) **Spot application :** Granules are applied @ 5 cm away and 5 cm deep on the sides of plant. This reduces the quantity of insecticide required.

e) **Ring application :** Granules are applied in a ring form around the trees.

f) **Root zone application :** Granules are encapsulated and placed in the root zone of the plant. (eg.) Carbofuran in rice.

g) **Leaf whorl application :** Granules are applied by mixing it with equal quantity of sand in the central whorl of crops like sorghum, maize, sugarcane to control internal borers.

h) **Pralinage :** The surface of banana sucker intended for planting is trimmed. The sucker is dipped in wet clay slurry and carbofuran 3G is sprinkled (20-40 g/sucker) to control burrowing nematode.

4. **Seed pelleting/seed dressing :** The insecticide mixed with seed before sowing (eg.) sorghum seeds are treated with chlorphyriphos 4 ml/kg in 20 ml of water and shade dried to control shootfly. The carbofuran 50 SP is directly used as dry seed dressing insecticide against sorghum shootfly.

5. **Seedling root dip :** It is followed to control early stage pests (eg.) in rice to control sucking pests and stem borer in early transplanted crop, a shallow pit lined with polythene sheet is prepared in the field. To this 0.5 kg urea in 2.5 litre of water and 100 ml chlorpyriphos in 2.5 litre of water prepared separately are poured. The solution is made upto 50 ml with water and the roots of seedlings in bundles are dipped for 20 min before transplanting.

6. **Sett treatment :** Treat the sugarcane setts in 0.05% malathion for 15 minutes to protect them from scales. Treat the sugarcane setts in 0.05% Imidacloprid 70 WS @ 175 g/ha or 7 g/l dipped for 16 minutes to protect them from termites.

7. **Trunk/stem injection :** This method is used for the control of coconut pests like black headed caterpillar, mite etc. Drill a downward slanting hole of 1.25 cm diameter to a depth of 5 cm at a light of about 1.5 m above ground level and inject 5 ml of monocrotophos 36 WSC into the stem and plug the hole with cement (or) clay mixed with a fungicide. Pseudo stem injection of banana, an injecting gun or hypodermic syringe is used for the control of banana aphid, vector of bunchy top disease.

8. **Padding :** Stem borers of mango, silk cotton and cashew can be controlled by this method. Bark of infested tree (5 x 5 cm) is removed on three sides leaving bottom as a flap. Small quantity of absorbant cotton is placed in the exposed area and 5-10 ml of Monocrotophos 36 WSP is added using ink filler. Close the flap and cover with clay mixed with fungicide.

9. **Swabbing :** Coffee white borer is controlled by swabbing the trunk and branches with HCH (BHC) 1 per cent suspension.

10. **Root feeding :** Trunk injection in coconut results in wounding of trees and root feeding is an alternate and safe chemical method to control black headed caterpillar, eriophyid mite, red palm weevil. Monocrotophos 10 ml and equal quantity of water are taken in a polythene bag and cut the end (slant cut at 45) of a growing root tip (dull white root) is placed inside the insecticide solution and the bag is tied with root. The insecticide absorbed by root, enter the plant system and control the insect.

11. **Soil drenching :** Chemical is diluted with water and the solution is used to drench the soil to control certain subterranean pests. (eg.) BHC 50 WP is mixed with water @ 1 kg in 65 litres of water and drench the soil for the control of cotton/stem weevil and brinjal ash weevil grubs.

12. **Capsule placement :** The systemic poison could be applied in capsules to get toxic effect for a long period. (eg.) In banana to control bunchy top vector (aphid) the insecticide is filled in gelatin capsules and placed in the crown region.

13. **Baiting :** The toxicant is mixed with a bait material so as to attract the insects towards the toxicant.

a) **Spodoptera :** A bait prepared with 0.5 kg molasses, 0.5 kg carbaryl 50 WP and 5 kg of rice bran with required water (3 litres) is made into small pellets and dropped in the field in the evening hours.

b) **Rats :** Zinc phophide is mixed at 1:49 ratio with food like popped rice or maize or cholam or coconut pieces (or) warfarin can be mixed at 1:19 ratio with food. Ready to use cake formulation (Bromodiolone) is also available.

c) **Coconut rhinoceros beetle :** Castor rotten cake 5 kg is mixed with insecticide.

