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Through the Artistry of Breeding's Embrace: Bollworm Resistance in Cotton

(*Rishi Raj Singh Chundawat, Radhika Shekhawat and Ajay Tanwar)
Rajasthan College of Agriculture, MPUAT, Udaipur
*Corresponding Author's email: chundawatrishirajsingh09@gmail.com

Research in pest control for cotton has been more extensive compared to any other crop. The economic loss of crops due to these insects is influenced not solely by the magnitude of pest attacks but also by the plant's response to infestation, the growth stage of the plant, and the duration of the assault. It's noteworthy that these insects undergo natural regulation by both abiotic and biotic factors. Abiotic factors, beyond human control, play their role, while biotic factors can be disrupted by the excessive use of insecticides. This intricate scenario poses a challenge, hindering the economic production of cotton.

The frego-bract, smooth plant body, nectar less flower, and leaf characteristics, along with high gossypol content, provides resistance to various insects in cotton. A successful breeding program for resistant cultivars is also a strategy for controlling bollworm attack, which requires essential cooperation between the breeders and entomologists.

Plant resistance is defined as the level of interaction between insects and their host plants under specific physiological, genetic, and environmental conditions that impact both the insect and the host plant.

Integrated Pest Management

To effectively tackle bollworm menace, an integrated pest management (IPM) approach is highly recommended. IPM involves combining various strategies and practices to minimize pest populations while reducing reliance on chemical insecticides. In the delicate realm of cotton agro ecosystems, certain agronomic practices wield the power to shape both the crop plant and its surrounding environment, becoming agents of change in the struggle against insect pests. These practices encompass a spectrum, from strategic planting dates and crop rotation to managing plant density, eradicating alternate host plants, and implementing various sanitary measures. Here are some key components of an IPM approach for managing bollworm:

- **Crop Rotation:** Rotate cotton crops with non-host plants like corn or sorghum to disrupt the bollworm life cycle. This practice can help reduce the population density of the pest.
- **Early and Late Planting:** By planting cotton earlier or later than the peak pink bollworm emergence period, you can avoid heavy infestation and reduce pest pressure on the crop.
- **Monitoring and Trapping :** Regularly monitor cotton fields using pheromone traps to detect the presence and density of bollworm populations. Trapping helps in determining the need for further control measures and facilitates decision-making.
- **Biological Control :** Encourage natural enemies of the bollworm, such as parasitic wasps and predators like ladybirds, to establish a balance in the ecosystem. These beneficial organisms help control bollworm populations naturally.

- **Chemical Control:** When necessary, judiciously apply insecticides to manage bollworm infestations. Rotate the use of different chemical classes to reduce the risk of resistance development. Timing the applications correctly based on the pest's life cycle is crucial for effective control. However, this seemingly effective approach carries its share of consequences. The aftermath of excessive insecticide use, leaves imprints on the harvested crop, introduces hazards to humans, animals, and vital pollinators, while contributing to environmental pollution.
- **Resistant Varieties:** Planting genetically modified (GM) cotton varieties that are resistant to bollworm can be an effective strategy. Bt cotton, which produces a toxin harmful to bollworm larvae, has shown considerable success in reducing infestations.

Breeding for Bollworm Resistant Cultivars

Genetic engineering has huge potential for increasing agricultural plant genetic variety by steady expression of foreign genes from diverse sources, including microorganisms. Bacillus thuringiensis (Bt) is the most likely source of insect resistance genes. One of the most effective tactics in modern agriculture is insect resistance through the use of Bt genes as in the case of Bt cotton, which is one of the earliest biotechnology crop protection products.

All the Bt cotton plants have one or more foreign genes obtained from the soil bacteria Bacillus thuringiensis, making them transgenic plants. The introduction of B. thuringiensis genes leads cotton plant cells to create crystal insecticidal proteins known as Cryproteins. These insecticidal proteins are efficient in eradicating some of the most damaging cotton caterpillar pests, such as tobacco budworm and bollworm larvae.

The three main components of the genetic package introduced into cotton DNA are as follows:

- **Protein gene** :- The Bt gene, which has been engineered for better expression in cotton, allows the cotton plant to manufacture Cry-protein. These insecticidal proteins are effective in killing some of the most injurious caterpillar pests of cotton, such as the larvae of tobacco budworms and bollworms.
- **Promoter** :- A promoter is a DNA sequence that regulates the quantity of Cry-protein generated in the plant and also where it is produced in the plant. Some promoters restrict protein synthesis to specific plant components, such as leaves, green tissue, or pollen. Others, such as those used in Bt cotton and some Bt maize types, induce the plant to manufacture Cry-protein all over the place. Promoters can also be employed to activate and deactivate protein synthesis.
- **Genetic marker** :- A genetic marker enables researchers to detect successful gene insertion into the plant's DNA. It also aids plant breeders in discovering and generating new Bt cotton lines. An herbicide tolerance gene related to the Bt gene is a frequently used marker by a breeder. Plants are sprayed with pesticide after the insertion of the Bt and marker genes into the plant's DNA. Those plants which were successfully transformed having the Bt gene, also shows resistance to the herbicide. Therefore, these plants will survive the herbicide spray. The plants without the marker gene, and hence without the linked Bt gene, will be killed by the herbicide.

Conclusion

The bollworm presents a significant challenge to cotton growers, but by adopting an integrated pest management approach, farmers can mitigate its impact. Through a combination of cultural, biological, and chemical control methods, along with the use of resistant cotton varieties, it is possible to reduce bollworm populations and protect cotton crops. Implementing these strategies, along with regular monitoring and collaboration, will help sustain cotton production while minimizing economic losses caused by this destructive pest. Transgenic crops are one of the most revolutionary developments in agricultural production. As with most new technology, there are exciting possibilities for the economic value of Bt cotton and apprehensions about its wise use.