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New pest in crop caused by large scale cultivation of Bt corn

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Abstract

Since the year 2000 it has been observed in the United States that genetically engineered corn (maize) plants expressing the Bt toxin classified as Cry1Ab are being infested by the larvae of the western bean cutworm (*Striacosta albicosta*). Originally this pest only occurred within narrowly confined regions and caused no major problems in corn. For several years now, however, this pest has been spreading into more and more regions within the North American Corn Belt and causing substantial economic damage. There are empirical findings that the new pest has been caused by large scale cultivation of genetically engineered plants expressing Cry1Ab. This is considered to be a specific case of 'pest replacement'. In this case the corn earwom (*Helicoverpa zea*), a naturally occurring competitor of the western bean cutworm has been accidentally eliminated by the extensive cultivation of Bt corn. Under these circumstances the new pest is able to spread on a large scale and to infest crops heavily. This contribution reviews facts and findings and discusses possible strategies to counteract this new pest and serves as an overview on recent pest management problems in Bt crops.

New pest spreads through US corn belt

Since the year 2000 it has been observed that genetically engineered corn expressing the Bt toxin Cry1Ab is being infested by western bean cutworm (*Striacosta albicosta*) (Rice 2000; O'Rourke & Hutchison 2000). The western bean cutworm was historically only found in some regions and caused only minor problems in corn. At present, it is spreading into more and more states of the United States where it is causing significant economic damage. In 2006, a scientific publication reported extensive damage in South Dakota (Catangui & Berg 2006). In the meantime, western bean cutworm damage has been documented for almost all states in the North American Corn Belt. States affected for example include Iowa, Missouri, Minnesota, Wisconsin, Indiana, Michigan and Ohio (Eichenseer et al. 2008).

Pest replacement in genetically engineered corn

There are several studies explaining how the spread of the western bean cutworm is fostered by growing genetically engineered corn. Apparently it is a case of so called pest replacement (Butzen et al. 2007). This is a phenomenon previously observed in inten-

sive agriculture, where there is a massive use of pesticides. Pest replacement opens up new ecological niches in which other competitors (pests) can thrive. In this case Cry1Ab expressed by genetically engineered corn (YieldGard © Monsanto) is not only active against the European corn borer but also active against the corn earworm (*Helicoverpa zea*). This latter pest feeds not only on corn but is also cannibalistic to other pest insects such as the western bean cutworm (Rice & Dorhout 2006). The corn earworm is sensitive to the Bt toxin Cry1Ab, while the western bean cutworm is not. Thus the equilibrium situation between the two insect pests can be significantly changed. Interaction between the western bean cutworm and the corn earworm was confirmed in 2010 (Dorhout & Rice 2010), showing the spread of the western bean cutworm is in fact fostered by the cultivation of Bt corn expressing Cry1Ab. Damages caused by the western bean cutworm can even exceed those caused by the European corn borer in conventional plants (Catangui & Berg 2006). There are other reports of increasing problems with Bt crops which have been grown permanently on a large scale. For example in 2006, shifts in pest insects were reported in Bt cotton grown in China (Lu et al., 2010). Tabashnik et al. (2009) present several cases of resistance of pest insects to Bt crops in the fields.

Tab. 1: Some recent publications about pest management problems in Bt crops.

Source (Year)	Species	Crop/ Region	Effect
O'Rourke & Hutchison (2000)	Western bean cutworm	Corn / USA (Minnesota)	Pest replacement
Dorhaut & Rice (2004)	Western bean cutworm	Corn / USA (Illinois, Missouri)	Pest replacement
Catangui & Berg (2006)	Western bean cutworm	Corn / USA (South Dakota)	Pest replacement
Li et al (2007)	Cotton bollworm	Cotton/ China	Higher tolerance (Cry1Ac)
Wang et al (2008)	Mirid bug	Cotton / China	Secondary pests
Di Fonzo & Hammond, (2008)	Western bean cutworm	Corn / USA (Michigan, Ohio)	Pest replacement
Tabashnik et al (2009)	Fall armyworm	Corn / Puerto Rico	Resistance (Cry1F)
Tabashnik et al (2009)	Maize stalk borer	Corn/ South Africa	Resistance (Cry1Ab)
Tabashnik et al (2009)	Cotton bollworm	Cotton/ USA	Resistance (Cry1Ac, Cry2Ab)
Zhao et al, (2010)	Aphids, spider mites, lygus bugs	Cotton/ China	Secondary pests
Lu et al, 2010	Mirid bug	Cotton/ China	Secondary pests
Monsanto (2010)	Pink bollworm	Cotton/ India	Resistance (Cry1Ac)

Points for discussion: Industry's solution

Pioneer Hi-Bred and Dow AgroSciences are marketing a further corn hybrid in the USA, so-called 'Herculex' Corn, which expresses another variant of the Bt toxin (Cry1F), meant to be effective against western bean cutworm larvae. This genetically engineered corn has been grown commercially in the US since 2001. But western bean cutworm infestation can be curbed by growing the new corn hybrid, not completely

prevented, since Herculex is only 80 to 90 percent effective against western bean cutworm (Eichenseer et al. 2008). Additionally in 2009, the USA and Canada licensed a genetically engineered corn hybrid with eight gene constructs incorporating six different Bt toxins called 'SmartStax'. In relation to the control of the western bean cutworm the active ingredient in SmartStax is also Cry1F – thus it inherits the same deficiency as the 'Herculex' plants. In addition, those plants also produce Cry1Ab thereby suppressing the natural competitor of the western bean cutworm. Large scale cultivation of crops like Herculex or SmartStax can cause the less sensitive larvae of the western bean cutworm being selected systematically and spreading rapidly throughout the population. Thus the so called solutions could even aggravate the current situation. The spread of the western bean cutworm will mean good business for companies even if growing genetically engineered corn can not deliver as promised. The company Dupont, for instance, which owns the seed producer Pioneer, is advertising not only genetically engineered corn but also insecticides such as 'Asana XL' to control the new pest.

Some more points for discussion

There is increasing evidence that strategies used for large scale cultivation of Bt plants such as corn, cotton or rice need to be reassessed. In a publication in the magazine Nature (Qiu 2008) plans for Bt rice cultivation in China are questioned because many of the already known pest insects could not be controlled by the Bt produced in the plants. In the article, a researcher from the International Rice Research Institute IRRI, the Philippines, raised a very basic question concerning the general strategy of growing Bt-plants: “Pests thrive where biodiversity is at peril. Instead of genetic engineering, why don't we engineer the ecology by increasing biodiversity?” There is a growing need to find alternatives to current practises. alternatives to current practices. There might be several reasons for pest replacement, like climate change, change in agricultural practices, but the large scale growing of Bt crops seems to play a major role here. Pest replacement and pest resistance seem to be an inevitable consequence of any strategy that continuously tries to suppress or eliminate pest organisms. This is especially true for the strategy underlying the usage of Bt crops or plants expressing VIP toxins (as propagated by company of Syngenta), since the release of the toxin is not targeted and time limited, but implies permanent exposure throughout the whole period of cultivation. The ecosystem can be destabilised by suppressing certain insects at the same time the door is opened to pest replacement and pest resistance in major pest insects. Subsequently, farmers will end up doing two things – buying expensive seeds to grow multi-stacked Bt-plants and spraying hazardous pesticides.

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