14. **Fumigation :** Fumigants are available in solid and liquid forms. They can be applied in the following way.

a) **Soil :** To control the nematode in soil, the liquid fumigants are injected by using injecting gun.

b) **Storage** : Liquid fumigants like Ethylene dibromide (EDB), Methyl bromide (MB), carbon tetrachloride etc. and solid fumigant like Aluminium phosphide are recommended in godowns to control stored product pest.

c) **Trunk** : Aluminium phosphide 7f to I tablet is inserted into the affected portion of coconut tree and plugged with cement or mud for the control of red palm weevil

**Lecture 25 : PESTICIDE COMPATIBILITY**

- In pest control treatment, two or more pesticides, fungicides or even fertilizers are sprayed or applied in the same operation to minimize cost of labour.
- Before mixing two different chemicals, their physical and chemical properties should be well understood.
- Incompatible pesticides should not be mixed. Only compatible pesticides can be mixed.

Incompatability of pesticides may be of following types

**a. Chemical incompatibility**

Chemical compounds in the two pesticides react with the another producing a different compound, reducing the pesticidal activity of the pesticides (Degradation of active ingredient).

**b. Biological incompatibility (Phytotoxic incompatibility)**

The mixed product exhibit phytotoxic action, which independantly is not phytotoxic.

**c. Physical incompatibility**

The physical form of the pesticides change, and one of them become unstable or hazardous for application (agglomeration, phase separation, explosive reaction, etc.).

**HAZARDS CAUSED BY PESTICIDES**

The adverse effect caused by pesticides to human beings during manufacture, formulation, application and also consumption of treated products is termed as the hazard.

Pesticide hazard occurs at the time of

a. Manufacturing and formulation
b. Application of pesticides
c. Consumption of treated products

Examples of hazards caused by pesticides

1. In Kerala, in 1953, 108 people died due to parathion poisoning
2. ‘Bhopal Gas Tradedy’ in 1984 at Bhopal where the gas called Methyl isocyanate (MIC) (an intermediate involved in manufacture of carbaryl) leaked killing 5000 people and disabling 50,000 people. Totally 2,00,000 persons were affected. Long term effects like mutagenic and carinogenic effects are felt by survivors.
3. Cases of Blindness, Cancer, Liver and Nervous system diseases in cotton growing areas of Maharashtra where pesticides are used in high quantity.
4. Psychological symptoms like anxiety, sleep disturbance, depression, severe head ache in workers involved in spraying DDT, malathion regularly.

5. Endosulfan - causing problem due to aerial spraying in cashew in Kerala - recent controversy - yet to be studied in detail.

**Safe handling of pesticides**

**1. Storage of pesticides :**

a) Store house should be away from population areas, wells, domestic water storage, tanks.

b) All pesticides should be stored in their original labeled containers in tightly sealed condition.

c) Store away from the reach of children, away from flames and keep them under lock and key.

**2. Personal protective equipment**

a) Protective clothing that covers arms, legs, nose and head to protect the skin.

b) Gloves and boots to protect hands and feet.

c) Helmets, goggles and facemask to protect hair, eyes and nose.

d) Respirator to avoid breathing dusts, mists and vapour.

**3. Safety in application of pesticides**

Safe handling of pesticides (Fig.68) involves proper selection and careful handling during mixing and application.

**a) Pesticide selection :** Selection of a pesticide depend on the type of pest, damage, losses caused, cost etc.

**b) Safety before application :**

i. Read the label and leaflet carefully.
ii. Calculate the required quantity of pesticides.
iii. Wear protective clothing and equipment before handling.
iv. Avoid spillage and prepare spray fluid in well ventilated area.
v. Stand in the direction of the wind on back when mixing pesticides.
vi. Do not eat, drink or smoke during mixing.
vii. Dispose off the containers immediately after use.

