

ISSUES – FIGURE SET

What Are the Ecological Impacts of Plant Biotechnology?

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Green and red peppers, © B. W. Grant

Figure Set 4: Glyphosate Tolerant Soybeans

Purpose: To examine the usefulness of Roundup ready soybeans as compared to conventional varieties, analyzing both yields and herbicide use rates.

Teaching Approach: formal group work

Cognitive Skills: (see Bloom's Taxonomy) —comprehension, analysis, synthesis

Student Assessment: concept mapping

CITATION:

Zycherman, D., and J. Taylor. August 2004, posting date. What Are the Ecological Impacts of Plant Biotechnology? Teaching Issues and Experiments in Ecology, Vol. 2: Issues Figure Set #1 [online]. http://tiee.ecoed.net/vol/v2/issues/figure_sets/biotech/abstract.html

BACKGROUND

Soybeans are one of the staples in our diet. They are used in many foods such as pancake mix, margarine, and crackers. They are also used as animal feed. In 2002, U.S. soybean production was 2.73 billion bushels, compared to 9.01 billion bushels of corn and 1.62 billion bushels of wheat. Therefore soybeans certainly are a significant part of the U.S. agricultural product. With the revolution of modern biotechnology tools, the prospect of improving soybean crop yields while using less chemical pesticide use became a possibility. Between 1995 and 1996, biotech soybeans were approved for sale by the Food and Drug Administration (FDA), making biotech crops agriculture's most rapidly embraced technology (CBI 2002).

Monsanto is a pesticide producer that entered the biotechnology market. They produce Roundup which contains the active ingredient glyphosate. Glyphosate is an herbicide that, when applied to foliage, prevents the plant from producing an essential amino acid. This in turn reduces the production of protein in the plant which results in inhibited plant growth. Monsanto's product, Roundup Ready soybeans, which are resistant to glyphosate, were planted on one million acres in 1996 (Simon 2001). The use of these modified soybeans grew quickly. In 1997, 17 percent of farmers' soybean acreage was from genetically modified seeds (Stokes 2002).

As a result of the increased use of glyphosate tolerant soybeans, the use of this herbicide has increased. Glyphosate is considered a less toxic herbicide when compared to others seeking similar results and therefore, is considered one of the safer herbicides. Although this herbicide has become more popular, the question of whether biotechnology will actually decrease the need for herbicides in the long run is still undetermined.

One problem associated with the use of any chemical to kill an organism is the ability of that organism to build resistance. Resistance occurs when those organisms that survive, despite their contact with a chemical, pass on their genes to future generations. They are able to survive because of genetic strengths. Those that cannot survive contact with that chemical will die and those with the genes that can survive will continue passing along the beneficial genes. This problem can be seen in current situations, such as mosquito resistance to various chemicals traditionally used to kill them.

The first two figures in this Figure Set are USDA data on increased use of genetically modified soybeans plus use of herbicides in soybean fields over the same time period. The third figure compares yields for Roundup Ready and conventional soybeans.

Literature cited:

- Simon, S. 2001. Biotech soybeans plant seed of risky revolution. *Los Angeles Times* 1 July 2001.
- Stokes, B. 2002. Avoid a food fight with Europe. *National Journal* 34.44: 3228.
- Council for Biotechnology Information. 2002. *Council for Biotechnology Information* 4 Nov. 2002. <http://www.whybiotech.com>.

STUDENT INSTRUCTIONS

Work in groups of four. One person should facilitate the discussion (keep it moving, make sure everyone understands), another should ask probing questions (the skeptic), a third should write down your comments and questions (the recorder), and the fourth should report out to the class as a whole (the reporter). Decide who will have the roles of facilitator, skeptic, recorder, and reporter. Then examine the figures and discuss the following questions.

Figure 4A depicts the percent of U.S. acreage planted with Roundup Ready soybeans between 1996 and 2000. Why do you think it was adopted so fast? What implications might this have for regulatory policies? Discuss long-term but unforeseen impacts of this rapid adoption.

Now examine Figure 4B. During the same period of time that the percentage of acreage devoted to herbicide-tolerant soybeans increased (Fig. 4A), what is the pattern of change for herbicide use on soybean fields? Be sure to compare pounds of herbicide applied versus acres. How might you explain the pattern you see here?

