



# HOST PLANT RESISTANCE

## TYPES AND MECHANISMS

“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)**

### Historical milestones in the development of HPR

- In 3<sup>rd</sup> century BC Theophrastus recorded difference in disease susceptibility among crops
- 1782: “Underhill” variety of wheat reported resistant to Hessian fly in USA.
- 1817- Sorghum crop reported to be resistant to grasshoppers, *Melanoplus* spp.
- 1831: “Winter Majetin” variety of apple reported resistant to woolly apple in USA.
- 1890: Control of grape phylloxera in Europe by grafting of European grapevine scions to resistant North American rootstocks.



- **1860s-** C.V. Riley grafted European grapes on American rootstocks resistant to grape phylloxera (introduced from N. America) (also introduced downy mildew ... led to “Bordeaux mix” fungicide)
- **1914-** At Kansas State University R.H. Painter began breeding efforts for the scientific development of cultivars resistant to Hessian fly. Painter is widely recognized as the **“Father of Host Plant Resistance.”**
- **1935-** Cotton reported to be resistant to leafhoppers, *Empoasca* spp.
- **1973-** The first BPH-resistant variety with Bph 1 gene, 1R26, was released

## Science of plant resistance

1. Preworld war II era
2. Immediate Post world war II era
3. Era of Environmental awareness of recent year

### Prior to world war II

1. Mainly co-operative effects was made by scientists, plant breeder and entomologist to develop resistant cultivar.
2. 2<sup>nd</sup> era showed significant studies of biology, HP interaction to the exploitation of newly developed organic chemical pesticides
3. Third era since, 1960 there has been further steps towards IPM. This IPM was conditioned by 2 major factors.
  - (1) development of resistant to insecticide
  - (2) Environmental pollution by insecticide

HPR is one of the important components in IPM in the new era.

## Resistance can be assessed by these four characteristics

- Resistance is heritable and controlled by one or more genes.
- Resistance is relative and can be measured only by comparison with a susceptible cultivar of the same plant species.
- Resistance is measurable, i.e. it's magnitude can be qualitatively determined by analysis of the standard scoring system, or quantitatively by insect establishment.
- Resistance is variable and is likely to be modified by the biotic and abiotic environments.

## Types of Resistance

### I. Ecological resistance ( Pseudoresistance )

- Apparent resistance which is the result of transitory character in potentially susceptible host

- i. **Host evasion** – host pass through most susceptible stage quickly or at a time when insect numbers are reduced

Early maturity, Late planting, Late maturity

- ii. **Induced resistance** – Temporarily increased resistance resulting from condition of plant environment

Soil moisture, Fertility

- iii. **Escape** – lack of infestation due to inadequate pest load

## II. Genetic Resistance

### A. Number of genes

- a) Monogenic resistance: Controlled by single gene, Easy to develop easy to break
- b) Oligogenic resistance: Controlled by few genes
- c) Polygenic resistance: Controlled by many genes

### B. Major or Minor genes

- a) Major gene resistance: Controlled by one or few major genes (vertical resistance)
- b) Minor gene resistance: Controlled by many minor genes (Adult resistance or mature resistance or field resistance or horizontal resistance )

