PLANT QUARANTINE

LEGAL CONTROL METHODS -

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.

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.

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		

STERIITY METHODS

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

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

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 60CO (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).

HOST PLANT 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.

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