Finally, examine and interpret Figure 4C. In this figure, 100% means that the yield of genetically modified soybeans is the same as that of unmodified ones; a value above 100% indicates that yield of Round-up Ready soybeans is higher. How do you compare the effectiveness of the Roundup Ready variety of soybeans with conventional varieties? Why might some states have experienced declines in yield performance? What is the significance of the overall average? What additional information about how the data were collected would help you address these questions with more confidence?

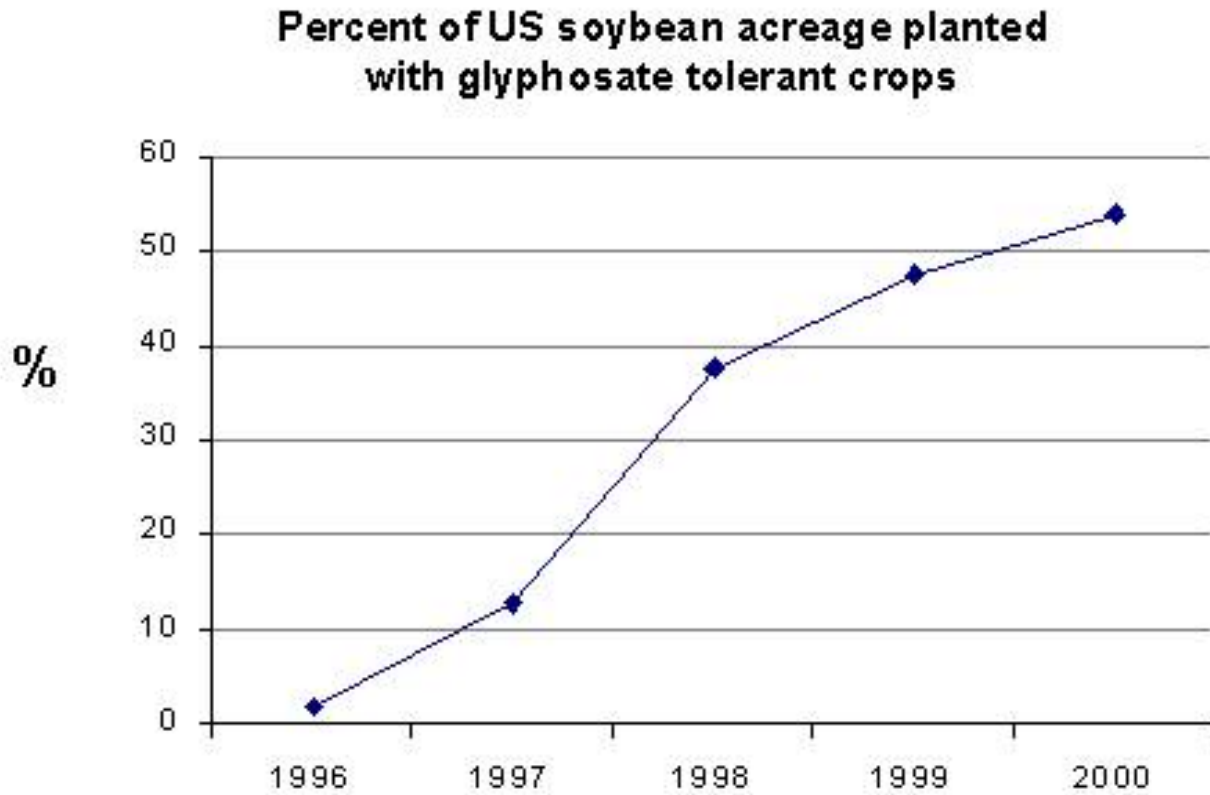
FIGURES

Figure 4A. Glyphosate tolerant soybean adoption (from Marshall, USDA National Agricultural Statistics Service 2000).