**c) Safety during application**

i. Wear protective clothing and equipment.
ii. Spray should be done in windward direction.
iii. Apply correct coverage.
iv. Do not blow, suck or apply mouth to any spray nozzle.
v. Check the spray equipment before use for any leakage.

**d) Safety after application**

i. Empty the spray tank completely after spraying.

ii. Avoid the draining the contaminated solution in ponds, well or on the grass where cattle graze.
iii. Clean the spray equipment immediately after use.
iv. Decontaminate protective clothing and foot wear.
v. Wash the hands thoroughly with soap water, preferably have a bath.
vi. Dispose off the containers by putting into a pit.
vii. Sprayed field must be marked and unauthorized entry should be prevented.

**First aid :** In cane of suspected poisoning; call on the physician immediately. Before calling on a doctor, first aid treatments can be done by any person.

**Swallowed poison**

i. During vomiting, head should be faced downwards.
ii. Stomach content should be removed within 4 h of poisoning.
iii. To give a soothing effect, give either egg mixed with water, gelatin, butter, cream, milk, mashed potato.
iv. In case of nicotine poisoning, give coffee or strong tea.

**Skin contamination**

i. Contaminated clothes should be removed.
ii. Thoroughly wash with soap and water.

**Inhaled poison**

i. Person should be moved to a ventilated place after loosing the tight cloths.
ii. Avoid applying frequent pressure on the chest.

**III. Antidotes and other medicine for treatment in pesticide poisoning**

| S.No. | Antidote / Medicine | Used in poisoning due to |
|---|---|---|
| 1. | Common salt (Sodium chloride) | Stomach poison in general |
| 2. | Activated charcoal (7g) in warm<br>Magnesium oxide (3.5g) water<br>Tannic acid (3.5g) | Stomach poison in general |
| 3. | Gelatin (18 g in water) or Flour or milk power (or) Sodium thiosulphate | Stomach poison in general |
| 4. | Calcium gluconate | Chlorinated insecticide, Carbon tetrachloride, ethylene dichloride, Mercurial compound |

| | | |
|---|---|---|
| 5. | Phenobarbital (or) Pentobarbital intravenous administration | Stomach poison of chlorinated hydrocarbon insecticides |
| 6. | Sodium bicarbonate | Stomach poison of organophosphate compounds |
| 7. | Atropine sulphate (2-4 mg intramuscular / intravenous administration) or PAM (Pyridine-Z aldoxime-N-methliodide) | Organophosphate Compounds |
| 8. | Atropine sulphate (2-4 mg intramuscular / intravenous administration) | Carbamates |
| 9. | Phenobarbital | Synthetic pyrethoid |
| 10. | Potassium permanganate | Nicotine, Zinc phosphide |
| 11. | Vitamin K1 and K2 | Warfarin, Zinc phosphide |
| 13. | epinephrine | Methlyl bromide |
| 14. | Methyl nitrite ampule | Cyanides |

**Impact of Pesticides in Agroecosystem**

The following are some problems caused by pesticides in agro-eco system

1. Pesticide residues
2. Insecticide resistance
3. Insect resurgence and secondary pest outbreak
4. Toxicity to non target organism

**1. Pesticide residues**

The pesticide that remains in the environment after application causes problems to humans and non-target organisms (Already dealt in theory - Read) e.g. Residues of DDT, HCH in milk, vegetable above MRL.

**2. Insecticide resistance**

Insecticide resistance is the development of an ability to tolerate a dose of insecticide, which would prove lethal (kill) to majority of the individuals of the same species.

This ability is due to the genetic change in pest population in response to pesticide application.

