- **Mechanism of Resistance to Bt Toxin**

  So far, the fear that bollworms will develop resistance to the Bt toxin has not been realized. The mechanism by which resistance in bollworms might develop is not completely understood, and researchers in the USA are trying to establish the basis for resistance. Researchers have used tobacco budworm *Heliothis virescens* gut cells, cultured in a laboratory, to demonstrate how the Bt toxin causes mature budworm gut cells to swell, burst and die. As the toxin-containing cells were killed, the remaining cells in the mid-gut started producing cytokinins—substances that signal budworm gut cells to multiply and rapidly differentiate to form new mature cells. If the insect received high doses of the toxin, all or most mid-gut cells were killed and there were no remaining cells to produce cytokinins in sufficient quantities to send messages to produce new mature mid-gut cells. But if the toxin was received by the target bollworm in lower doses, only a small quantity of mid gut-cells were killed and enough cells were produced to compensate for the cells killed. Consequently, the target bollworm was able to survive on low doses of the Bt toxin. Researchers have concluded that resistance development is quite possible because some cotton varieties express Bt toxin more than others. Similarly, some parts of the cotton plant express the protein more than others.

  When the U.S. researchers working with the tobacco budworm washed the Bt toxin from the cultured gut cells exposed to low doses, the ratio of cell types returned to normal and the bollworm recovered from the toxin effects. This is one of the early theories on how bollworms could develop resistance to some toxins, and at the same time it explains why low doses of the toxin do not kill all insects. It has been observed that in order to have good control of the target bollworm, the toxin must be expressed in high doses and should be able to kill all or the majority of mature gut cells simultaneously, before signals are sent and the insect starts creating replacement cells.

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