### C. Biotype reaction

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

## III. Based on population/Line concept

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

## IV. Multitrophic interactions

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

## V. Based on evolutionary concept

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

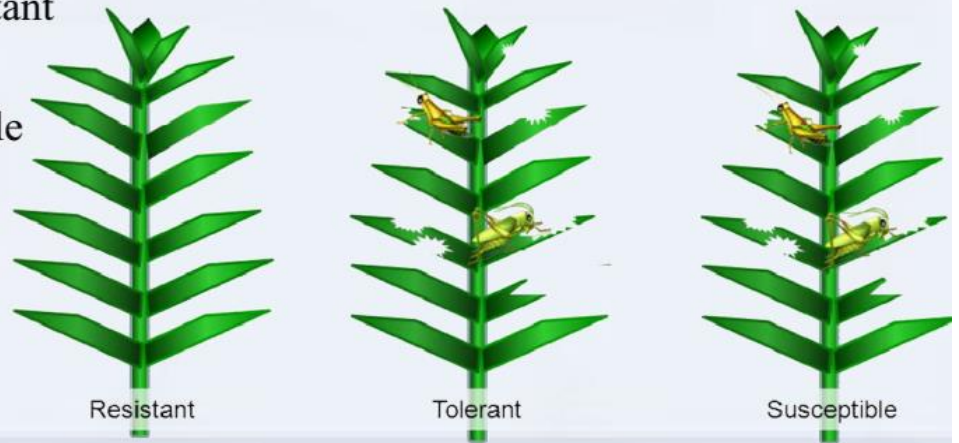
## Intensity of resistance

Two scale to measure the degree of resistance

A. Absolute scale

B. Relative scale –

- Highly resistance
- Resistant
- Moderately resistant
- Susceptible
- Highly susceptible