Insecticide resistance in insect pests in India

| | Name of pest | Common name | Insecticides to which resistant |
|---|---|---|---|
| 1. | *Aphis craccivora* | Aphid | Carbamates, OP, Cypermethrin, Endosulfan, Monocrotophos |
| 2. | *Bemesia tabaci* | Whitefly | |
| 3. | *Helicoverpa armigera* | Cotton boll worm | OP, Synthetic pyrethroid, *Bacillus thuringiensis* |
| 4. | *Plutella xylostella* | Diamond back moth on cabbage, cauliflower | Abamectin, Bt, OP compounds |

**Simple resistance** : Insect develops resistance only against the insecticide to which it is exposed

**Cross resistance** : Insect develops resistance not only to exposed insecticide but also to other related insecticides to which it is not exposed.

**Pest Resurgence**

Tremendous increase in pest population brought about by insecticides despite good initial reduction in pest population at the time of treatment.

Insecticides lead to pest resurgence in two ways.

After initial decline, resistant population increase in large numbers

Killing of natural enemies of pest, cause pest increase

e.g. Quinalphos, phorate - Cause resurgence of BPH in rice

Carbofuran - Leaf folder in rice

**Secondary pest outbreak**

Application of a pesticide against a major pest, kills the natural enemies of minor or secondary pest. This causes the outbreak of a secondary pest.

e.g. Use of synthetic pyrethroids against bollworms in cotton killed natural enemies of whitefly causing an outbreak of whitefly which was a minor pest till then.

**Toxicity of non-target organisms**

i. Natural enemies : Predators and parasitoids are killed loading to pest outbreak

ii. Bee toxicity : Bees are important pollinators. Killing bees reduce crop productivity

iii. Soil organisms : Soil organisms like microbes, arthropods, earthworm,

| | | | |
|---|---|---|---|
| | | | etc. are required for maintaining soil fertility. These are killed by some pesticides e.g. DDT, HCH |
| iv. | Fishes | : | Pesticides from treated surface run off to nearby lakes and kill the fishes |

Hence while choosing an insecticide it should be safe (causing less harm) to these organisms.

Specific IPM practices for rice and cotton. Biotechnology in pest management.

**Lecture 26: IMPACT OF GLOBAL WARMING ON PESTS**

What is global warming?

SUN

Earth reflects some solar energy as infrared radiation

Green house gases

Infra red radiation from earth reflected back to earth by green house gases. This increases the temperature of earth and lower atmosphere. This is called global warming or greenhouse effect

Solar radiation falls on earth surface. Earth absorbs and gets heated up

EARTH

- Warmth from sun heats the surface of the earth
- Earth absorbs most of the energy but reflects back some energy in the form of infra red radiation
- Greenhouse gases (e.g. $CO_{2,}$ Methane, CFC (Chloro Fluoro Carbon), Nitrous oxide) present in atmosphere trans the infrared radiation and reflects back to earth
- This reflected energy falls on earth and also lower atmosphere and keeps it warmer (Heats the earth's surface)

  This is called global warming or green house effect.

**Effect of global warming on world and agriculture**

- Increase in overall temperature on earth (e.g.) Earth's surface temperature has increased 1.4$^{o}$F in lst one century (Forecast: 5$^{o}$F rise in next century)
- Change in climate tremendously
- Melting of ice in Polar region
- Increase in seas level and submerging of coastal areas
- Flooding and intense down pours
- Drought in warmer regions

**Impact of global warming on pest status**

1. Due to change in climate, temperature and water availability, the farmers may change the type of crops grown.
2. Due to increase in temperature, there can be outbreak of certain insect pests and diseases.

3. In forest areas there will be a shift in tree species and also pest species.
4. In agriculture lands since cropping pattern is changed new crops to suit the climate is introduced and new pests are also introduced.
5. When water availability is less, crops will be raised as rainfed. It will be difficult to take up control measures without water.

