

## Farm-Level Effects of Adoption

This section presents the estimated farm-level effects on pesticide use, crop yields, and net returns from the adoption of genetically engineered cotton and soybeans using the econometric adoption impact model and 1997 data described in the “Data and Methods” section. This model allows one to isolate the effect of adoption of genetically engineered crops once the effects of other factors are statistically controlled.

### Pesticide Use

Results of the econometric analysis using 1997 data show that, controlling for other factors, the adoption of crops with traits for herbicide tolerance and insecticide resistance led, in most cases, to reduced pesticide use, although in some cases the effect was not statistically significant (table 9).

◆ An increase in the adoption of herbicide-tolerant soybeans is estimated to have led to a statistically significant reduction in the use of other herbicides (other than acetamides or glyphosate) and a significant increase in the use of glyphosate. The change in acetamides was not statistically significant. Acetamides constitute about 17 percent of all the herbicides used on soybeans, glyphosate 19 percent, and

other herbicides represent nearly two-thirds of herbicides used on soybeans (table 2).

◆ While the percentage increase in glyphosate use for a given percentage increase in adoption was relatively high, the actual amount of the increase in glyphosate was smaller than the decrease in other herbicides. The net result was a decrease in total herbicide use.

◆ The change in herbicide use associated with the use of herbicide-tolerant cotton was not statistically significant.<sup>4</sup>

◆ While the changes in the use of organophosphate and pyrethroid insecticides associated with an increase in Bt cotton adoption were not statistically significant, adoption led to a significant decrease in use of other chemical insecticides.

<sup>4</sup> The effect of the adoption of herbicide-tolerant crops on herbicide use differs by region. For example, mean herbicide use rates on herbicide-tolerant cotton were about 20 percent lower than on all other cotton in the Southern Seaboard, but not significantly different in the Mississippi Portal (USDA, ERSb, 1999).

**Table 9— Econometric results on the impact of adopting herbicide-tolerant and insect-resistant field crops**

	Effect with respect to an increase in the adoption of:		
	Herbicide-tolerant soybeans, 1997 <sup>1</sup>	Herbicide-tolerant cotton, 1997 <sup>1</sup>	Bt cotton, 1997 (Southeast) <sup>1</sup>
Change in yields	small increase <sup>2</sup>	increase <sup>3</sup>	increase <sup>3</sup>
Change in net returns	0 <sup>4</sup>	increase <sup>3</sup>	increase <sup>3</sup>
Change in pesticide use: <sup>4</sup>			
<b>Herbicides—</b>			
Acetamide herbicides	0 <sup>5</sup>		
Triazine herbicides		0 <sup>5</sup>	
Other synthetic herbicides	decrease <sup>3</sup>	0 <sup>5</sup>	
Glyphosate	increase <sup>3</sup>	0 <sup>5</sup>	
<b>Insecticides—</b>			
Organophosphate insecticides			0 <sup>5</sup>
Pyrethroid insecticides			0 <sup>5</sup>
Other insecticides			decrease <sup>3</sup>

<sup>1</sup> Based on Fernandez-Cornejo, Klotz-Ingram, and Jans (1999).

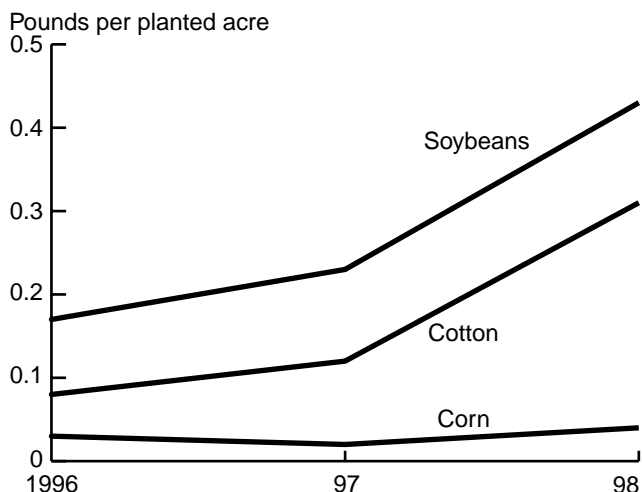
<sup>2</sup> Small increases or decreases are less than 1-percent change for a 10-percent change in adoption.

<sup>3</sup> Increases or decreases are more than 1-percent change but less than 5-percent change for a 10-percent change in adoption.

<sup>4</sup> Percent change in acre-treatments.

<sup>5</sup> Underlying coefficients are not statistically different from zero.

Figure 3  
**Use of glyphosate herbicides**



The overall downward trend of herbicide application rates used for major U.S. crops during this period appears to confirm the herbicide-reducing effect of herbicide-tolerant crops. For soybeans, as adoption of herbicide-tolerant varieties increased from 7 to 45 percent between 1996 and 1998, the average annual rate of application of glyphosate increased from 0.17 pound per acre in 1996 to 0.43 pound per acre in 1998 (fig. 3) and all other herbicides combined dropped from about 1 pound per acre to 0.57 pound per year (fig. 4). As a result, the overall rate of herbicide use in soybeans declined by nearly 10 percent in that period.

