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FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

Lecture-6 METHODS OF CONTROL

Host Plant Resistance (HPR)

"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 plants 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. Pseudo resistance 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 and 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)	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.

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 neighboring plants.

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: Resistant variety increases efficacy of insecticides and natural enemies

Compatibility: 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 resistant 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 limitation: Absence of resistance genes among available germination

Cultural Control

1. Cultural methods or agronomic practices:

a. Use of resistant varieties

b. Crop rotation

c. Crop debris destruction

d. Tillage of soil

e. Variation in time of planting or harvesting

f. Pruning or thinning and proper spacing

g. Judicious and balanced use of fertilizers

h. Crop sanitation

i. Water management

j. Planting of trap crops

2. Mechanical methods:

a. Handpicking and destruction

Handpicking and destruction of large sized, conspicuous, immature or mature stages of insects is the most ancient method. It can prove fairly effective under certain conditions. In the field, insects can be handpicked if they are:

- Easily accessible to the picker,
- Large and conspicuous, and
- Present in large numbers.

b. Exclusion by barriers

Mechanical exclusion: Mechanical exclusion consists of the use of devices by which insects are physically prevented from reaching crops and agricultural produce. The various methods include:

a) The application of a fluffy cotton band 6" wide, or a band of a sticky material or a band of slippery sheets like alkathene around the tree trunk of mango tree to prevent the upward movement of the mango mealy bug.

b) Screening windows, doors and ventilators of the house to keep away houseflies and mosquitoes, bugs etc. In the morning and at dusk when mosquitoes gather on the screen they can be squashed with a piece of cloth. Screening placed over cavities and windows serves to exclude termites.

c) Packaging is a barrier to prevent insect infestation. Polymer films, and laminations can protect packages from insect infestation, whereas polyester, polyurethane resist insect penetration. Wrapping individual fruits of pomegranate and citrus with butter paper envelope to save them from attack of the butterfly and fruit-sucking moths respectively.

c. Use of traps

Trapping is popular method to lure insects to bait, light etc. to kill them. Traps usually fail to give adequate crop protection but prove useful to know population build up and are convenient to collect insect samples. Many trap designs have been developed room time to time to suit different insect species. Hopper-dozers were formerly used to collect grasshoppers. In these the insects after hitting the back of the machine fall to the bottom and then through a narrow opening collect into a box.

Yellow-pan traps containing water and few drops of oil were proved useful in killing hopper adults on paddy, sugarcane and wheat crops.

Sticky traps are boards of yellow color smeared with sticky substance, which trap and kill the flying insects that are attracted to and try to rest on it.

Pitfall traps are pan-like containers bearing insecticide and embedded below the ground level. Crawling and fast-running insects often fall into them and die.

Light traps attract night-flying insects, which fall into a container having insecticide, water or oil, or hit an electric grid. Light source emitting UV light is most attractive to insects.

Pheromone traps are particularly effective against the lepidopterous pests. Females release specific pheromone to which males are attracted from considerable distance.

d. Flaming and Burning

Flaming and burning are methods which use heat to kill insects and to eliminate breeding sites. Flaming, with kerosene as the fuel, started in US to control chinch bugs and the green Dug. The burning of locust adults and hoppers with the help of flamethrowers and flame torches, although costly, has a good psychological effect in mobilizing the public for locust control operations. In Suriname agricultural land was developed from rain forests by burning and flaming.

e. Shaking or Jarring

Shaking small trees and shrubs, particularly early in the morning in the cold season when the insects are benumbed, and collecting them in open tubs containing kerosinized water or simply burying them in pits is effective against locust and the defoliating beetles.

f. Clipping, Pruning and Crushing

Pruning and destruction of infested shoots and floral parts is effective in checking the multiplication of scales, mealy bugs and gall midges attacking fruit trees like grapes, citrus, ber, fig, custard apple etc

g. Use of Hand-nets and Bag-nets

The collection of adults with hand nets is recommended for Pyrilla (pest of sugar cane), ,when these insects are migrating in April- May from maize to sugarcane. The field bag is a strong cloth bag, 2 meters long with its mouth measuring lx 1.5 meters supported with bamboo sticks and two strings on the upper side. It is scraped on the surface of the ground by two men and is recommended against surface grasshoppers, rice grasshoppers, crickets etc. Even a one-man bag can be devised by reducing the size of its mouth.

3. Physical methods:

a. **Application of heat**

Hot water treatment: Exposing of infested grain to sun - Super heating of empty godowns at 50 degree C to kill hibernating stored grain pests.

Dry heat: Application of dry heat includirig exposure to sun rays during hot summer months helps in killing a number of pests in seeds and stored commodities. Exposure of cottonseeds to sun in thin layers for 2-3 days helps in killing the diapausing (suspended metamorphosis during winters) larvae of pink bollworm.

Exposure to sun: Exposing infested grain to the sun on a pucca floor in June also kills stored grain insects in the adult stage. Treatment of sugarcane setts with heat kills the scale insects carried over through the setts.

Superheating: Superheating of empty the storehouse to temperature above 50 ^{0}C for 10-12 hours kills the hibernating stored grain pests.

