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# Ecological impact of herbicides associated with transgenic soybeans on spider mites

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***Abstract:*** *How do RoundUp® Ready soybeans affect the growth of fungi that may keep down the populations of some significant soybean pests? Experiments in the laboratory and soybean fields explored this question.*

***Question:*** *Will RoundUp® applications on RoundUp® Ready soybeans destroy fungi that control insect pests, resulting in more insect outbreaks?*
***Answer:*** *Results of the research showed that ingredients in RoundUp® applications may cause larger spider mite populations in soybeans under dry conditions. Farmers who use the RoundUp® Ready system should be aware of this and monitor their soybeans for increased spider mite populations.*

## Background

A dramatic change in soybean production practices has come with the adoption of transgenic crops resistant to herbicides. In 1997, 14 percent of U.S. soybean acreage was planted to RoundUp® Ready soybeans. By 2000, the total had increased to 59 percent.

RoundUp® is a broad-spectrum herbicide that ranks among the top ten herbicides used in the United States. It has been determined that RoundUp® has fungicidal properties on some pathogenic and saprophytic fungi. Studying the interaction of glyphosate with fungi that attack insects (entomopathogenic fungi) is important because a wider use of this herbicide is predicted with glyphosate-tolerant crops. Under normal weather conditions, entomopathogenic fungi are considered the most important mortality factor of several arthropod pests (insects and spider mites) in Iowa, maintaining these pest populations below economic thresholds.

The main objective of this research was to determine if outbreaks of spider mite and green cloverworm populations could be promoted with the use of transgenic herbicide resistant soybeans and their herbicides in commercial fields.

The project objectives were to:

1. Determine the effect of glyphosate and glyphosate formulations on four entomopathogenic fungi important in Iowa crops,
2. Determine the suitability to green cloverworms of glyphosate-treated and untreated transgenic soybeans compared to traditional varieties,
3. Quantify twospotted spider mite and green cloverworm densities in commercial fields planted with transgenic glyphosate-resistant soybeans and fields with non-transgenic varieties, and
4. Determine the occurrence of *Neozygites floridana* on spider mites and *Nomuraea rileyi* on green cloverworm in commercial fields planted with transgenic glyphosate-resistant soybeans and non-transgenic varieties.

## Approach and methods

Objective 1) Four species of entomopathogenic fungi were obtained from the USDA-ARS collection. They were placed in various growth media and received treatments (seven glyphosate formulations, five blank formulations, glyphosate and distilled water). In-vitro tests were conducted and growth inhibitors were measured.

Objective 2) Green cloverworms were exposed via feeding experiments to transgenic soybeans treated with glyphosate and not treated with glyphosate. Developmental traits were calculated, including sex ratio and morphological measurements.

Objectives 3) and 4) Observational data were obtained from commercial fields planted and managed by soybean producers so several

factors could not be controlled. Statistics were collected on spider mites and occurrence of *N. floridana* and green cloverworm and occurrence of *N. rileyi*. Variables included leaf area, density, intensity, numbers of infected mites, cloverworm larvae mortality, and incidence of parasitism.

## Results and discussion

Laboratory studies determined that some RoundUp® formulations, but not the active ingredient (glyphosate) had fungicidal properties on four entomopathogenic fungi important in Iowa crops (*Neozygites*, *Nomuraea rileyi*, *Beauveria bassiana*, and *Metarhizium anisopliae*). Host suitability studies showed that green cloverworm does equally well developmentally, and possibly reproductively, when fed traditional varieties and RoundUp® treated and non-treated RoundUp® Ready varieties.

Field studies conducted in 1999 (Iowa, Minnesota, and Ohio) and 2000 (Iowa) showed that in drought conditions, commercial fields planted with RoundUp® Ready soybeans had higher spider mite populations than fields planted with traditional varieties. Occurrence of *N. floridana* (entomopathogen of spider mites) was lower in fields planted with RoundUp® Ready soybeans than with traditional varieties. No statistical differences were detected in green cloverworm populations or occurrence of its entomopathogenic fungus (*N. rileyi*) between traditional and RoundUp® Ready varieties.

