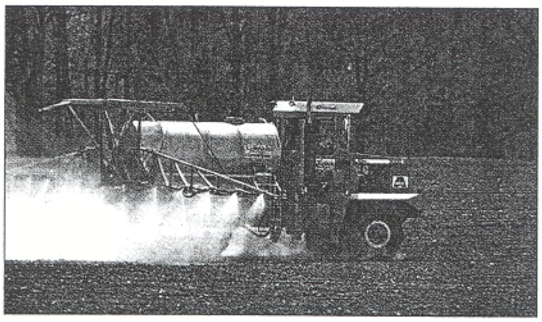
GM Crops and Patterns of Pesticide Use

IN THEIR REVIEW "THE ECOLOGICAL RISKS and benefits of genetically engineered plants" (*Science*'s Compass, 15 Dec., p. 2088), L. L. Wolfenbarger and P. R. Phifer provide an informative overview of a complicated set of issues. However, their discussion of changes in pesticide use includes little of the evidence available on pesticide use trends, and thus they underestimate reductions in pesticide use. In particular, the authors cite analyses of trends in corn and soybeans, but do not discuss cotton, the crop for which the most dramatic reductions in pesticide use have been observed. Further, the authors mischaracterize the need for additional studies on changes in pesticide use and the impact of these changes on the environment.

Using U.S. Department of Agriculture (USDA) data, we have analyzed changes in pesticide use since the introduction of genetically modified (GM) corn, cotton, and soybeans (*1*). Since the introduction of Bt cotton varieties with engineered insect resistance, U.S. cotton farmers have reduced the amount of insecticides used by ~2.7 million pounds (~1.2 million kilograms) per year. Corn farmers have achieved more modest reductions through the planting of insect-resistant varieties, because most growers had previously not been treating for the difficult-to-control target pest, the European corn borer. For soybean growers who have adopted herbicide-tolerant varieties, the impact has been to switch from using three or four different herbicides to using one or two, with little change in the total amount of herbicides being used.

Regarding future studies, Wolfenbarger and Phifer call for "[c]arefully designed experiments...to ascertain what effect individual transgenic crops have on agrochemical use, independent of other important variables." Although precisely measuring changes in pesticide use attributable solely to the adoption of GM crops remains a challenge, it is survey, not experimental, data that will address this question.

As for changing patterns in pesticide use, the authors are correct that this depends on the toxicity of the chemicals. However, in calling for experiments to assess toxicity, the authors appear to be unaware of the large number of studies that have been conducted on the ecological impacts of pesticides, both before and after commercialization. For example, a compendium of references on the nontarget impacts of the herbicide glyphosate lists several hundred studies (*2*). Furthermore, although the benefits of reductions in pesticide use may be clear, assessing potential benefits of substituting one chemical for another raises complex issues surrounding relative toxicity. Glyophosate has replaced the use of other herbicides in soybeans and is considered by many to be environmentally benign (*3*).



How does pesticide use change when genetically engineered crops are grown?

While scientists continue to debate risks such as the effect of genetically engineered corn pollen on butterfly populations, dramatic reductions in pesticide use achieved since the introduction of GM crops remain largely ignored. By focusing solely on potential ecological benefits, the authors overlook the other reasons U.S. farmers have planted GM crops on millions of acres: decreased costs, increased yields, and ease of management.

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References and Notes

1. *Agricultural Chemical Usage: Field Crops Summary* (U.S. Department of Agriculture, National Agricultural Statistics Service, Washington, DC, various years).
2. *Non-target Impacts of Herbicide Glyphosate: A Compendium of References and Abstracts* (Applied Mammal Research Institute, Summerland, British Columbia, Canada, ed. 4, 1997).
3. J. P. Giesy, S. Dobson, K. R. Solomon, *Rev. Environ. Contam. Toxicol.* 167, 35 (2000).

Response

TWO STRAIGHTFORWARD, ALTHOUGH NOT necessarily simple, questions need to be addressed before we can understand how GM crops affect pesticide use and the subsequent ecological effects. First, what effect does adoption of GM crops have on pesticide use? For example, does use increase or decrease, or is one pesticide substituted for another? Second, how does any resulting change in pesticide use impact ecological systems? We agree that carefully designed surveys will address the first question. However, surveys are not sufficient to answer the second question.

In reviewing the literature on ecological effects of reduced pesticide use associated with GM crops, we found, but did not include in our *Science* Review, a few studies addressing pesticide use in Bt cotton. We chose instead to cite a report by USDA's Economic Research Service (ERS) that parallels the conclusions and extends the analyses of these individual studies by using a multivariate approach. Even though the USDA report represented the most comprehensive survey to date, the study might both underestimate and overestimate pesticide use associated with the adoption of GM soybeans, cotton, and corn. For example, Bt cotton targets primary pests, but increasing populations of secondary pests have been reported for Bt cotton and might require additional pesticide input (*1*). Analyses of changes in pesticide use with adoption of GM crops have focused on those insecticides that act on Bt target insects and not necessarily those used on secondary pests. Such omissions would overestimate reductions in pesticide use. The ERS analyses could also underestimate reductions in pesticide use if growers adopting Bt crops would have used an above-average amount of pesticides on conventional crops (*2*).

Carefully designed field experiments can address the impacts of changes in pesticide exposure due to GM crops on ecological systems, and it is this latter question we addressed in our Review. If researchers and analysts wish to infer ecological effects from pesticide use patterns, then the toxicity of the chemicals used needs to be incorporated into the analysis and the effect on ecosystems assessed. Although we are aware of the large amount of data, published and unpub-