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Battling the Pink Bollworm Outburst in Bt Cotton: Strategies to Overcome the Threat

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INTRODUCTION

Cotton (*Gossypium* spp.), often referred to as "White Gold," stands as a vital commercial crop in India, consuming over 45% of the country's total pesticide usage. Fortunately, the cotton gene pool possesses genetic resistance, a highly effective method for controlling sap-sucking pests like jassids and whiteflies. Over the years, India has developed numerous resistant and tolerant cotton varieties and hybrids, which have proven effective against these troublesome insects. However, a significant challenge persists in combating bollworm infestations, as no known resistance has been identified. Hence, an alternate strategy is explored to circumvent this problem by cloning and transferring the genes encoding the toxic crystal δ-endo toxin protein from the soil bacterium, *Bacillus thuringiensis*. This resulted in the successful creation of Bt transgenic cotton, known as Bollgard by Monsanto which has the ability to control the bollworms at the early stages of crop growth (upto 90 days) effectively. It was the first commercial Bt cotton variety released in USA in 1996 and 2002 in India, which contains Cry 1Ac gene of *B. thuringiensis*. Furthermore, Bollgard II, which received approval in India in 2006, also proved to be highly effective in controlling bollworms (Mohan, 2017; Mohan & Manjunath, 2002). Bt cotton's success story extended far beyond American and Indian borders. It is now commercially cultivated in numerous countries, including China, Australia, Mexico, South Africa, Argentina and Indonesia. India, as one of the world's leading cotton producers, has experienced a remarkable transformation in its cotton industry with the introduction of Bt cotton (Barwale et al., 2004). This technology empowers farmers to cultivate cotton with heightened resistance to insect pests, reducing the reliance on chemical pesticides and boosting crop yields.

It has been a game-changer in the world of cotton farming, offering sustainable pest management, increased yields, and reduced environmental impact. Nonetheless, as with any innovation, challenges have emerged over the years. The pink bollworm (*Pectinophora gossypiella*) has developed resistance to Bt cotton, raising concerns among cotton farmers (Fand et al., 2019). To ensure the continued success and sustainability of Bt cotton, it is essential to maintain focus on ongoing research and development, the responsible deployment of the technology, and a deep understanding of the ecological implications involved.

Challenges Faced by Bt Cotton

a. Resistance development: While Bt cotton has been highly effective in controlling bollworms and other target pests, some insect populations have developed resistance to the Bt proteins. This resistance occurs when insects that survive exposure to the toxin pass on their resistant genes to their offspring. To combat this issue, crop scientists must continually develop new Bt cotton varieties with different toxin profiles.

b. Non-target effects: Despite its specificity, there are concerns about the potential impact of Bt cotton on non-target insects. Research has indicated that the technology can affect beneficial insects like pollinators and natural enemies of cotton pests. Careful monitoring and field studies are essential to understand and mitigate these unintended effects.

c. Deployment strategies: The success of Bt cotton depends on proper deployment strategies. These include planting non-Bt cotton as a refuge area, monitoring pest populations, and adhering to recommended planting practices. Failure to follow these guidelines can lead to resistance development and a decrease in the technology's effectiveness.

d. Economic considerations: While Bt cotton has brought economic benefits, the initial cost of Bt cotton seeds can be a barrier for small-scale farmers. These seeds tend to be more expensive than conventional cotton seeds. However, many farmers find that the long-term benefits outweigh the initial investment (Arora & Bansal, 2012).

e. The pink bollworm challenge: The pink bollworm, a notorious pest in cotton farming, has managed to adapt to the Bt cotton technology. This insect is a formidable adversary due to its rapid reproduction and ability to develop resistance to the Bt toxin. The pink bollworm's ability to develop resistance to Bt cotton poses a significant threat to cotton farmers' livelihoods and the Indian cotton industry as a whole.

Factors contributing to pink bollworm resistance

Monoculture: Growing the same Bt cotton varieties repeatedly in a region has led to increased selection pressure on pink bollworms. This has accelerated the development of resistance.

Variability in Bt expression: Not all Bt cotton varieties express the toxin at the same level. Variability in toxin expression has allowed some pink bollworm populations to survive and reproduce on certain Bt cotton plants.

Crossbreeding: Pink bollworms have the ability to mate across cotton varieties, allowing resistance genes to spread more quickly.

Strategies to overcome pink bollworm resistance

Crop rotation: One of the most effective strategies is to encourage crop rotation. By planting non-Bt crops such as soybeans or maize in the off-season, farmers can disrupt the pink bollworm's life cycle and reduce its population.

Refuge areas: Maintain refuge areas of non-Bt cotton within or near Bt cotton fields. This strategy provides a place for non-resistant pink bollworms to thrive, reducing the likelihood of resistance developing in the population.

Stacked traits: Consider using Bt cotton with stacked traits that express multiple toxins,

making it harder for pink bollworms to develop resistance.

Pest Monitoring: Regular monitoring of pink bollworm populations allows farmers to take timely action with targeted pesticide use when needed.

Insecticides: If pink bollworm populations become unmanageable, judicious use of insecticides can help control the infestation. Integrated Pest Management (IPM) practices should be followed to minimize environmental impact.

Research and Development: Continuously invest in research and development to develop new Bt cotton varieties with enhanced resistance and improved toxin expression.

Farmer Education: Educating cotton farmers about the importance of adopting resistance management strategies is crucial to their successful implementation.

CONCLUSION

The pink bollworm's adaptation to Bt cotton in India underscores the importance of a multifaceted approach to pest management. While Bt cotton has undoubtedly improved cotton farming, its long-term sustainability depends on proactive resistance management strategies. Farmers, policymakers, and the biotechnology industry must work together to overcome the pink bollworm threat and secure the future of the Indian cotton industry. By implementing strategies such as crop rotation, refuge areas, and ongoing research, it is possible to maintain the benefits of Bt cotton while minimizing the risks associated with pest resistance.

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