**Sources of green house gases**

Developed countries : Emission from Automobiles and factories contain CFCs

Developing countries : Deforestation causes rise in $CO_2$ level Methane gas from paddy fields and livestock Nitrous oxide from 'N' based fertilizer

**Lecture 27**: **INTEGRATED PEST MANAGEMENT - HISTORY, PRINCIPLES AND STRATEGIES RELATIONSHIP BETWEEN DIFFERENT COMPONENTS AND ECONOMICS**

**History of Integrated Pest Management**

- Michelbacher and Bacon (1952) coined the term "integrated control"
- Stern *et al*. (1959) defined integrated control as "applied pest control which combines and integrates biological and chemical control"
- Geier (1966) coined the term "pest management"
- Council on Environmental Quality (CEQ, 1972) gave the term "Integrated Pest Management"
- Food and Agricultural Organization (FAO, 1967) defined IPM as "a pest management system, that, in the context of associated environment and population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economic injury"
- In 1989, IPM Task Force was established and in 1990. IPM Working Group (IPMWG) was constituted to strengthen implementation of IPM at international level.
- In 1997, Smith and Adkisson were awarded the World Food Prize for pioneering work on implementation of IPM.

Principles and strategies of Integrated Pest Management

**I. Monitoring insect pests and natural enemies**

Pest surveillance and forecasting are essential tools in IPM which help in making management decision.

**II. Concepts of injury levels**

ETL (Economic threshold level) and EIL (Economic injury level) concepts are followed to reduce the use of insecticide and their impact on environment.

**III. Integration of pest control tactics**

Proper choice of compatible tactics and blending them so that each component complements the other.

The strategy of applying pest management tactics is similar to that of human medicine.

i.e. Preventive practice
Curative practice

**Preventive methods of IPM include the following**

a. Natural enemies
b. Host plant resistance
c. Cultural control
d. Legal control (Plant Quarantine)

**Curative methods of IPM include the following**

a. Physical and mechanical methods
b. Inundative method releasing biocontrol agents
c. Chemical insecticides, IGR

- Preventive methods can be used, irrespective of the level of pest incidence. It can be followed as a routine, even if the pest is at a low level.
- Curative methods have to be followed only when the pest attains economic threshold level (ETL).

**Integration of different components of IPM**

There are two steps involved

i. Selection of appropriate method
ii. Integration of pest control method

**i. Selection method**: It could be preventive (prophylactic) or curative.

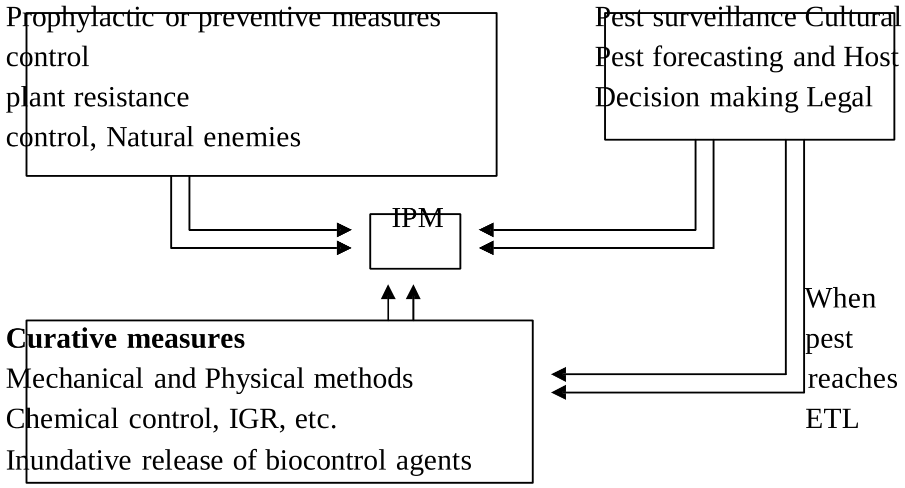
While selecting the method, it should possess following features:

a. It should be ecofriendly and cause minimum adverse effect on agro-eco system
a. There should not be any conflict between the methods
b. The methods should be least expensive

**Integration of tactics**

- Integrating management tactics is not simply adding a number of these tactics to form a program.
- Actual integration involves proper choice of compatible tactics and blending them so that each complements the other.
  e.g. (1) Host plant resistance can be easily blended with crop sanitation
  (2) Insecticide control is compatible with other preventive methods
  (3) It is difficult to blend natural enemy release with others like pesticides
- Integration of tactics, requires interdisciplinary approach.
- A knowledge of other subjects like, nematology, plant pathology, microbiology, crop and farm management also required when we go upward in level of integration.