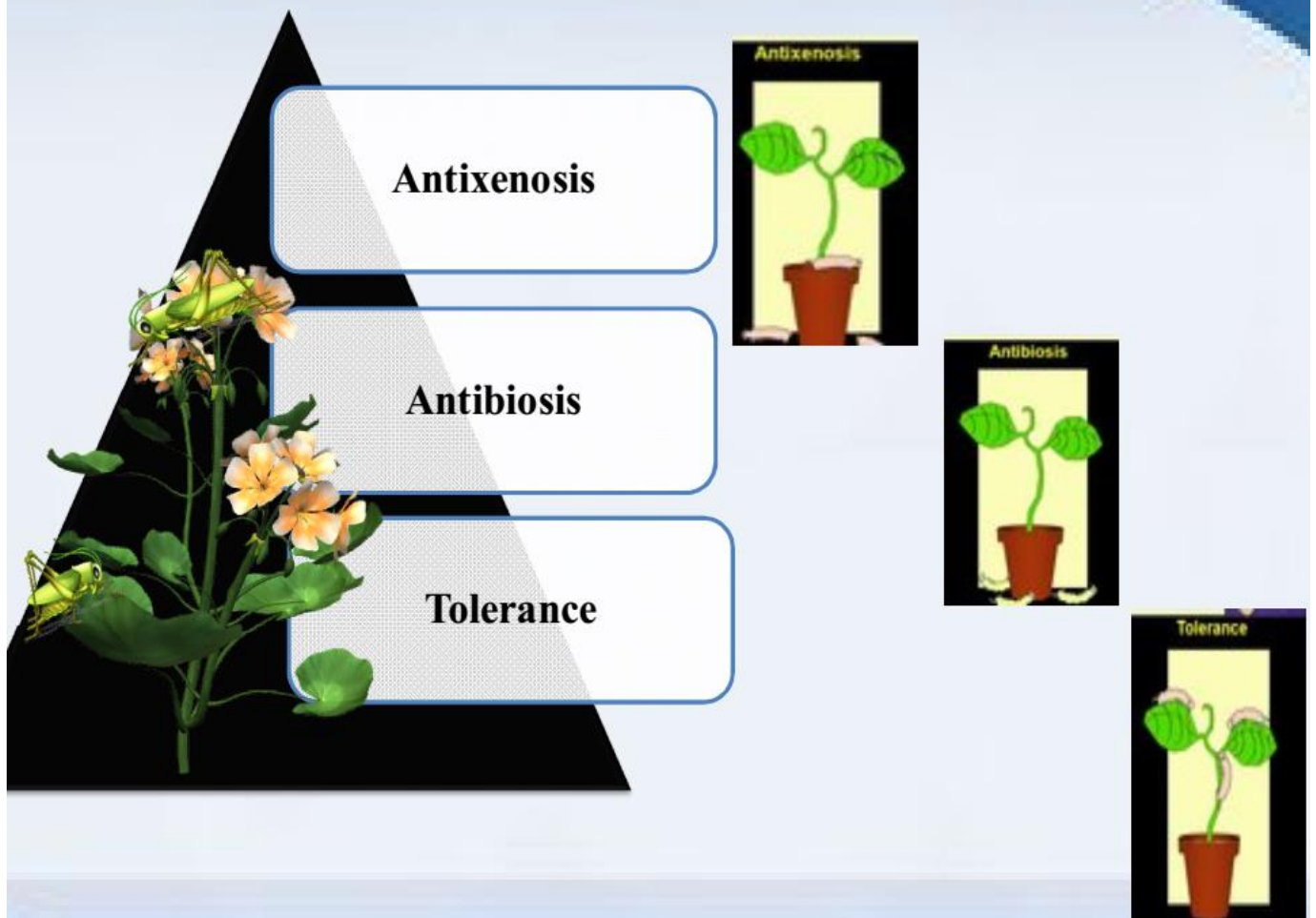
## Multitrophic interactions

- a) Intrinsic resistance : Through physical (Trichomes or toughness) or chemical (Toxins or digestibility ) or both (Glandular trichomes or resins)
- b) Extrinsic resistance : Natural enemies (Third trophic level) of insect pest (second trophic level) benefit the host plants (First trophic level) by reducing the pest abundance

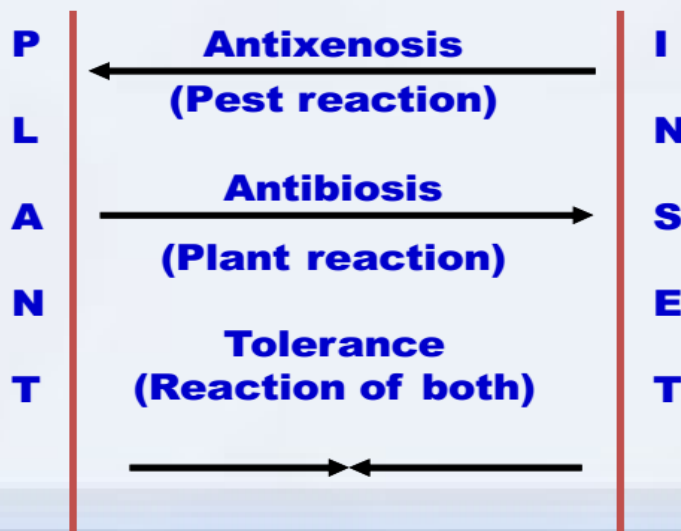
## Factors that affect resistance expression

- Physical Factors
- Plant Nutrition
- Biotic Factors
  - Plant factors
  - Pest factors
    - Biotype
    - Initial infestation level

