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FORUM

# Assessing the risks of insect resistant transgenic plants on entomophagous arthropods: Bt-maize expressing Cry1Ab as a case study

Anna DUTTON, Jörg ROMEIS and Franz BIGLER*
*Swiss Federal Research Station for Agroecology and Agriculture (FAL), Reckenholzstr. 191, 8046 Zurich, Switzerland*
**Author for correspondence; e-mail: franz.bigler@fal.admin.ch*

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**Abstract.** One of the primary concerns related to the adoption of insect resistant transgenic plants in the environment is the detrimental effect that these may pose on non-target organisms, including entomophagous arthropods (parasitoids and predators) which have an important function in regulating pests. Despite the fact that regulatory bodies require information regarding the potential risk of releasing transgenic plants in the environment, to date, no specific protocols have been designed for assessing the risks of insect resistant transgenic crops on entomophagous arthropods. Here a framework for risk assessment is proposed to evaluate the effects of insect resistant plants on entomophagous arthropods. Using maize expressing the *Bacillus thuringiensis* gene which codes for the Cry1Ab toxin, we illustrate the procedure necessary for assessing the risks. As a first step, it is required to determine which entomophagous arthropods play a major role in regulating maize pests, and which may be at risk. Because the risk which transgenic plants pose to entomophagous arthropods depends on both, their exposure, and their sensitivity to the insecticidal protein, it is essential to determine, as a second step, if and at what level organisms are exposed to the transgene compound. Exposure will be associated with the feeding behaviour of phytophagous and entomophagous arthropods together with the tissue and cell specific temporal and spatial expression of the insecticidal protein. For those organisms which could potentially be exposed to the insecticidal protein, sensitivity tests, as a third step, should be performed to assess toxicity. The testing procedure and the type of tests which should be adopted to quantify the effects of insect resistant plants on natural enemies are subsequently illustrated. Taking the green lacewing *Chrysoperla carnea* as an example, we propose a procedure on how to perform tests and give evidence that Bt-maize poses no risk to this predator.

**Key words:** *Chrysoperla carnea*, exposure, genetically engineered crops, parasitoids, predators, risk assessment, test procedure, tiered system, toxicity

## Introduction

To date, the only insect resistant transgenic plants that are commercially available are those expressing genes which code for *Bacillus thuringiensis*

(Bt) toxins. The amount of area being cultivated with these crops is rapidly increasing (James, 2002), and other genes coding for new Bt-toxins, lectins, proteinase or $\alpha$-amylase inhibitors, and other insecticidal products have been successfully engineered in plants (Schuler et al., 1998; Jouanin et al., 1998). Some of these plants are being tested at the field scale, such as peas (*Pisum sativum*) expressing the gene coding for common bean $\alpha$-amylase inhibitors ($\alpha$AIs) (Morton et al., 2000). Moreover, in 2002, over 200 applications for release permits to conduct field tests with 11 different transgenic crops expressing various insect resistant genes were notified in the USA alone (ISB, 2002), indicating that the adoption of various transgenic plants is likely to increase.

Similar to other plant protection technology, insect resistant transgenic plants bear risks and benefits to the environment (NAS, 2002). The primary ecological concerns to the release of transgenic plants include those related to their possible invasiveness in ecosystems, out-crossing, horizontal gene transfer, development of pest resistance, and effects on non-target organisms (Conner et al., 2003). Effects of GM plants on non-target entomophagous arthropods (predators and parasitoids) have been a major concern as these organisms often play an important role in natural pest regulation, and are considered to be of economic value. Moreover, this group of organisms may be a good indicator of potential ecological impacts of transgenic plants as they belong to the third trophic level in the food chain (Groot and Dicke, 2002). Although we are aware that other non-target arthropods such as herbivores, pollen feeders (bees), soil arthropods as well as other organisms including birds, mammals, and fish could be affected by transgenic plants, here we shall limit ourselves to the assessment of the risks of transgenic plants on entomophagous arthropods.

Despite the fact that regulatory bodies in different countries require a detailed environmental risk assessment for the release of transgenic plants (Nap et al., 2003), it is often debated what and how to measure (Conner et al., 2003). This is distinctively the case for the assessment of non-target organisms as these include a large number of species. Moreover, these organisms can potentially be affected by insect-resistant transgenic plants through various ways (Schuler et al., 1999; Groot and Dicke, 2002). For example, the impacts on non-target entomophagous arthropods can be due to direct toxic effects through exposure to the insecticidal protein, indirect effects via reduction in prey/host quantity and/or quality, or indirect effects due to unintended changes of plant properties (chemical or physical) caused by the insertion of a new gene (pleotropic effects or insertional mutagenesis). Although this complexity can make testing and assessment difficult, uncertainty can be