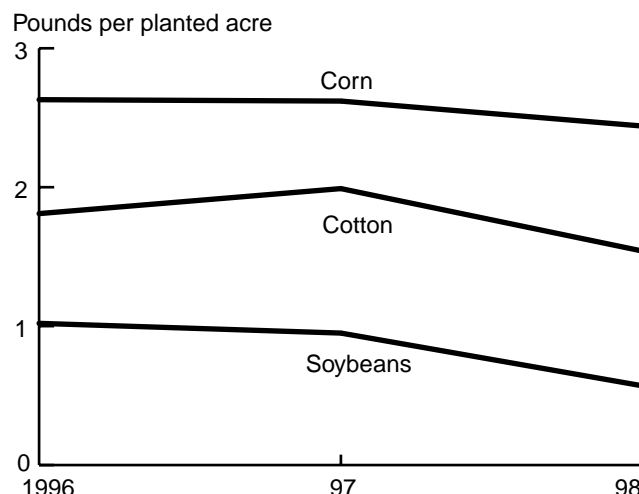
### Crop Yields

Results of the econometric research using the 1997 data show, controlling for other factors, a statistically significant relationship between increased yields and increased adoption of herbicide-tolerant and insecticide-resistant crops, although in one case the effect is small (table 9):

- ◆ Increases in the adoption of herbicide-tolerant cotton are estimated to have led to significant increases in yields.
- ◆ Increases in the adoption of Bt cotton are estimated to have led to significant increases in yields.
- ◆ Increases in the adoption of herbicide-tolerant soybeans are estimated to have led to significant (but relatively small) increases in yields. Yields increased less than 1 percent for a 10-percent increase in adoption.

Differences in the crop yields of genetically engineered and all other crops will vary by region and over time as technologies change. Comparisons of significant

Figure 4  
**Use of all herbicides, other than glyphosate**



mean yield differences between genetically engineered and all other crops generally support the econometric findings, suggesting that yields of genetically engineered varieties have been greater than those of all other varieties, but the yields can vary substantially across years, regions, and the types of biotechnologies (USDA, ERS, 1999b).<sup>5</sup>

### Net Returns

The econometric analysis using the 1997 data shows that, controlling for other factors, in most cases there is a statistically significant relationship between increased farm net returns and increases in the adoption of herbicide-tolerant and insecticide-resistant crops (table 9):

- ◆ Increases in the adoption of herbicide-tolerant cotton led to significant increases in net returns.
- ◆ Increases in the adoption of Bt cotton led to significant increases in net returns.
- ◆ Increases in the adoption of herbicide-tolerant soybeans did not lead to a statistically significant increase in net returns.

The substantial rate of adoption by farmers of the herbicide-tolerant and Bt cotton technologies supports the findings of higher farm net returns for the genetically engineered cotton compared with other cotton varieties. On the other hand, the failure to observe higher

<sup>5</sup> Biotechnology companies can also influence the yield by their choice of the seed lines in which to insert the genetic material.

returns for herbicide-tolerant soybeans is surprising given their particularly rapid rate of adoption by farmers. However, this result may be explained by regional variation. While the results presented in table 9 are valid for the entire sample, a comparison of mean costs and returns for herbicide-tolerant and all other soybeans suggests that the net returns associated with her-

bicide-tolerant soybeans varies by region (table 10). Mean net returns from the herbicide-tolerant soybeans were significantly higher, about \$40 per acre, in the Heartland where more than 70 percent of soybeans are produced. Mean net returns for herbicide-tolerant and all other soybeans were not significantly different in either of the southern regions.

**Table 10—Costs of and returns from herbicide-tolerant seed technology used in soybean production compared with all other seed technologies, by region, 1997<sup>1</sup>**

Item	Heartland		Mississippi Portal		Southern Seaboard	
	Biotech	All other	Biotech	All other	Biotech	All other
<i>Dollars per planted acre</i>						
Value of production	330.80**	287.88	204.80	225.78	239.63	205.68
Seed and weed-control costs:						
Seed <sup>2</sup>	30.03**	17.70	26.78**	14.96	29.43**	15.74
Herbicide	19.20**	28.16	20.61**	28.15	12.54**	24.64
Herbicide application	2.88	3.34	3.57	3.91	2.20	2.83
Weed scouting	0.45	0.29	0.21**	0.60	1.12	0.69
Weed cultivation	0.31**	1.27	0.38*	1.35	0.28	1.04
Total seed & weed-control costs	52.87	50.75	51.54	48.96	45.56	44.94
Value of production less costs	277.93*	237.12	153.26	176.82	194.07	160.74

\*\*significantly different from all other at the 5-percent level.

\*significantly different from all other at the 10-percent level.

<sup>1</sup>Statistically compared using a difference of means test. The biotech category includes all acreage on which herbicide-tolerant soybeans were planted. The "all other" category includes acreage planted to all other purchased and homegrown seed. Differences between the mean estimates cannot necessarily be attributed to the use of the seed technology since they are influenced by several other factors not controlled for, including irrigation, weather, soils, nutrient and other pest management practices, other cropping practices, operator management, etc.

<sup>2</sup>Includes seed technology fee.