How much do natural refuges mitigate resistance risks

Genetically-modified crops producing insecticidal proteins from *Bacillus thuringiensis* (Bt crops) are perceived as being at high risk from pest adaptation (Gould 1998). Several regulatory authorities around the world mandate or recommend the planting of non-Bt crops as structured refuges, where insects targeted by Bt crops can develop and breed. These refuges are intended to provide a reliable source of insects that are susceptible to the Bt proteins and can mate with any resistant insects emerging from the Bt crops, passing on Bt-susceptibility to their offspring. There has been much debate in the scientific literature about exactly how large these refuges should be, and how they should be managed (Mellon and Rissler 1998, Tabashnik et al. 2003) . Therefore, resistance management plans developed by Industry and regulators tend to be based on highly conservative assumptions. However, scientists are now learning that the perceptions from a decade ago may not be borne out by reality (Tabashnik et al. 2003). One of the underpinnings of the mandated structured refuge in the United States is the assumption that alternative (crop or non-crop) hosts for the target pest insects do not serve as natural, unstructured, refuges (SAP 2001).

In other countries, alternative hosts are recognized as providing important mitigation of the resistance risks. In China, Bt cotton is widely grown without mandated non-Bt cotton refuges, recognizing that other crops such as maize provide important sources of susceptible insects. In Australia, growers have the option of planting non-Bt pigeon pea as a refuge for Bt cotton, since this alternate crop is even more productive of the target pest, cotton bollworm, than is cotton. Currently, the US Environmental Protection Agency is considering relaxing the refuge requirements for Bt cotton lines that produce two Bt different proteins for control of tobacco budworm and bollworm (such "pyramided" traits are believed to be at far less risk of resistance development than are single-gene traits). New data demonstrate that alternative hosts play important roles in reducing the selection pressure for resistance. The EPA recently convened a Scientific Advisory Panel meeting (http://www.epa.gov/scipoly/sap/meetings/2006/index.htm#june) to consider whether the new data indicate that these alternative host crops reliably produce sufficient susceptible insects in proximity to and at the same time as any potentially resistant insects produced in Bt cotton fields. Industry and regulators have to balance any additional resistance risks that may result from relaxing the refuge rules with the financial and environmental benefits that would result from removing a barrier to the planting of additional Bt cotton acreage. The EPA is expected to make a decision later this year.

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