**Relationship among different components of IPM**




## ECONOMICS OF INTEGRATED PEST MANAGEMENT

An Integrated Pest Management (IPM) programme can be successful only if reduces cost on control measures, or increases crop yield (or both) and also reduce environmental pollution and health hazards.

**The following are some examples of successful IPM programmes worldwide**

1. In Philippines, in 1993, IPM farmers obtained 4.7 to 62% higher rice yield and reduced pesticide use by 15% compared to non-IPM.
2. In India in 1995, IPM farmers obtained 6.2 to 42.1% increased rice yield, and reduced pesticide use by 50% compared to non-IPM farmers.
3. In India on cotton crop, adoption of IPM technology resulted in 73.7 and 12.4% reduction in the number of insecticide sprays against sucking pests and bollworms. In spite of reduction in pesticide sprays 21-27% increase in seed cotton yield was obtained in IPM areas compared to non-IPM. Natural enemy population also increased 3 folds.
4. In Thailand in 1993 adoption of IPM technology resulted in 145% increase in net profit in IPM fields over non-IPM fields in cruciferous vegetables.
5. IPM is useful and economical in high value, plantation crops like Coconut, Coffee, Tea, Cashewnut and Arecanut.

**Institutional support for IPM**

International: IPMWG, FAO, CABI, ICIPE
Global IPM facility (1992) - Sponsored by FAO, UNDP, UNEP and World Bank

National : NCIPM: National Centre for Integrated Pest Management at Faridabad (Near Delhi) (1988) - Supports IPM in India

## Lecture 28: INTEGRATED PEST MANAGEMENT - ISSUES AND OPTIONS ECOFRIENDLY IPM-INDIGENOUS/TRADITIONAL TECHNOLOGIES IN IPM

Constrains in IPM have been listed by IPM task force as follows:

**i. Institutional constraint**

IPM requires interdisciplinary approach to solve pest problem. Lack of coordination among different institution is a constraint. Research programme based on farmer's neem - is lacking.

**ii. Informational constraint**

Lack of information on IPM among farmers and extension worker. Lack of training on IPM.

**iii. Sociological constraint**

Some farmers feel it is risky to adopt IPM compared to use of pesticides alone. Our farmers are habituated to using more pesticides.

**iv. Economic constraint**

Lack of funds for training farmers and extension workers on the use of IPM.

**v. Political constraint**

- Vested interest associated with pesticide trade
- Pesticide subsidy by Government

These are the constraints for the implementation of IPM.

**Options/strategies in IPM implementation**

Acceleration of IPM implementation requires the following

**i. Farmer's participation**

Farmers must be encouraged to participate in IPM and give their views.

**ii. Government support**

Government can remove subsidies on pesticides and allot more fund for IPM implementation.

**iii. Legislative measures**

Suitable legislation (law) may be passed for adopting IPM by all farmers (IPM will be successful only if adopted on community basis).

**iv. Improved institutional infrastructure**

National level institution for implementation of IPM is a must. Data base on role of biotic and abiotic factors on pest population, crop yield are required.

**v. Improved awareness**

Awareness should be created at all levels on IPM i.e. Policy makers, farmers, consumers and general public. NGOs (Non Governmental Organisation) should be made aware of the advantages of IPM.

**Ecofriendly IPM**

- IPM which lays more importance on environmental safety. All methods except the use of chemical insecticides are encouraged.
- 'Organic farming' is a new concept where no chemical pesticide or fertilizer is used in agriculture.
- Ecofriendly IPM may be followed in organic farming
- Ecofriendly IPM uses methods like biological control, behavioural method, physical, cultural and mechanical methods.
- Here more stress is given to environmentally sustainable pest management.

**Indigenous/Traditional technologies in IPM**

The following are some examples of traditional technologies in IPM

i. **Cultural methods**: (a) Farm level (b) Community level

- which were originally practiced by farmers.

