



Host Plant Resistance

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Plant resistance to pests and pathogens is a crucial aspect of modern agriculture, as it can significantly reduce crop losses and minimize the need for chemical control measures environmentally friendly and sustainable solutions to plant disease and pest management (M.J.Scout, 2014). One such approach is host plant resistance, which involves exploiting a plant's natural defense mechanisms to combat biotic stressors.

Plant-pest interactions are a captivating illustration of the intricate relationships found in nature, even within the managed settings of agricultural fields. These interactions are far from simplistic, involving a multi-faceted process by which herbivores identify, assess, and ultimately utilize their host plants (Rasmann and Agrawal, 2009). As herbivores navigate their environment, they rely on a combination of sensory cues, including visual and olfactory signals, to locate potential food sources. This initial searching phase is followed by a critical evaluation stage, where herbivores employ a suite of sensory modalities to determine the suitability of a plant for feeding and reproduction. This evaluation involves integrating information from visual cues, physical contact, and chemical signals emitted by the plant. The herbivore's success ultimately hinges on their ability to navigate the complex interplay of factors present within their chosen host, including nutrient availability, the presence of defensive compounds, and other plant characteristics that influence their growth and development (Smith and Clement, 2012). A deeper understanding of these dynamic interactions is essential for developing effective and sustainable pest management strategies in agriculture.

Types of Host Plant Resistance (HPR)

Host plant resistance encompasses various mechanisms, broadly categorized as follows:

Ecological Resistance or Pseudo-resistance: This type of resistance, also known as apparent resistance, arises from transitory characteristics in potentially susceptible host plants due to specific environmental conditions. It is not a stable form of resistance and can be categorized into three subtypes: (Howe and Jander, 2008; Wu and Baldwin, 2010).

- **Host Evasion:** The host plant may complete its susceptible stage quickly, coinciding with a period of low insect activity, or evade injury by maturing early. This evasion strategy pertains to the entire host plant population.
- **Induced Resistance:** This refers to a temporary increase in resistance due to altered plant conditions or environmental factors, such as changes in water availability or soil nutrient status.
- **Escape:** This occurs when a host plant remains uninfested or uninjured due to a transitory process like incomplete pest infestation. Escape pertains to a limited number of individuals within the host plant population.

Genetic Resistance: Genetic resistance, unlike ecological resistance, is heritable and offers a more stable and reliable form of defense against pests and pathogens. It is categorized based on the number and effect of genes involved, as well as other factors:

Based on the Number of Genes:

- **Monogenic Resistance:** This type of resistance is controlled by a single gene, making it relatively easy to incorporate into plants through breeding. However, it is also easily overcome by evolving pest populations.
- **Oligogenic Resistance:** This type is governed by a few genes, offering a broader spectrum of resistance compared to monogenic resistance.
- **Polygenic Resistance:** This complex form of resistance is controlled by multiple genes, providing durable and stable resistance against a wider range of pests and pathogens. (*Stout and Davis, 2009*).

Based on the Effect of Genes:

- **Major Gene Resistance:** This type is conferred by one or a few major genes, providing a high level of resistance against specific races or biotypes of pests or pathogens. However, it can be overcome if new, virulent pest biotypes emerge.
- **Minor Gene Resistance:** This type is governed by many minor genes, each contributing a small effect. The cumulative effect of these minor genes results in adult plant resistance, mature plant resistance, or field resistance. Horizontal resistance offers broader and more durable protection against a wider range of pests and pathogens compared to vertical resistance. (*González and Niks, 2012*)

Based on Biotype Reaction:

- **Vertical Resistance:** This type of resistance is effective against specific biotypes of pests or pathogens, offering a high level of protection against those particular strains. However, it can be overcome if new biotypes emerge.
- **Horizontal Resistance:** Also known as non-specific resistance, this type is effective against all known biotypes of a particular pest or pathogen. It provides broader and more durable protection compared to vertical resistance. (*Eskes and B., 2019*)

Based on Population/Line Concept:

- **Pureline Resistance:** This type of resistance is exhibited by lines that are both phenotypically and genetically similar.
- **Multiline Resistance:** This type is exhibited by lines that are phenotypically similar but genetically dissimilar. This approach involves mixing different lines with resistance to different biotypes of a pest or pathogen, creating a heterogeneous population that is less likely to be devastated by a single biotype.

Miscellaneous Categories:

- **Cross Resistance:** This occurs when a variety bred for resistance against one pest also exhibits resistance to another, often related, pest.
- **Multiple Resistance:** This refers to varieties that have been bred to resist multiple environmental stresses, such as insects, diseases, nematodes, heat, drought, and cold.

Mechanisms of Resistance

Plants deploy a variety of defense mechanisms to resist pest and pathogen attacks. Three primary mechanisms of resistance are antixenosis, antibiosis, and tolerance. (*Stout and J., 2013*)

Antixenosis: Antixenosis refers to plant characteristics that deter insects from choosing them for shelter, oviposition, or feeding. This resistance mechanism involves morphological factors that alter insect behavior, hindering their establishment on the plant. Examples of antixenosis include:

- **Physical Barriers:** Trichomes (hair-like structures) on cotton plants impede whitefly movement and feeding. Similarly, the waxy bloom on crucifer leaves deters feeding by diamondback moths. Cuticle thickening can hinder the entry of fungi and other pathogens.
- **Visual Cues:** Plant shape and color can also influence insect preference. For instance, open panicles in sorghum varieties are less favorable for *Helicoverpa* (cotton bollworm) oviposition and larval development compared to more compact panicle structures.