## MECHANISM OF RESISTANCE



## Three fold basis Resistance based insect plant interaction according to Painter (1951) is

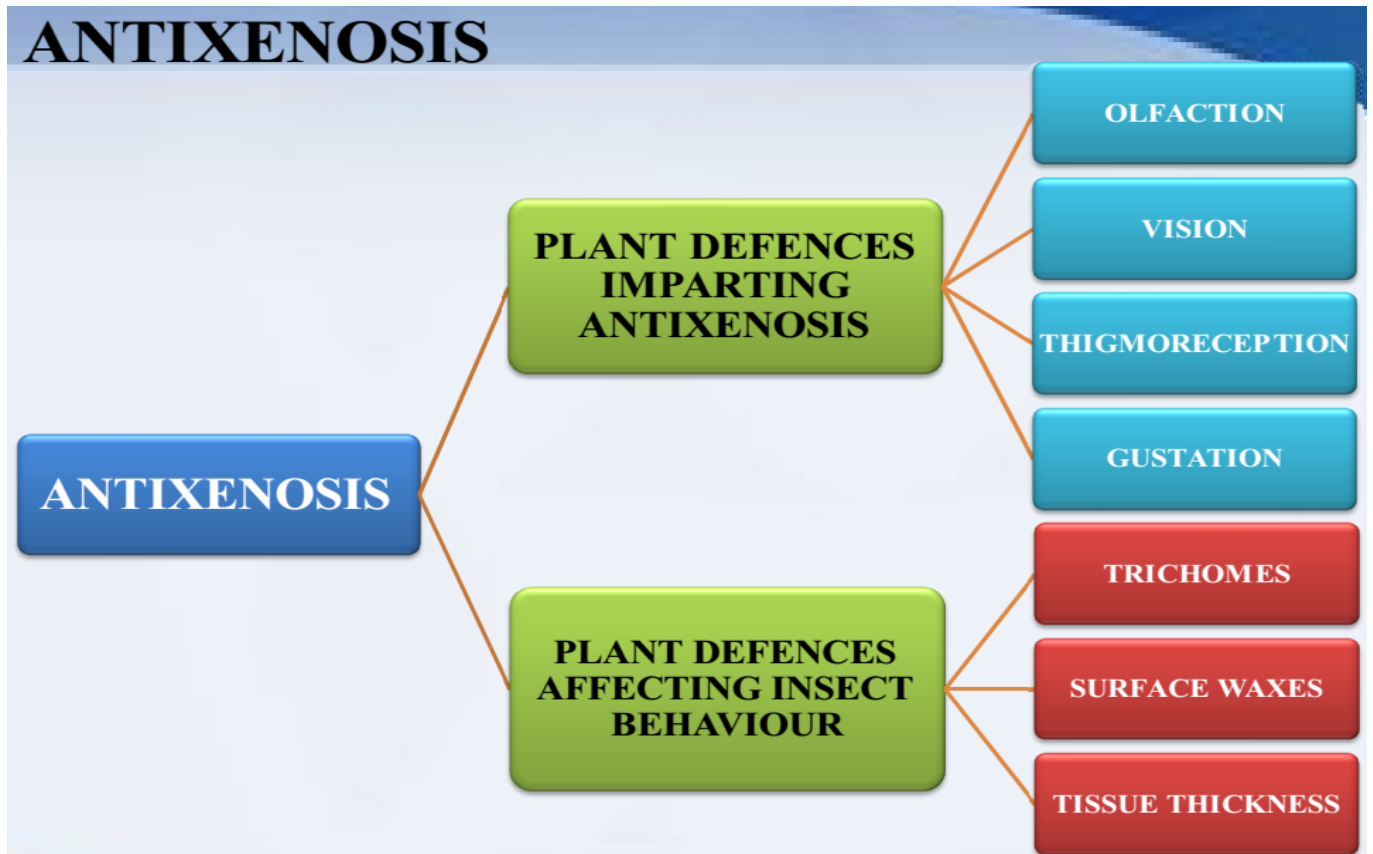


### Antixenosis (Non acceptance)


Xeno- meaning guest

Type of resistance where insect will not accept for feeding & breeding even if there is no alternative source.


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




## Examples for antixenosis




Trichomes in cotton - resistant to whitefly



Wax bloom on crucifer leaves - deter feeding by DBM



Plant shape and colour also play a role in non preference



Open panicle of sorghum - Supports less Helicoverpa

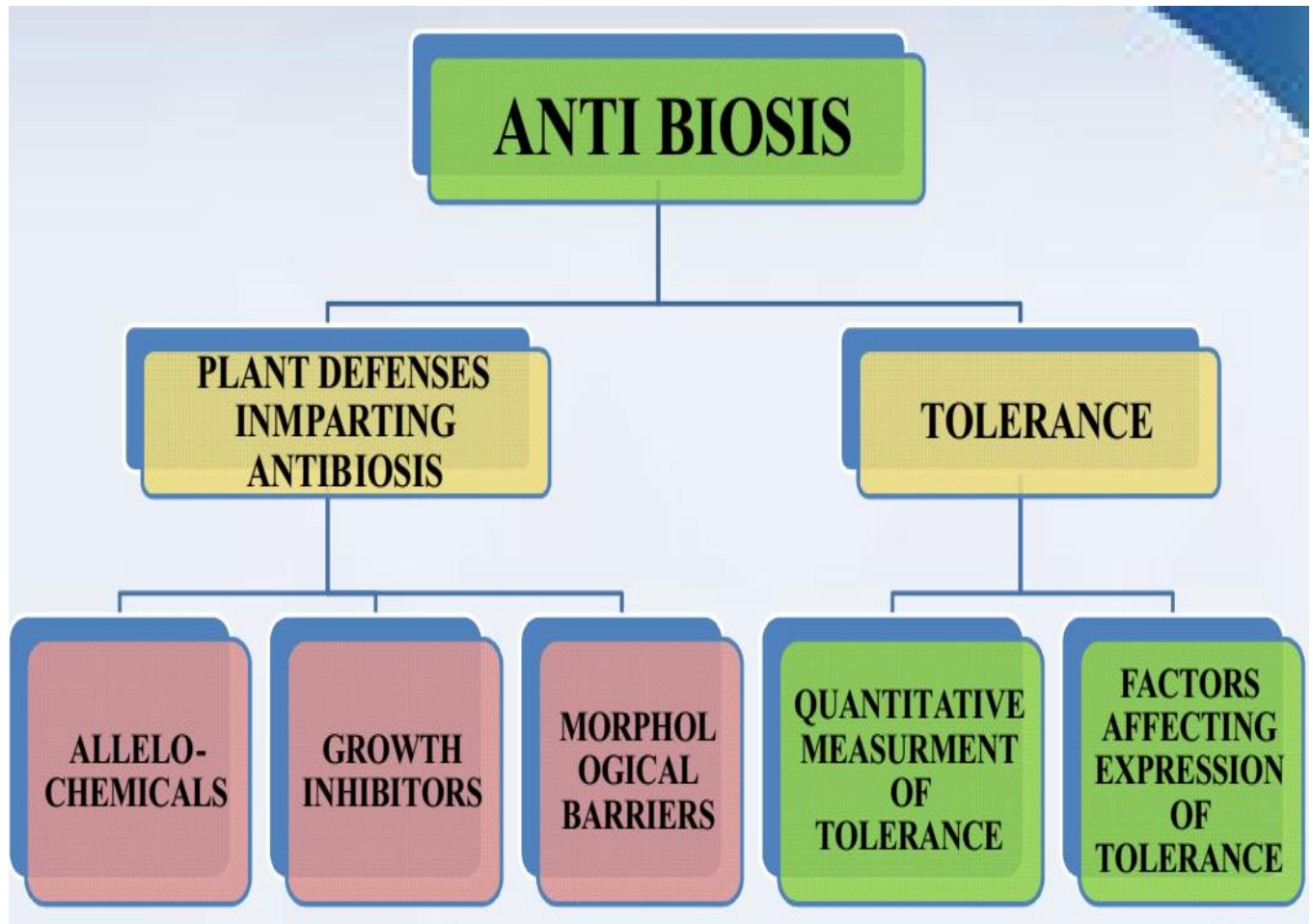
**Table 1. Important non preference characters**

