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Host Plant Resistance to Insects: An Eco-Friendly Approach for Pest Management and Environment Conservation

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Abstract
Host plant resistance (HPR) to insect is an effective, economical and environment friendly method of pest control. Annually, the cost of insect pest control in agriculture crosses billions of dollars around the world. Until recently, broad-spectrum synthetic pesticides were considered as the most effective means of pest control in agriculture. However, over the years, the over reliance on pesticides has caused adverse effects on beneficial insects, human health and the environment and has led to the development of pesticide resistant insects. There is a critical need for the development of alternative pest management strategies aiming for minimum use of pesticides and conservation of natural enemies for maintaining the ecological balance of the environment. Host plant resistance plays a vital role in integrated pest management but the development of insect-resistant varieties through conventional ways of host plant resistance takes time and is challenging as it involves many quantitative traits positioned at various loci. The most attractive feature of the HPR is that farmer virtually do not need any sill in application technique and there is no cash investment by the resource poor farmers. Considerable progress has been made in identification and devlopment of crop cultivars with resistance to the major pests in dfferent crops. There is a need to transfer resistance genes into high yielding cultivars with adaptation to different agro ecosystems. Resistance to insects should from one of the criteria to release varieties and hybrids for cultivation by the farmers. Genes from the wild relatives of crops and noval genes such as those from Bacillus thuringinsis cans also be deployed in different crops to made HPR an effective weapon to minimize the losses due to insect pest. HPR will not only cause a major reducation in pesticide use and slowdown the rate of development of resistance to insecticides in insect populations, but also lead to increased activity of beneficial organisms and reducation in pesticide residues in food and food products.

Keywords: Host plant resistance, insect, pest management, environment conservation

Introduction
Host plant resistance (HPR) to insect is an effective, economical and environment friendly method of pest control. Annually, the cost of insect pest control in agriculture crosses billions of dollars around the world. Under the changing climate scenario, the world's population is estimated to increase by 2 billion in the next 30 years, rising from the current 7.7 billion population to 10 billion by 2050 (Zsogon *et al*., 2022). In this context, there is a continuous need for an increment of food production to fulfill the need of the rising worldwide

population. Additionally, it is assessed that total global food demand will increase from 35% in 2010 to 56% in 2050 (van Dijk *et al*., 2021). Host plant resistance is the key component of pest management and one of the most appreciated control tactics in advanced agriculture (Horgan *et al*., 2020; El-Dessouki *et al*., 2022). It is the consequences of heritable plant characteristics that make a plant to be less damaged than a plant lacking these qualities. Insect-resistant crop varieties reduce the number of insect pests by increasing their tolerance for injury. Three types of resistance determine the relationship between the insect and the plant, *e.g*. antibiosis, antixenosis (non-preference) and tolerance (Koch *et al*., 2016; Iqbal *et al*., 2018).The development of insect-resistant plants began in 1782 when Havens published an article on a Hessian fly-resistant wheat cultivar. Since that time, several insect-resistant cultivars have been developed by the international and national research centers, the private sector using conventional or biotechnological tools (Jaiswal *et al*., 2018). Furthermore, for global food security and agricultural sustainability, temporary agriculture's primary goal is to enhance yields using existing land and resources. Therefore, innovative technologies have to be exploited to control pests and ensure adequate food availability in the future. Different plant protection innovations have been created to control, prevent and manage these pests with the trend of emphasizing/concentrating on the use of newer.

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

A. Ecological Resistance or Pseudo resistance

Apparent resistance resulting from transitory characters in potentially susceptible host plants due to environmental conditions. Pseudo resistance may be classified into 3 categories

1. 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.

2. 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

3. Escape

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

B. Genetic Resistance

1. 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

2. Based on biotype reaction

- Vertical resistance: Effective against specific biotypes (specific resistance)

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

3. 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

4. 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.

5. 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 white fly

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: dverse 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.

Chemicals present in plants	Imparts resistance against
DIMBOA (Dihydroxy methylthyl benzoxazin)	Against European corn borer, Ostrinia nubilalis
Gossypol (Polyphenol)	*Helicoverpa armigera* (American bollworm)
Sinigrin	Aphids, *Myzus persicae*
Cucurbitacin	Cucurbit fruit flies
Salicylic acid	Rice stem borer

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

Physical factors in antibiosis

Thick cuticle, glandular hairs, silica deposits, tight leaf sheath, etc.

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

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

Examples of resistant varieties in major crops

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

References

1. Zsogon, A., Peres, L.E.P., Xiao, Y., Yan, J. and Fernie, A.R. (2022). Enhancing Crop Diversity for Food Security in the Face of Climate Uncertainty. The Plant Journal, 109(2):402-414.
2. van Dijk, M., Morley, T., Rau, M.L. and Saghai, Y. (2021). A Meta-Analysis of Projected Global Food Demand and Population at Risk of Hunger for the Period 2010-2050. *Nature Food*, 2(7):494-501.
3. Horgan, F.G., Garcia, C.P.F., Haverkort, F., de Jong, P.W. and Ferrater, J. B. (2020). Changes in Insecticide Resistance and Host Range Performance of Plant hoppers Artifificially Selected to Feed on Resistant Rice. *Crop Protection*, 127: 104963.
4. El-Dessouki, W.A., Mansour, M.R.K. and Eryan, N.L. (2022). Effects of Certain Weather, Biotic Factors and Chemical Components on the Population of Aphids in Egyptian Wheat Fields. *Egyptian Academic Journal of Biological Sciences A, Entomology*, 15(1):1-13.
5. Iqbal, M.A., Hassan, M.W., Hafifiz, M.U.R., Muhammad, A. and Moazzam, J. (2018). Evaluation of Different Wheat Varieties for Resistance against Aphid, Schizaphis graminum R. (Homoptera: Aphididae) under Laboratory Conditions. *Asian Journal of Agriculture and Biology*, 6:549-555.
6. Koch, K.G., Chapman, K., Louis, J., Heng-Moss, T. and Sarath, G. (2016). Plant Tolerance: a Unique Approach to Control Hemipteran Pests. *Frontiers in Plant Science*, 7:1363.
7. Jaiswal, D.K., Raju, S.V S., Kumar, G.S., Sharma, K.R., Singh, D.K. and Vennela, P.R. (2018). Biotechnology in Plant Resistance to Insects. *Indian Journal of Agriculture and Allied Sciences*, 4: