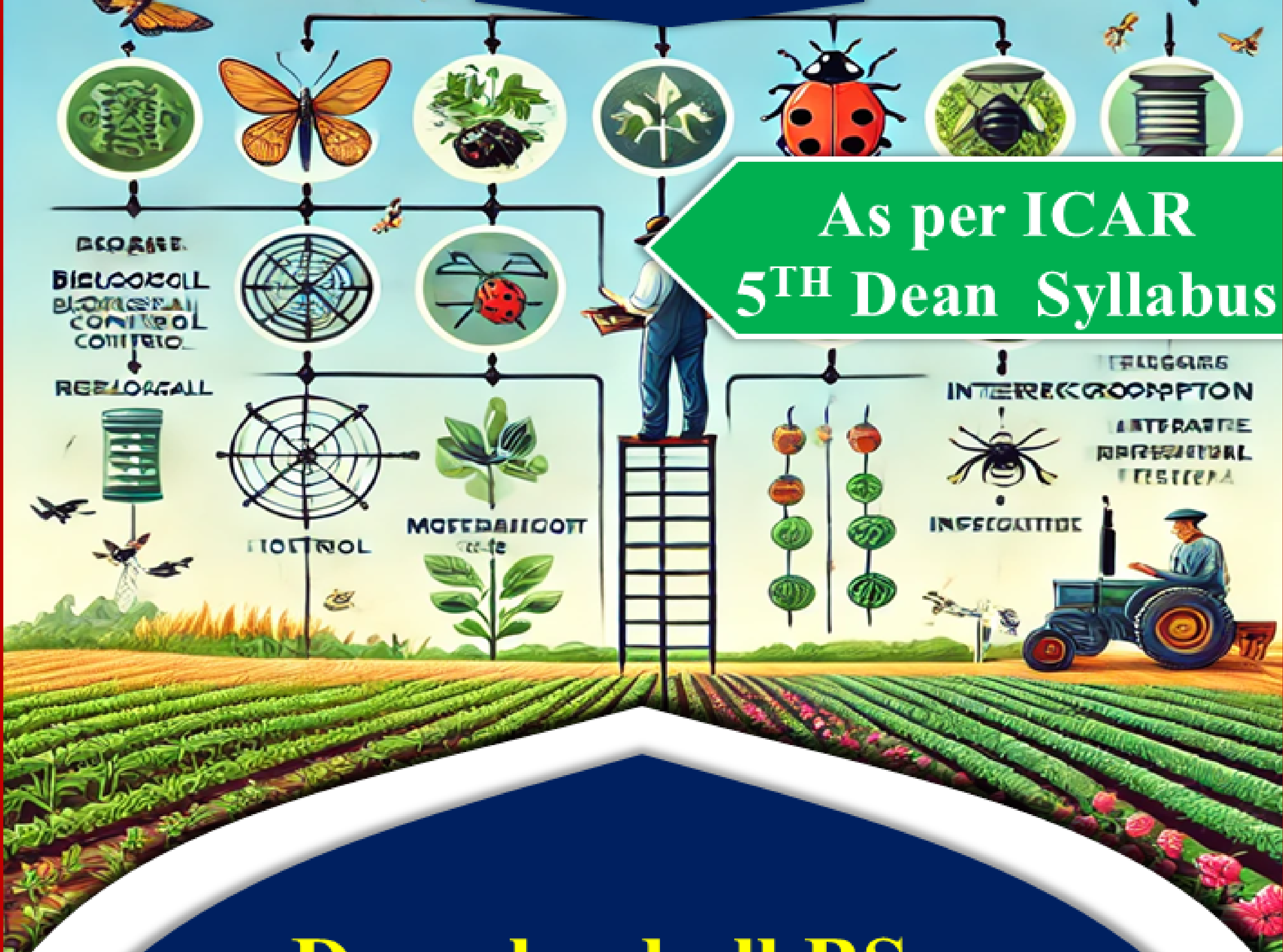
B.Sc. Ag
V Sem

Principles of Integrated Pest and Disease Management

Credit - 3(2+1)

As per ICAR 5TH Dean Syllabus



Lecture 1 : 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 2 : 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

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

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 b. Management costs	} Primary factors
c. Degree of injury per insect d. Crop susceptibility to injury	} Secondary factors

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 3: 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 4: 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°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°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^{o}C)

↓

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.