Insect pests	Host plant characters	
	Non-preference	Preference
Bollworms	Smooth leaves	Hairy leaves
	Nectarileness	Nectarine
	Long pedicel	Short pedicel
	Thick boll rind	Thin boll rind
	Okra leaf	Soft boll rind
Boll weevil	Frego bract	Normal bract
	Red plant body	Green plant body
	Hairy leaves	Smooth leaves
	Leathery leaves	Succulent leaves
Whitefly	Smooth leaves	Hairy leaves
	Thin leaves	Normal leaves

## 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
- It may be due to :
  - a. Presence of toxic substances-
  - b. Absence of sufficient amount of essential nutrients
  - c. Nutrient imbalance/improper utilization of nutrients

Chemical means	Physical means
<b>DIMBOA</b> (Dihydroxy methyl benzoxazin) against <b>European corn borer</b>	<b>Thick cuticle</b>
<b>Gossypol</b> against <b>American boll worm</b>	<b>Glandular hairs</b>
<b>Sinigrin</b> against <b>Aphids</b>	<b>Silica deposits</b>
<b>Cucurbitacin</b> against <i>Myzus persicae</i>	<b>Tight leaf sheath</b>



- The effects may be

Direct

- |                   |                |
|-------------------|----------------|
| 1) Growth         | 2) Development |
| 3) Reproduction   | 4) Survival    |
| 5) General vigour |                |

Indirect

- 1) Vulnerability to biocontrol agents
- 2) Vulnerability to environmental aberration
  - Overall all effect is reduction in rate of population increase
  - Often mechanisms of antixenosis and antibiosis overlap

## Toxins of Plant origin

- Lectin
  - Lectin phytohemagglutinin
  - Wheat germ agglutinin
  - Snowdrop lectin, *Galanthus nivalis* Sucking pests, Pulse beetle and storage pests
- Enzymes & Enzyme inhibitors
- Protease inhibitors
  - Trypsin inhibitors
  - Alpha amylase inhibitors
  - Leguminaceae
  - Solanaceae
  - Poaceae

**Table 2. Biochemical components**

Components	Confer resistance
High gossypol	Bollworms, tobacco budworm and red spider mite
High phenol	Bollworms
High condensed tannin	Bollworms, aphids, lygus bugs, red spider mites and leaf miners
High tannin	
In leaves	Jassids
In buds	Bollworm tolerance
Low sugar	
In anther	Boll weevil and bollworms