Examples: Already covered in previous classes.

ii. **Physical and mechanical methods** originally followed by farmers

e.g. (a) Use of storage bins, treatment of stored grain with vegetable oil etc., to ward off storage pest.

(b) Tanjore bow trap for rats

Other examples can also be quoted.

iii. **Farmers' wisdom on pest control tactics as follows**

e.g. (a) Use of **scare crows** to ward off bird pests

(b) Use of '*Kavankal*' to ward off birds

(c) Use of '*Pachakavya*' a mixture of cowdung, with other ingredients has been tried as a pest control agent - Research is ongoing.

(d) Use of chilli mash and garlic juice spray against rice earhead bug

Many other similar techniques are followed by farmers. Research has to be done to prove their usefulness in IPM.

**Lecture 29**: **IPM (Integrated Pest Management) for Rice**

1. Avoid use of excess nitrogenous fertilizer which induces BPH and leaf folder
2. Remove/destroy stubbles after harvest
3. Trim field bunds and keep field free from weeds
4. Control irrigation by intermittent draining to manage BPH (Alternate wetting and drying of field)
5. Avoid close planting, especially in BPH and leaf folder prone areas/seasons
6. Provide rogue spacing of 30 cm at every 2.5 m interval to take up plant protection operation
7. Use light traps to monitor incidence of pests
8. Avoid resurgence inducing chemicals against BPH like Methyl parathion and quinalphos
9. Remove stem borer egg masses by dipping off tip of rice seedling during transplanting
10. Select and use resistant varieties against major pests
11. Manage caseworm by passing rope on crop and draining water
12. Release egg parasitoid *Trichogramma japonicum* on 30 and $37^{th}$ day after planting against stem borer
13. Release egg parasitoid *T. chilonis* and bacteria *Bacillus thuringiensis* against leaf folder
14. Use of Neem Seed Kernel Extract 5% (NSKE 5%) or Neem oil 2% against Earhead bug
15. Use insecticides as need based application if pest reaches ETL

| S.No. | Pest (on rice) | ETL |
|---|---|---|
| 1. | Thrips | 25/5 passes of wet palm |
| 2. | Stem borer | 10% Dead heart or 2% white ear |
| 3. | Gall midge | 10% Silver shoot |
| 4. | Leaf folder | 10% leaf damage (at vegetative stage)<br>5% leaf damage (at Bootleaf stage) |
| 5. | GLH | 5/hill at vegetative stage, 10/hill flowering stage, 2/hill in RTV endemic areas |
| 6. | BPH (Brown Plant Hopper) | 1/tiller; 2/tiller when spider present at 1/hill |
| 7. | Earhead bug | 5 bugs/100 panicle - Flowering stage<br>16 bugs/100 panicle - Milky stage |

**IPM FOR COTTON**

1. Selection and use of resistant/tolerant varieties against major pests
2. Use of light trap to monitor hoppers, bollworms, cutworm
3. Use of pheromone traps for monitoring/mass trapping bollworms
4. Collection and destruction of infested plant parts, squares and bolls
5. Growing trap crop (e.g.) Castor for *Spodoptera litura*
6. Manual collection and removal of egg masses of *S. litura*
7. Hand picking of bollworm larvae
8. Use of insect viruses SlNPV and HaNPV against *Spodoptera litura* and *Helicoverpa armigera* respectively
9. Avoid ratoon and double cotton crop
10. Avoid staking of stalks in the field
11. Synchromise sowing time at village level
12. Follow crop rotation with unrelated crops
13. Removal of alternate hosts
14. Judicious use of nitrogen and water to manage hoppers and white flies
15. Use of yellow sticky traps for whiteflies
16. Observe IRM (Insecticide Resistance Management) practices like
    - **a.** Treat seeds with Imidacloprid 7.5 g/kg seed of cotton to manage early stage sucking pests
    - **b.** Use of predators like *Chrysoperla carnea*
    - **c.** Use of egg parasitoid *Trichogramma* sp. against bollworms
17. Apply insecticides only based on need, when pest population/damage reaches ETL

| S.No. | Cotton pest | ETL |
|---|---|---|
| 1. | Leaf hopper/thrips | 50 nos./50 leaves (or 1/leaf) |
| 2. | Whitefly | 5 nymphs/leaf |
| 3. | Bollworms | 10% damage of reproductive parts |
| 4. | Stem weevil | 10% infested plants |
| 5. | *Spodoptera litura* | 8 egg masses/100 m row |