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 5 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 6 : 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 7: 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 8 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 9 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.

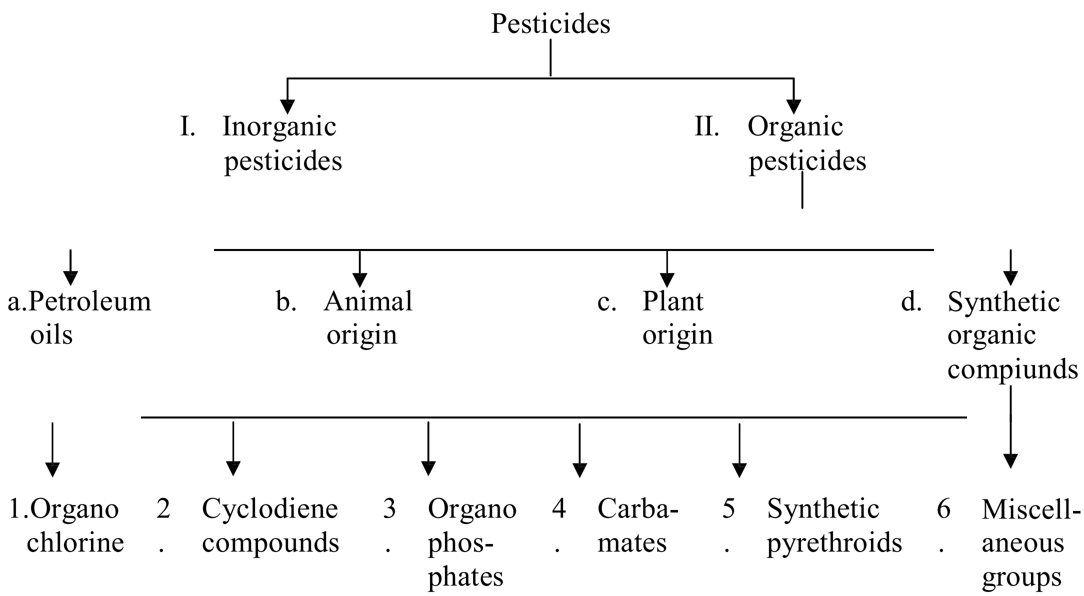
c) Respiratory poison : Chemicals which inactivate respiratory enzymes (eg.) hydrogen cyanide.

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 Magnesium oxide (3.5g) water 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.

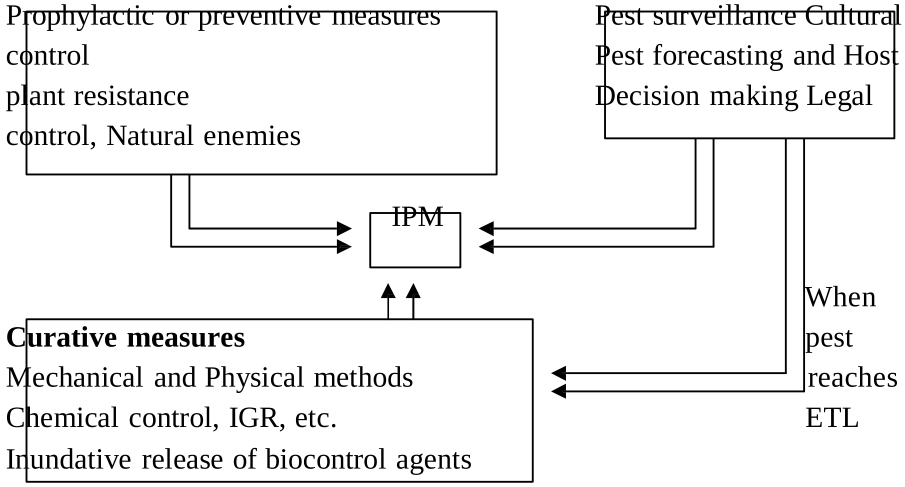
While selecting the method, it should possess following features:

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) 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 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.