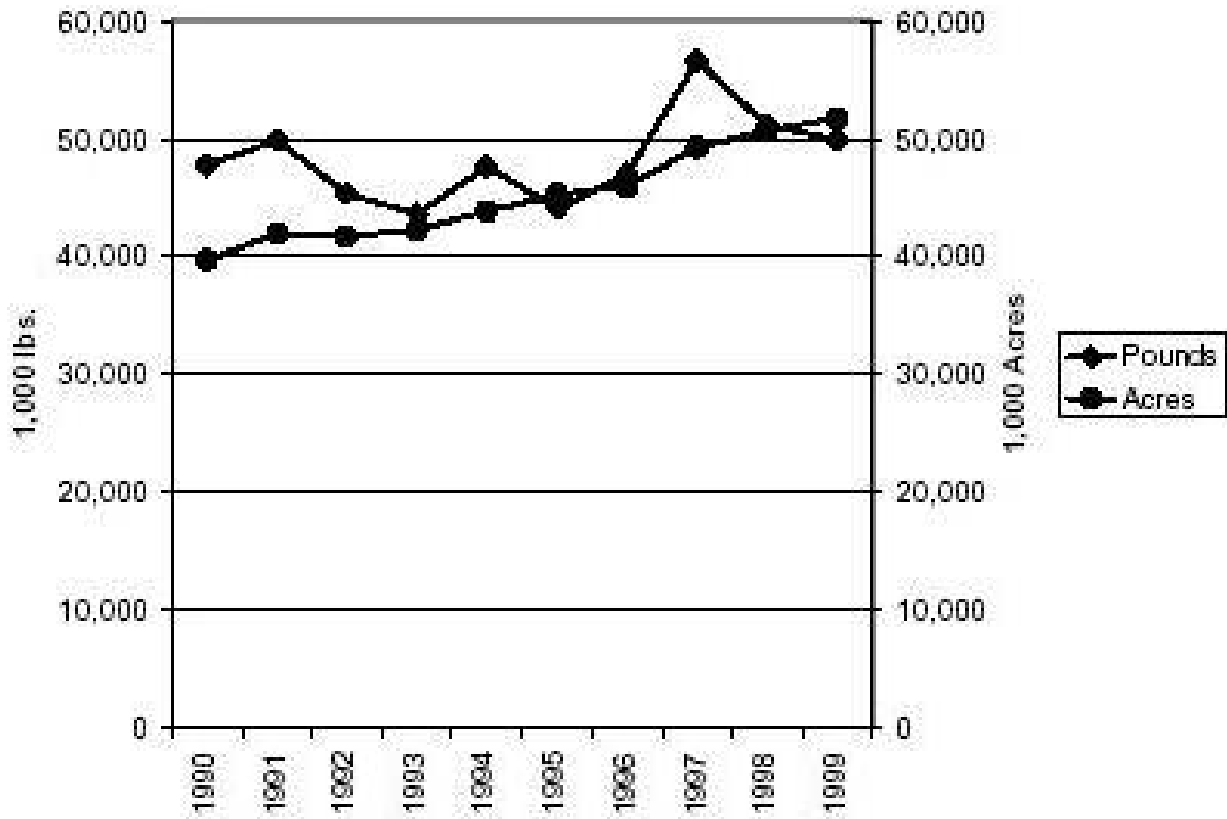


Figure 4B. Herbicide use in soybeans (AR, IA, IL, IN, MN, MO, NE, OH) (from USDA National Agricultural Statistics Service 1991-2000).

