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Host Plant Resistance and Integrated Pest Management

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Host plant resistance (HPR) and integrated pest management (IPM) are two complementary approaches used in agriculture to mange pest populations and reduce crop damage. Plant resistance is the expression of a resistance associated with plant traits that disrupt one or more aspects of the plant's genetic structure. Here's an overview of each approach and how they integrate:

Host Plant Resistance (HPR)

Host plant resistance refers to the natural or genetically engineered ability of plants to withstand or deter pest attacks. This can be achieved through various mechanisms i.e. Antibiosis, antixenosis (non-preference) and tolerance.

HPR can be achieved through traditional breeding methods, selecting for naturally resistant varieties, or through genetic engineering, where specific genes for resistance are introduced into the plant genome.

Integrated Pest Management (IPM)

IPM is a holistic approach to pest management that combines multiple strategies to control pest populations in an environmentally and economically sustainable manner. Key components of IPM include; Cultural practices, biological control, mechanical and physical controls**.** chemical control and genetic control

Integration of HPR in IPM

Host plant resistance is a critical component of IPM because it provides a foundation for reducing pest populations and damage with minimal input of other control measures. The integration of HPR into IPM involves:

1. Monitoring and Thresholds
2. Reduced Pesticide Use
3. Synergy with Biological Control:
4. Sustainable Practices

Historical development in host-plant resistance

Selection for plant resistance against herbivore attacks probably occurred in the very early stages of agriculture. This process continued until man started to selection of desired one by favouring certain plants of desired qualities. During the selection process natural resistance was often suppressed in favour of other traits. Starch reserves in the roots of primitive cassava plants are protected from herbivores by the presence of cyanogenic glucosides. The sweet cassavas are low in glucosides. In Africa bitter cassava may be the only crop plant that can grow in regions where wild pigs and percupines are abundant.

In modern era wheat variety resistant to Hessian fly, *Mayetiola destructor* (Say) was first reported in 1782 in the USA. In England the apple variety 'Winter Majetin' was resistant to the woolly apple aphid, *Eriosoma lanigerum* (Hausmann) was reported by Lindley in 1831, The most dramatic early success in plant resistance, however, was the control of the grape phylloxera, *Phylloxera vitifoliae* (Fitch), in European grapevines. Complete control of the pest was achieved by 1890 in ten years, after French vineyards were reconstituted using resistant North American rootstocks.

In India, hairy cotton varieties resistant to *Empoasca devastans* Distant evolved by earlier worker Lal (1937) and Hussain and Lal (1940). By 1943, other resistant varieties including 4F, LSS and 289 F/43 covered extensive areas in localities where jassids had posed a serious threat (Afzal *et al.*, 1944).

Despite these stunning examples, plant resistance attracted little attention during the beginning of this century. Systematic work on plant resistance to insects was initiated by R.H. Painter and his co-workers in the late 1920s. Awareness of complexities and far-reaching implications of pest management gave a new impetus to the research and utilization of plant resistance as one of the soundest tactics in the repertoire of the agricultural entomologists.

Host-plant selection and mechanisms of resistance

Every step in the host selection process, except for host habitat-finding is mediated by plant components. All the important components must be present at the correct time and in adequate levels for the regular growth and development of the insects. Therefore, a disturbance of the regular sequence of events can lead to plant resistance. This disruption can occur due to either an increase or decrease in the activity of substances called kairomones, which are beneficial to pests, or because allomones are present and their action is enhanced.

The majority of resistance traits are influenced by genetics. On the other hand, some characteristics are highly malleable and drastically change in response to external factors. As a result, resistance mechanisms can be divided into two categories: ecological resistance, which is mostly controlled by environmental variables, and genetic resistance, which is primarily controlled by genetic factors.

Ecological resistance

i. Phenological asynchrony

For an oligophagous insect, choosing the right plant at the right stage of development is frequently just as crucial as choosing the appropriate host. The same host plant's leaves could be the death knell for a larva that depends on fruiting structures for healthy development. Plant and insect phenologies must coincide such that the plant structure is present when a particular stage of the insect life cycle requires it. Host evasion is a form of resistance characterized by changes in plant development patterns that cause asynchronies of insect-host phonologies (Painter, 1951). Following examples are related to this mechanism:

- Winter maize-free of maize borer damage.
- Early sown cucurbits - escape damage of red pumpkin beetle.
- Winter guava fruit-free of fruit fly damage.

ii. Induced resistance

Plants can undergo physiological changes as a result of specific environmental factors and disease infections, making them unfit as hosts. The reactions of crop plants to common cultural methods, such fertilization and irrigation, which might result in significant quantitative or qualitative changes in the plant, are grouped under induced resistance.

Insects typically respond to high nitrogen budgets by increasing their survival and developing at faster rates. Aphids are particularly sensitive to a plant's nitrogen levels, although they react adversely to potassium levels, according to Van Emden (1966). Numerous plants produce and concentrate specific phenolic chemicals called phytoalexins in response to disease infestations. Phytophthora megasperma var. sojae is a fungal pathogen that can be injected into soybean plants to stimulate the synthesis of phytoalexins.

