Pyramided Bt Cotton And Factors Leading To Potential Compromised Longevity: Cautionary Findings For Bt Corn And Western Corn Rootworm?

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In late March 2013, an article was published in the Proceedings of the National Academy of Sciences (PNAS) titled "Potential shortfall of pyramided transgenic cotton for insect resistance management." The authors of the paper were as follows: Thierry Brévault, Shannon Heuberger, Min Zhang, Christa Ellers-Kirk, Xinzhi Ni, Luke Masson, Xianchiun Li, Bruce E. Tabashnik, and Yves Carrière. The scientists pointed out in their introduction that the first generation of Bt cotton plants, those expressing the Cry1Ac protein, were first used by US producers beginning in 1996. During that same year, corn producers began to grow Bt corn hybrids for European corn protection across many Corn Belt states. From 2003 to 2011, the authors of the PNAS paper indicated that the use of cotton plants expressing a single Cry protein were gradually phased out as producers began to use more pyramided products (either Cry1Ac + Cry2Ab or Cry1Ac + Cry1F). The scientists who wrote this PNAS article outlined several assumptions that explained the justification and increased use of pyramided cotton plants: 1) assumed – evolution of field resistance could be delayed by using more pyramided Bt cotton products, 2) assumed – insects that were resistant to one Cry protein would be killed by the other Cry protein expressed in plant tissue (redundant killing), 3) assumed – recessive resistance and only insects that had two resistant genes (homozygous for resistance) for each Cry protein (toxin) would survive on pyramided cotton plants, and 4) assumed – insects that are resistant to both Cry proteins are very rare within the overall population (assumed that target insect population has not been exposed to either Cry protein). Central to the effectiveness and long term durability of pyramided Bt plants is the concept of redundant killing. Redundant killing can be potentially compromised according to the authors of the PNAS article by the following factors: 1) some susceptible insects survive even though exposed to the Cry proteins, 2) as plants mature, Cry protein concentrations may decline, potentially increasing the number of survivors, 3) if an insect population has an inherently reduced susceptibility to a given Cry protein, exposure to reduced Cry protein levels as plants age may increase overall survivorship of the target insect pest, and 4) if cross resistance exists between Cry proteins being expressed in Bt plants.

The investigators reported that a Helicoverpa zea (cotton bollworm) strain that had been selected for resistance to the Cry1Ac protein had increased survivorship on pyramided cotton plants. They also concluded that cross resistance occurred between the Cry1A and Cry2A proteins. By using these data, they ran some simulation models and determined that the use of pyramided Bt plants – designed to substantially delay resistance development – could be compromised for Helicoverpa zea. They further pointed out that in order to prolong the usefulness of pyramided Bt plants to control Helicoverpa zea, large refuges may be needed as part of an IPM program that integrates several management strategies.

As we move forward into the 2013 growing season, it is increasingly clear that more corn producers will rely upon pyramided Bt hybrids for corn rootworm control. Have some of the assumptions regarding redundant killing already been violated with respect to the western corn rootworm and the use of pyramided Bt hybrids? Unlike the use of high dose events for many lepidopteran pests, Bt hybrids for corn rootworms are generally recognized as low dose – there are survivors and occasionally severe pruning in some high pressure fields. The following passage in the PNAS paper is worthy of reflection: "Previous experimental evidence on the pyramid strategy comes primarily from a model system with diamondback moth and noncommercial Bt broccoli plants producing Cry1Ac and Cry1C. Although most of the optimal conditions for pyramids apply to this model system, they may not apply for some other pest-Bt crop combinations, particularly when pests have inherently low susceptibility to one or more of the toxins in the pyramid." We also know that root protection generally declines with some corn rootworm Bt hybrids as the season progresses. Consequently, a late-hatch and prolonged feed period can result in more severe root damage. Thus far, there has been no confirmation of western corn rootworm cross resistance between Cry3Bb1 and Cry34/35Ab1. That's good news. However, as new rootworm Bt proteins (e.g., eCry3.1Ab) enter the market place and are expressed in pyramid combinations, potential cross resistance will need to be continuously evaluated. Δ

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