## Conclusions

Results from these studies suggest that outbreaks of twospotted spider mite are more likely to occur on RoundUp® Ready soybeans than on traditional varieties under environmental conditions suitable for spider mites. Results showed that glyphosate formulations had fungicidal properties against all fungal species.

## Impact of results

Three studies were conducted to determine if outbreaks of twospotted spider mite and green cloverworm populations could be promoted with the use of transgenic glyphosate-resistant soybeans and glyphosate use in commercial fields. The first study evaluated the fungicidal effects, under laboratory conditions of glyphosate and seven glyphosate formulations on four entomopathogenic fungi. Results showed that glyphosate did not have fungicidal effects on any of the fungi tested. However, glyphosate formulations had fungicidal properties against all fungal species. For example, *N. floridana* and *M. anisopliae* were susceptible to all glyphosate formulations. The strongest fungicidal properties were observed with the RoundUp® Ready-To-Use formulation. The results of this in-vitro study indicate that the four tested fungi are susceptible to various glyphosate formulations when exposed to field concentrations. Thus, application of these formulations in soybean fields could have an impact on the natural fungal epizootics necessary for adequate pest regulation.

Pest incidence in crops also may be affected by changes in plant suitability as a result of stress factors, such as herbicide metabolism in the plant. Therefore, the second study evaluated whether host suitability to green cloverworm differs between transgenic glyphosate-resistant soybeans compared to conventional varieties, as well as if plant stress, induced by glyphosate, affects plant suitability to green cloverworm. No statistical differences among treatments were detected on developmental time and survivorship, sex ratio, and morpho-

logical performance. Although treatments did not affect size (calculated with principal component analyses), significant differences were observed between males and females. These results suggest that soybean genetic differences (between conventional varieties and analogous transgenic varieties) or plant stress (induced by glyphosate metabolism) do not affect the plant suitability for green cloverworm. Thus, conventional varieties and varieties of RoundUp® Ready soybeans with or without glyphosate stress, contribute similarly to the insect's development, survival, and reproductive potential.

Field pest populations are strongly influenced by epizootics caused by entomopathogenic fungi. Thus, evaluations of field responses of these emtomopathogens to pesticides with fungicidal activity are important. In the third objective, commercial fields planted with transgenic glyphosate-resistant and non-transgenic soybeans were evaluated for twospotted spider mite and green cloverworm populations, as well incidence of their entomopathogenic fungi, *N. floridana*, and *N. rileyi*. Economic spider mite populations required insecticide applications in six transgenic and three non-transgenic fields. Spider mite intensity was greater in transgenic soybeans than in non-transgenic soybeans, while percentage of infection by *N. floridana* was smaller in transgenic (54 percent) than in non-transgenic (58 percent) fields. Populations of green cloverworm were similar in transgenic and non-transgenic fields and were characterized as endemic. No statistical differences were detected between the treatments on the incidence of *N. rileyi*, which was less than 5 percent. Results from this observational study suggest that green cloverworm populations and incidence of its entomopathogenic fungus *N. rileyi* would be similar in fields planted with transgenic glyphosate-resistant soybeans and conventional varieties with endemic populations. Results from this study all suggest that under favorable conditions for spider mites, fields planted with transgenic glyphosate-resistant soybeans may have greater predisposition to outbreaks than fields planted with non-transgenic varieties.

In conclusion, larger spider mite populations observed in RoundUp® Ready soybeans may be partially a result of differences in field characteristics. However, outbreaks may have been enhanced as a result of lower incidence of *N. floridana* in the RoundUp® Ready soybean fields due to fungicidal effects of inert ingredients in glyphosate formulations.

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## Education and outreach

Three scholarly publications were written to summarize the results of this project and all have been submitted to journals.