Genetic resistance

The three major mechanisms of genetic resistance are 1) tolerance, 2) antibiosis, and 3) antioxenosis. The third appears to have no effect on the insect, but the first two either alter the physiology or behavior of the insect.

i. Antixenosis

It is the resistance mechanism employed by the plant to deter or reduce the colonization of insects. The antixenosis mechanisms may be due to biophysical or biochemical factors or combination of both. Some times antixenosis mechanism is so effective that insects starve and die.

ii. Antibiosis

Antibiosis is the resistance mechanism that operates after the insects have colonized and started utilizing the plans. The antibiotic effects may result in decline in insect size or weight, reduced metabolic process, an increase in restlessness and a greater or pre-adult mortality. Plants that exhibit antibiosis may reduce the rate of population increase by reducing the rate of reproduction and survival of the insect. Sometimes, it becomes difficult to distinguish between antixenosis and antibiosis mechanisms of resistance.

iii. Tolerance

Tolerance refers to the capacity of certain plants to repair injury or grow to produce an adequate yield despite supporting an insect population at a level capable of damaging a more susceptible host. Tolerance usually results from one or more of the following factors: (1) the general vigor of the plants, (2) the regrowth of damaged tissues, (3) the strength of the stems and the resistance to lodging, (4) the production of additional branches, (5) the efficient utilization by the insect of nonvital plant parts, and (6) lateral compensation by neighboring plants.

Use of Host Plant Resistance in Integrated Pest Management

Plant resistance has six outstanding characteristics that greatly enhance its utility in IPM systems (Kogan 1982).

1. **Specificity:** Plant resistance is specific either to a single key insect species or a complex of pest organisms.
2. **Cumulative effectiveness:** Any reduction in insect pest density due to antibiotic resistance usually is the result of lowered fecundity, growth and development.
3. **Persistence:** Some varieties with durable resistance are likely to maintain their resistance for long periods.
4. **Compatibility:** The unique feature of plant resistance is that it is compatible with most of the other techniques of pest management.

5. **Environmental friendliness:** As no unnatural elements are used, there is no danger of contaminating the environment or endangering humans or wildlife. However, the environmental consequences of genetically engineered crops need to be understood.
6. **Ease of adoption:** Once the resistance varieties are developed, they are easily adopted in normal farm operations at no additional cost.

Integrated pest management (IPM)

It aims at utilization of different pest control tactics singly or in combination in a manner that is ecologically sound, economically practicable and socially acceptable (Metcalf and Luckmann, 1994, Kogan, 1998).

HPR as principal method of pest control

HPR to insects has been used as a primary method of pest control long before the advent of synthetic organic insecticides. A few insect pests have been controlled for many years by the use of resistant crop varieties alone (Table 1). The first deliberate use of plant resistance to control a major insect pest was the import of resistant root stocks of grapes (*Vitis spp*) from America to France for the control of grape *phylloxera, Viteus* (Phylloxera) *vitifoliae* (Fitch). This insect had destroyed over one million ha of vineyards and caused tremendous loss to French wine industry but the use of resistant root stocks allowed a quick recovery and gave effective control of phylloxera for more than 100 years (Smith, 1992).

In India, insect resistant varieties have been developed for the control of 65 insect pests of 22 crops (Sharma, 2002).

Integration of HPR with other control methods

A. HPR with biological control

Antibiosis type of resistance retards the development of nymphal/larval stages, reduces size and makes them less active and exposes them longer to natural enemies. The interactions between resistant crop varieties and natural enemies can be synergistic, additive, non-apparent or antagonistic (Hare, 1992).

Parasitoids: An analysis of interactions between resistant crop varieties and parasitoids revealed that antagonistic interactions were found.

Predators: The use of resistant cultivars combined with predators has generally proven beneficial in reducing insect numbers.

Pathogens: Positive interactions of HPR have been observed with bacteria *Bacillus thuringiensis* Berliner and protozoan parasite, *Nosema pyrausto* (Paillot) whereas both positive and negative interactions of HPR with nuclear polyhedrosis (NPV) and fungus Nomuraea.

Transgenic plants

Few studies conducted to study the interaction between transgenics and biological control agents indicated positive, neutral and negative interaction.

B. HPR with cultural control

The use of cultural management techniques can aid in the induction of resistance and the asynchronization of the pest's destructive stage with the vulnerable plant stage. cultural practices can be changed to either reduce the number of pests in crops or protect them against pest harm.

C. HPR with chemical control

When combined with resistant cultivars, chemical control becomes more effective as long as need-based treatment is followed. The widespread planting of rice gall midge resistance cultivars in India is one of the best instances of a significant decrease in the use of insecticides when paired with resistant variants.

Conclusion

Over the past few decades, an integrated approach involving plant breeders, entomologists, molecular biologists, and biochemists has resulted in the development of insect-resistant varieties of various crop plants. Generally speaking, the HPR has been shown to minimize pest issues, either on its own or in combination with other control measures. Plant allelochemicals have been found to cause HPR to negatively interact with other control strategies in a small number of cases. Hence, extensive investigations on diverse allelochemicals in plants or secondary plant metabolites and their effect on herbivores and natural enemies must be an intrinsic part of the development of insect resistant cultivars.

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Table 1 Selected examples of deliberate use of varieties with resistance to insect pests as the principal method of control

Crop	Insect pest		Region
	Common name	Scientific name	
Alfalfa	Spotted alfalfa aphid Pea aphid	*Therioaphis maculata* (Buckton) *Acyrthosiphon pisum* (Harris)	USA
Corn	European corn borer Corn earworm	*Ostrinia nubilalis* (Hubner) *Helicoverpa zea* (Boddie)	USA
Cotton	Cotton jassid	*Jacobiella facialis* (Jacobi)	Africa
Grapes	Grape phylloxera	*Viteus vitifoliae* (Fitch)	Worldwide
Rice	Brown planthopper Green leafhopper	*Nilaparvata lugens* (Stal) *Nephotetti virescens* (Distant)	Worldwide
Sorghum	Sorghum midge	*Contarinia sorghicola* (Coquillett)	India
Wheat	Hessian fly Wheat stem sawfly	*Mayetiola destructor* (Say) *Cephus cinctus* Norton	Worldwide

Source: Stoner (1996)

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