# Tolerance

- Ability of the plant to grow and reproduce and even repair injury to a marked degree in spite of supporting a population approximately equal to that damaging a susceptible host
  - Plant is damaged but there is no economic yield loss or lowering of quality
  - Often tolerance is confused with low level of resistance or moderate resistance
  - It totally different from other two causes by not coming in/on to the way of insect activity
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- Therefore, it may be regarded as susceptible based on insect number or damage
  - It is an adaptive mechanism for the survival of plant and is more or less independent of the effect upon the insect
  - This type of resistance refers strictly to resultant effects and not to mechanisms.

## Insect-resistant cultivar developed for different crops in India

Common name	Scientific name	Cultivar
<b>Cotton</b>		
American bollworm	<i>Helicoverpa armigera</i>	Sujata, Abadhita, Sujay
Pink bollworm	<i>Pectinophora gossypiella</i>	LD135, Sujata, Abadhita
Spotted bollworm	<i>Earias vittella</i>	LD1245, Sanguineum
Cotton jassid	<i>Amarsca bigutulla</i>	Mahalaxmi, Sujay
<b>Sugarcane</b>		
Internode borer	<i>Chilo sacchariphagus indicus</i>	Co6806, Co975
Top borer	<i>Scirpophaga exercerpatalis</i>	Co7224, Co1158
White grubs	<i>Holotrichia spp.</i>	Co6304, Co5510
<b>Maize</b>		
Maize shoot fly	<i>Atherigona sp.</i>	DMR5, VC80
Pink stem borer	<i>Sesamia innferens</i>	Deccan 101 and 103
<b>Rice</b>		
Brown plant hopper	<i>Nilaparvata lugens</i>	IET7575, Jyoti
Gall midge	<i>Oaseolia virens</i>	Phalgun, IR36
Yellow stem borer	<i>Scirpophaga incertulas</i>	Ratna, MTU5849

<b>Groundnut</b>		
Leaf miner	<i>Aproaerema modicella</i>	ICGV86031, ICG57
Tobacco leaf caterpillar	<i>Spodoptera litura</i>	ICGV86031, FDRS 10
<b>Soyabean</b>		
Leaf miner	<i>Aproaerema modicella</i>	Nimsoy, PL507
<b>Chick pea</b>		
Pod borer	<i>Helicoverpa armigera</i>	Anupani, ICCV10, Dulia
<b>Pigeon pea</b>		
Pod borer	<i>Helicoverpa armigera</i>	Bori, ICPL332, BSMR 1
<b>Brinjal</b>		
Shoot and fruit borer	<i>Leucinodes orbonalis</i>	Pusa purple long, SM68
Jassid	<i>Empoasca kerri</i>	Krishna, UPB 1
<b>Potato</b>		
Potato tuber moth	<i>Phthorimaea operculella</i>	QB 1A 21-29
<b>Tomato</b>		
Fruit borer	<i>Helicoverpa armigera</i>	Pant bahar, BT 1, T 32

## **A. Advantages of host plant resistance**

- Cumulative and persistent
- No additional cost to grower (other than purchasing seed resistant to pests.
- No harmful residues
- No damage to beneficial fauna
- Integrates effectively with other control methods
- Conserves bio-control agents
- Most useful in low economic crops.

## **B. Primary disadvantages of host plant resistance**

- Several years to develop for one pest, longer for multiple resistance
- Different varieties needed for different geographical areas
- Need for good agronomic quality along with resistance
- Resistance most often found in species of off types of poor agronomic quality require much time to develop to an acceptant variety
- Biotypes. Insects adapt or change so as to feed on formerly resistant plants
- Incompatibility of resistance character with other characters
- Replacement of varieties by better yielders

## Compatibility of HPR in IPM

### a. Compatibility 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
- Compatibility: HPR can be combined with all other components of IPM
- Decreased pesticide application: Resistant varieties requires less frequent and low doses of insecticides
- Persistence: Some varieties have durable resistance for long periods
- Unique situations: HPR effective where other control measures are less effective
  - e.g. a. When timing of application is critical
  - b. Crop of low economic value
  - c. Pest is continuously present and is a single limiting factor