Steaming: Fruits and vegetables may be heated to disinfest insects by exposure to hot water, hot dry air, infrared radiation and micro wave radiation. Fruit flies and scale insects were controlled successfully by steaming. By steaming woolen clothes, the wooly bear is killed.

Radio-frequency energy: The radio-frequency portion of the electromagnetic spectrum, generally accepted to be between 1 and 100 MHz, causes heating of stages. Biological materials

specially wood, stored grain and food stuffs. This aspect has been found to have potential for insect control. The thermal tolerance of the host must be lower than the pest to create differential heating.

b. Application of cold

The first use of cold temperatures was in 1889 to control apple maggots. All eggs and larvae of apple maggots were killed within 35 days at 0 ^{0}C.

- Cold storage of fresh and dry fruits and vegetables is often resorted to for escaping fruit fly, potato tuber moth and pathogen damage. A temperature of 10 ^{0}C for several days kills fruit fly maggots.
- Stored grains pests are killed when stored grains are exposed to subzero temperatures by opening doors and windows of godowns.

c. Manipulation of moisture - Reduction of moisture content of grains helps to prevent from the attack of stored grain pests.

c. Energy - Light traps

d. Controlled atmospheres

Use of controlled atmospheres (CA) to manage insect pests has gained momentum in recent years. Carbon dioxide (CO_2) is toxic to insect, but its action is low. Eggs and adults of pulse beetle die when exposed to 100% CO_2 at 32 ^{0}C and relative humidly of 70%. Carbon dioxide under high pressure is found to be effective against stored grain pests. Carbon dioxide and nitrogen treatment have been found effective for grain beetle. A nitrogen atmosphere effectively controls all stages of fruit fly.

e. Irradiation

Electromagnetic energy consists of ionizing radiation and non-ionizing irradiation. Ionizing radiation consists of gamma rays and electron beam irradiation. Non-ionizing in-adiutjon includes radio waves, infrared waves, visible light and microwaves.

Microradiation (use of microwaves) and gamma radiation are being used against stored grain pests effectively. Infrared radiation can be used dually to the insects or to the stored grain infested with insects. Ionizing radiations (X-rays. λ-rays) are sterilizing at lower dosages but lethal at higher dosages. Although irradiation can disinfest various food stuffs but major obstacle of this control measure is the acceptability of irradiated food by consumer.

4. Biological control:

a. Protection and encouragement of natural enemies

b. Introduction, artificial increase and colonization of specific parasitoids and predators.

- Conservation of natural enemies
- Parasites and Parasitoids

Egg Parasitoids

Larval Parasitoids

Pupal Parasitoids

c. Propagation and dissemination of specific bacterial, viral, fungal and protozoan diseases.

Management of pests and disease causing agents utilizing, parasitoids, predators and microbial agents like viruses, bacteria and fungi is termed as biological control. It is an important component of IPM.

The three important approaches in biological control are:

a. Importation: Importation is also called classical method of biological control where bio-control agents are imported to control a pest of exotic origin.

b. Conservation: This is a method of manipulating the environment to protect the bio-control agents.

c. Augmentation: Augmentation aims at mass production of natural enemies / microbial agents and field release. Genetic improvement of bio-control agents to have superior traits also comes under this category.

List of biocontrol agents used for managing insects

S. No.	Biocontrol agent	Pest managed
	I. Parasitoids	
	Egg parasitoids	
1.	*Trichogramma sp.*	*Borers, bollworms*
2.	*Telenomus remus*	*Spodoptera litura*
	Egg larval parasitoid	
3.	*Chelonus blackburni*	Cotton bollworms
	Larval parasitoids	
4.	*Bracon brevicornis*	Coconut black headed caterpillar
5.	*Goniozus nephantidis*	Coconut black headed caterpillar
6.	*Elamus nephantidis*	Coconut black headed caterpillar
7.	*Bracon kirkpatrici*	Cotton bollworms
	Pupal parasitoids	
8.	*Brachymeria spp.*	Coconut black headed caterpillar
9.	*Tetrastychus Israeli*	Coconut black headed caterpillar
	II. Predators	
10.	*Chrysoperla carnea* (Green lacewing)	Soft bodied homopteran insects
11.	*Cryptolaemus montrouzieri* (Australian lady bird beetle)	Mealy bugs
	III Insect Pathogens	

12.	NPV of *Helicoverpa armigera* (Virus)	*H. armigera*
13.	NPV of *S.litura* (Virus)	*S.litura*
14.	*Bacillus thuringiensis* (Bacteria)	Lepidopteran insects
15.	*Beauveria bassiana* (Fungus)	Many insect pests

IV. Fungal Antagonists

16.	*Beauveria bassiana*	Aphids, Whiteflies, Mealybugs, Psyllids, Grasshoppers, Termites
17.	*Metarhizium anisopliae*	Termites, thrips
18.	*Verticillium lecanii*	Whitefly and several aphids
19.	*Nomuraea rileyi*	*Spodoptera litura*

5. Genetic methods:

- Use of sterile male technique

6. Regulatory methods:

- Plant quarantine

a. Foreign quarantine

b. Domestic quarantine

7. Chemical methods:

- Use of attractants
- Use of repellants
- Use of growth inhibitors
- Use of insecticides