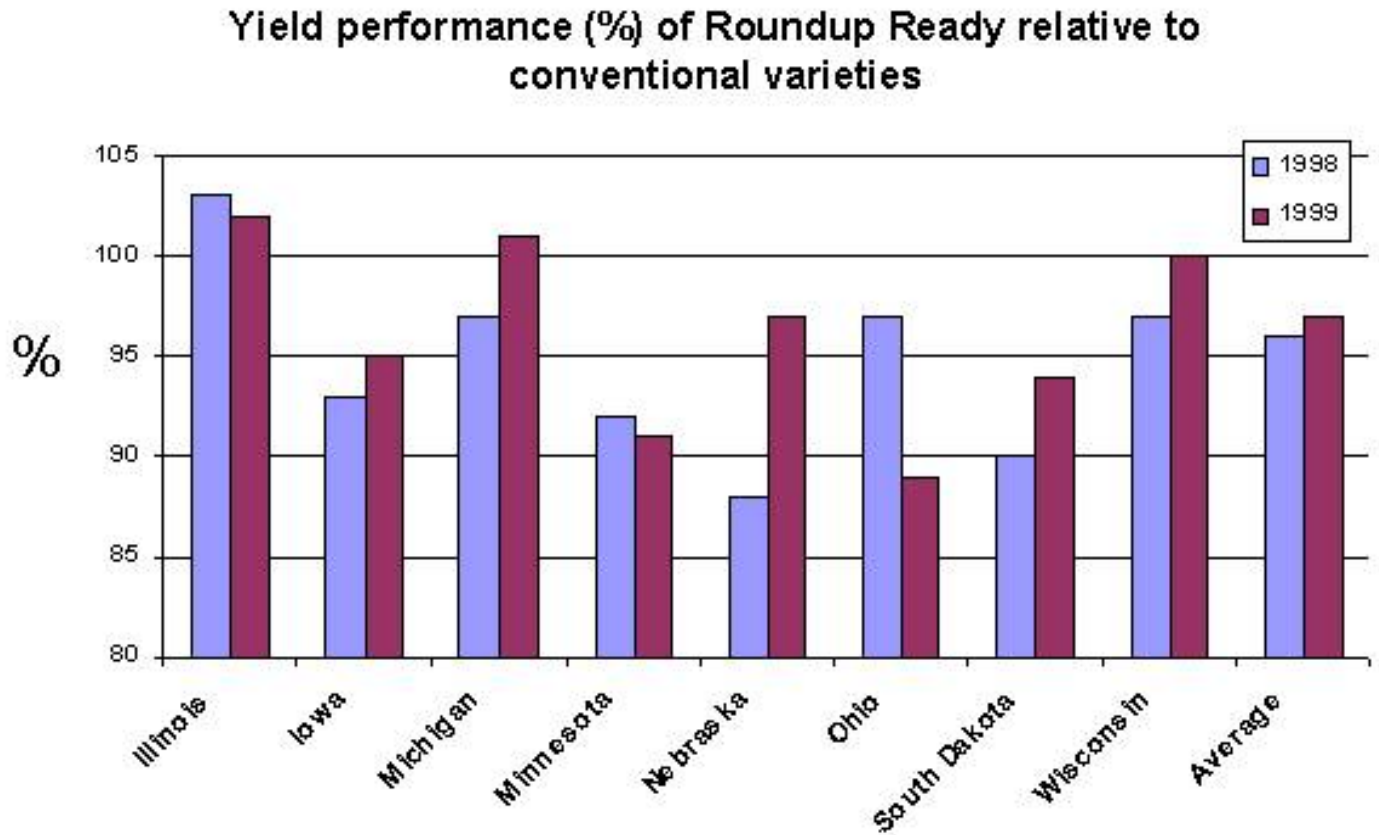


Figure 4C. State average yield performance of Roundup Ready Relative to conventional varieties 1998 and 1999, (numbers are calculated as Roundup Ready / conventional crop yields, from Carpenter, J. E. 2001. Comparing Roundup Ready and conventional soybean yields 1999. National Center for Food and Agricultural Policy. January 2001).

NOTES TO FACULTY

Group work with formal roles

When students work in groups, they often assume roles most comfortable for them - the shy student doesn't say much, the dominant student takes over, etc. The purpose of roles such as facilitator and reporter is to change that pattern. Make sure that students are maintaining their roles by periodically checking on each group. After the groups are finished discussing, have each reporter relay his/her group's answers briefly. Then, allow the whole class to discuss and answer any questions.

The Figures

The data are fairly straightforward. You may need to explain the use of double-y axes in Figure 4B.

During your discussion, stress that there is not enough data to support solid conclusions, particularly about yields. Since this is still a new technology, it is difficult to fully appreciate the benefits and disadvantages of Roundup Ready soybeans. The difference in yields between states (Fig. 4C) also demonstrates the important point that variation is the norm - another reason why it is difficult to make conclusions about the new technology.

After discussing these data, you could suggest that students look at data Monsanto publishes on its website about benefits of Roundup Ready soybeans. These sites are easily found with your favorite browser.

Student Assessment:

Have students in groups of four. Each pair should list questions about the effectiveness of glyphosate. Then, they should switch questions with the other pair and make educated guesses with the data that has been provided. Pairs should hand in the list of their questions, select one, and write a summary of the discussion they just had about this question.

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