## Lecture 30 : BIOTECHNOLOGY IN PEST MANAGEMENT

Use of molecular biology techniques for the management of insect pests. The following are some strategies.

1. **Wide hybridization**: This technique involves transfer of genes from one species to other by conventional breeding. The genes for resistance are transferred from a different species. e.g. WBPH resistant gene has been transferred to *Oryza sativa* from *O.officinalis*.
2. **Somaclonal variability**: The variation observed in tissue culture derived progeny. e.g. Somaclonal variants of sorghum resistant to *Spodoptera litura* has been evolved.
3. **Transgenic plants**: Transgenic plants are plants which possess one or more additional genes. This is achieved by cloning additional genes into the plant genome by genetic engineering techniques. The added genes impart resistance to pests.

Transgenic plants have been produced by addition of one or more following genes.

a. Bt endotoxin from *Bacillus thuringiensis*
b. Protease inhibitors
c. -Amylase inhibitors
d. Lectins
e. Enzymes

c. **Bt endotoxin gene**: The gram positive bacteria *Bacillus thuringiensis* produces a crystal toxin called (delta) endotoxin.

The endotoxin is a stomach poison and kills the lepidopteran insects if consumed.

The gene (DNA fragment) responsible for producing endotoxin is isolated from Bt and cloned into plants like cotton, potato, maize, etc. to produce Transgenic cotton, etc.

| **Transgenic Bt plants** | **Target insect pests** |
|---|---|
| 1. Cotton | Bollworms, *S. litura* |
| 2. Maize | European corn borer |
| 3. Rice | Leaf folder, stem borer |
| 4. Tobacco, Tomato | Cut worms |
| 5. Potato, Egg plant | Colarado potato beetle |

**b. Protease inhibitors (PI) gene**

Insects have proteases in their gut which are enzymes helping in digestion of protein. Protease inhibitors are substances inhibit the proteases and affect digestion in insects. The protease inhibitor gene are isolated from one plant and cloned into another to produce transgenic plants.

e.g. Transgenic apple, rice, tobacco containing PI. e

e.g. Cowpea trypsin inhibitor (CpTI) is a PI isolated from cowpea and cloned into tobacco. This transgenic tobacco is resistant to Heliothis virescens.

**c. -Amylase inhibitor gene**

-Amylase is a digestive enzyme present in insects for digestion of carbohydrate. -Amylase inhibitor, affect digestion in insects.

Transgenic tobacco and tomato expressing -amylase inhibitor have been produced which are resistant to Lepidopteran pests.

**d. Lectins genes**

Lectins are proteins that bind to carbohydrates. When insect feed on lectins, it binds to chitin in peritrophic membrane of midgut and prevents uptake of nutrients. e.g. Transgenic tobacco containing pea lectin gene is resistant to *H. virescens*

**e. Enzyme genes**

Chitinase enzyme gene, and cholesterol oxidase gene have been cloned into plants and these show insecticidal properties.

PYRAMIDING GENES

Engineering transgenic crops with more than one gene to get multi-mechanistic resistance is called pyramiding of genes. e.g.

1. The CpTi gene and pea lectin gene were cloned to produce a tranagenic tobacco.
2. Transgenic potato which express lectin and bean chitinase have been produced.

**Potentials/Advantages of Biotechnology in IPM**

1. Slow development of resistance against transgenic Bt, PI, lectins
2. All plant parts express toxin and so no need for insecticide spray
3. No need for continuous monitoring
4. No environmental pollution, safe to NE, non-target organism

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