Collaboration for Environmental Evidence

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Plain Language Summary
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Systematic Review
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Genetically modified insect-resistant maize has little impact on studied non-target invertebrates

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Graphic by Michael Meissle, Agroscope; published open access by *Environmental Evidence* as a cover of the review protocol, https://doi.org/10.1186/2047-2382-3-7)

Genetically modified Bt maize is protected against certain insect pests by producing insecticidal proteins from the bacterium *Bacillus thuringiensis*. A new systematic review including statistical analysis of global field data confirms that populations of most non-target organisms studied remain unharmed in untreated Bt maize. When compared with conventional maize treated with broad-spectrum insecticides for pest management, Bt maize provides benefits for non-targets.

Why is this Evidence Synthesis Needed?

For genetically modified crops that produce insecticidal proteins, adverse effects on beneficial species, such as natural enemies of pests or decomposers, are a major area of concern and are thus a focus of research and regulatory risk assessments. Over the past 25 years, hundreds of studies on environmental effects of maize that produces insecticidal proteins of the bacterium *Bacillus thuringiensis* (Bt) have been published. Systematic reviews including statistical meta-analyses are valuable for various stakeholders to address uncertainties regarding environmental impacts of the technology.

This review covers field studies from multiple countries worldwide investigating Bt maize that produces one or several insecticidal proteins. Those Bt proteins are intended to target pest caterpillars or corn rootworm larvae, while other insect groups remain largely unaffected. In many cases, Bt maize has replaced pest control with broad spectrum insecticides.

This Collaboration for Environmental Evidence systematic review examines evidence of the effect of growing of Bt maize on abundance or ecological functions of non-target animals compared to the growing of non-Bt maize. The review summarizes evidence from 166 articles. Of 120 articles, quantitative data was extracted and entered into a database, resulting in >7200 records from 233 experiments. The database was used for statistical meta-analyses.

Main Findings

What studies are included?

The review includes replicated studies that compare populations of non-target animals in Bt maize (*Zea mays*) with those in non-Bt maize, either untreated or treated with insecticides. Approximately 86% of the 7279 records derived from experiments conducted in the USA and Europe. In more than 50% of the records Bt maize that produces Cry1Ab-protein against pest caterpillars was used and in 25% Cry3Bb1-protein against corn rootworm larvae was used. Most data were available for activity density (53% of records) or abundance (46%) of invertebrates, while the ecological functions of predation and parasitization were studied less frequently (1%). When insecticide was applied to non-Bt maize (2224 records), pyrethroids were the most common insecticide class (67% of records).

Meta-analyses revealed no effects of Bt maize on most analyzed invertebrate groups

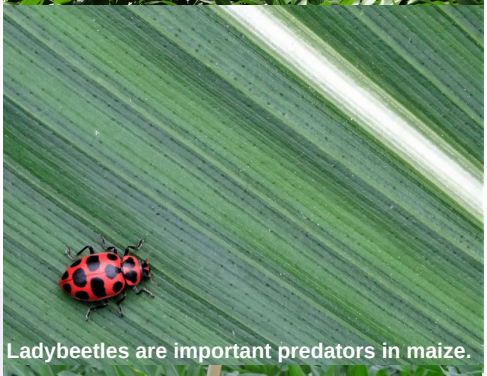
Most analyzed invertebrate groups were not affected by Bt maize when no insecticides were applied. However, Bt maize harbored fewer parasitoids of the European corn borer, the main target pest of Bt maize. Some analyses revealed lower numbers of sap beetles (Nitidulidae), rove beetles (Staphylinidae), and hoverflies (Syrphidae), but higher numbers of ladybeetles (Coccinellidae), flower bugs (Anthocoridae), and lacewings (Neuroptera) in Bt maize compared with untreated non-Bt maize. Those effects could be indirect and caused by food web or other ecological mechanisms and not by direct toxicity of the plant-produced Bt proteins. Larger differences were evident between untreated Bt maize and insecticide-treated non-Bt maize. In particular, populations of predators, such as spiders (Araneae), ladybeetles (Coccinellidae), and flower bugs (Anthocoridae), were reduced when broad spectrum insecticides of the pyrethroid class were applied to non-Bt maize. It was also examined if authorship or financial support by biotechnology companies affected the outcome of the meta-analyses. Negative effects by Bt maize on nontargets, however, were found more often in studies with private sector support than in studies where no backing by biotech companies was declared.

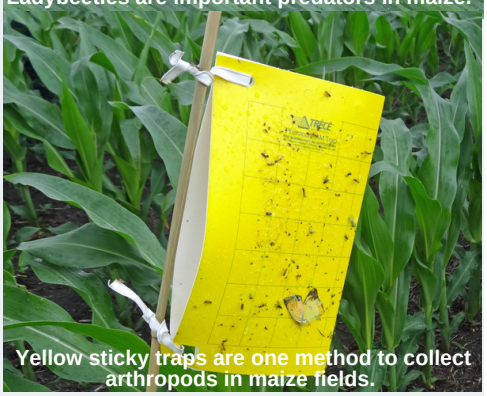
What are the Implications of the Review Findings?

The current work, following predefined standards to ensure unbiased, comprehensive, transparent, repeatable, and robust data collection and analysis, largely confirmed results of previously published reviews and meta-analyses. Bt maize represents a highly selective pest control technology with relatively few negative consequences for studied non-target invertebrates. Benefits are evident when compared with the use of broad-spectrum insecticides for managing Bt-targeted pests. The Bt maize lines that have been cultivated commercially worldwide have all gone through regulatory environmental risk assessments that concluded that no unacceptable risks for non-target organisms and biodiversity exist. Our systematic review generally supports these conclusions.

One shortcoming of the present and all prior reviews, however, is the limited availability of data in a form suitable for meta-analyses. Although many study authors provided datasets, some data could not be used for analyses or estimates had to be made, which increased the uncertainty of the analyses. Full datasets should be published along with scientific articles to facilitate future meta-analyses.


Maize field in Iowa


Ladybeetles are important predators in maize.


Yellow sticky traps are one method to collect arthropods in maize fields.

Photos: Jörg Romeis, Agroscope

Synthesis Time Frame

The review authors searched for studies published until August 2019. This CEE Systematic Review was published in June 2022.

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