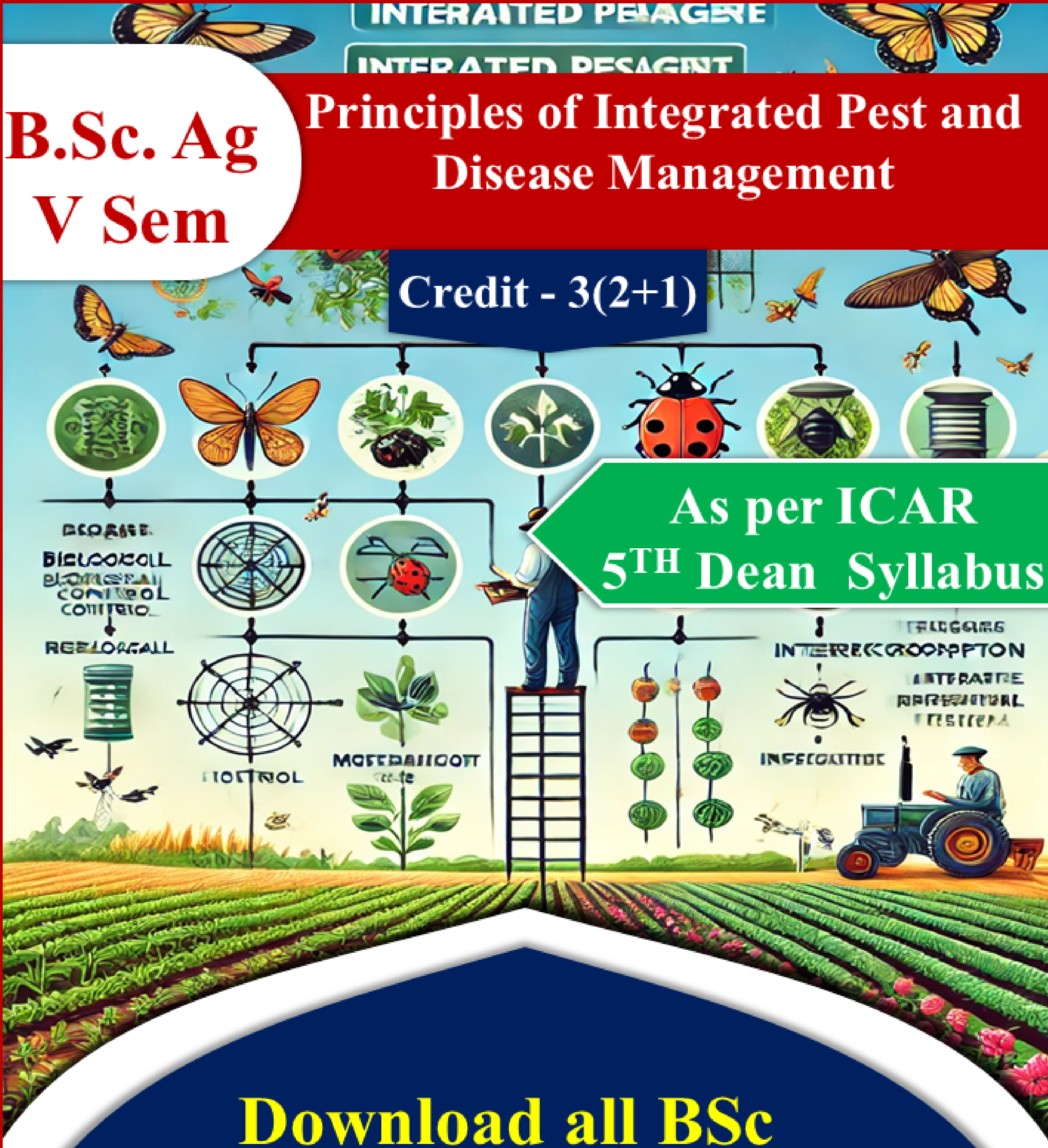
PYRAMIDING GENES

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



B.Sc. Ag V Sem

Principles of Integrated Pest and Disease Management

Credit - 3(2+1)

As per ICAR 5TH Dean Syllabus