Antibiosis: Antibiosis describes the adverse effects of a host plant on the biology of insects and their progeny. This mechanism involves biochemical and biophysical factors within the plant that negatively impact insect survival, development, and reproduction. Antibiosis can manifest as larval death, abnormal larval growth, reduced fecundity, or other detrimental effects. Several factors contribute to antibiosis:

- **Toxic Substances:** Plants may produce secondary metabolites, such as alkaloids, terpenoids, and phenolics, that are toxic to insects upon ingestion or contact.
- **Nutrient Deficiency:** Resistance can arise from the absence or insufficient availability of essential nutrients required for insect growth and development.
- **Nutrient Imbalance:** Plants may hinder insect performance by creating nutrient imbalances or interfering with nutrient utilization pathways.

Chemicals produced by the host	Resistance against the pest
DIMBOA (Dihydroxy methyl benzoxazine)	<i>Ostrinia nubilalis</i> (European corn borer)
Cucurbitacin	<i>Bactrocera cucurbitae</i> (Cucurbit fruit flies)
Gossypol (Polyphenol)	<i>Helicoverpa armigera</i> (American bollworm)
Sinigrin Aphids	<i>myzus persicae</i> (green peach aphid)
Salicylic acid	<i>Scirpophaga incertulas</i> (Rice stem borer)

Tolerance: Tolerance refers to a plant's ability to withstand or recover from damage caused by pests or pathogens with minimal yield loss.

Tolerant plants possess mechanisms that enable them to compensate for damage, such as:

- **Compensatory Growth:** Tolerant plants can activate dormant buds or accelerate growth in undamaged tissues to compensate for lost photosynthetic capacity.
- **Wound Healing:** Efficient wound healing responses can limit the extent of damage and prevent secondary infections.
- **Physiological Adaptations:** Some plants exhibit physiological adaptations, such as increased photosynthetic rates or altered resource allocation patterns, that enable them to tolerate pests or pathogen pressure.

Advantages of Host Plant Resistance

Host plant resistance plays a crucial role in Integrated Pest Management by offering a sustainable and environmentally friendly approach to pest control. Here are some key advantages of incorporating HPR into Integrated Pest Management (IPM) strategies:

Specificity and Environmental Friendliness

- **Targeted Pest Control:** HPR offers a high degree of specificity, targeting only the intended pest species while leaving beneficial insects and natural enemies unharmed.
- **Eco-Friendly Approach:** Unlike chemical pesticides, HPR does not introduce harmful pollutants into the environment, making it safe for humans, animals, and ecosystems.

Sustainability and Long-Term Benefits

- **Cumulative and Lasting Effect:** The resistance conferred by HPR can persist for multiple generations of crops, providing long-term pest management benefits.
- **Reduced Pesticide Reliance:** HPR reduces the need for frequent pesticide applications, minimizing the development of pesticide resistance in pest populations.

Economic and Practical Advantages

- **Cost-Effectiveness:** By reducing pesticide use and crop losses, HPR offers significant cost savings for farmers.
- **Easy Adoption:** High-yielding, insect-resistant varieties are readily accepted and adopted by farmers due to their economic and practical benefits.
- **Compatibility with IPM:** HPR seamlessly integrates with other IPM components, such as biological control and cultural practices, for a holistic pest management approach.

Enhanced Effectiveness and Unique Applications

- **Increased Efficacy:** HPR can enhance the effectiveness of both insecticides and natural enemies, leading to improved pest control outcomes.
- **Unique Situations:** HPR proves particularly valuable in situations where other control measures are less effective or impractical.

In conclusion, host plant resistance offers a multifaceted solution for sustainable pest management. Its specificity, environmental benefits, long-term effectiveness, and economic advantages make it an indispensable component of successful IPM strategies.

Disadvantages of Host Plant Resistance

While Host Plant Resistance offers numerous advantages for pest management, it's essential to acknowledge its limitations:

Time-Consuming Development

- **Lengthy Breeding Programs:** Developing resistant varieties through traditional breeding is a time-intensive process, often requiring 3 to 10 years to achieve desired results. This can pose challenges in responding rapidly to new pest outbreaks or evolving pest pressures.

Biotype Development and Genetic Limitations

- **Emergence of Biotypes:** A significant concern with HPR is the potential for biotypes to develop. These are pest populations that can overcome the resistance mechanisms of previously resistant plant varieties. This evolutionary adaptation can undermine the effectiveness of HPR over time.
- **Limited Resistance Genes:** The success of HPR depends on the availability of suitable resistance genes within the plant's gene pool. In some cases, the absence of effective resistance genes in available germplasm can hinder the development of resistant varieties for specific pest-crop combinations.

In conclusion, while HPR is a valuable tool in integrated pest management, it's crucial to be aware of its limitations. The time required for development, the potential for biotype emergence and genetic constraints can impact its long-term effectiveness. Therefore, integrating HPR with other pest management strategies is essential for sustainable and resilient pest control.

Conclusion

Host plant resistance offers a powerful tool for sustainable pest management, providing targeted, enduring, and environmentally friendly pest control. However, the time required for development, potential for pest adaptation, and genetic limitations necessitate a realistic perspective. Integrating HPR with other IPM strategies remains essential for long-term effectiveness.

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