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Potential Economic Impact of Herbicide-resistant Corn

There have been no economic studies completed on herbicide-tolerance of crops or on very many biotechnological products. Some argue the reason is because little money has been allocated for economic research in biotechnology. Others argue that these new products are not yet available, so how can economic impacts be measured? However, economists can perform analyses given facts and assumptions, but it is very important that the results be useful and not misleading; the results do not have to be 100 percent accurate. As these products move closer and closer to completion, then economic estimates can be refined.

The potential economic impact of using herbicide-tolerant corn depends upon a number of factors. One, of course, is the cost difference of the new herbicide and seed technology compared to the old. The cost difference will influence a farmer's acceptance and adoption of a specific technology. Yield improvement from better weed control is also an important factor. Together, the cost difference and the yield increase potential will influence the adoption rate.

All of these factors influence farmer behavior which effects prices and the production of other crops. The only way to sort through all of these changes is to employ a model. We used the AGSIM model built by R.C. Taylor at Auburn University, to determine the impact of herbicide-tolerant corn on U.S. agriculture. The model simulates supply and demand of the major crops in ten multi-state regions plus

Illinois. The major crops considered are corn, soybeans, cotton, milo, barley, oats, and alfalfa. The model simulates supply and demand for ten years, beginning in 1987. Demand is comprised of three segments: demand for livestock feed, demand from domestic consumers, and export demand.

The supply component of this model consists of acreage and yield per acre. Total acreage is a function of annual farm income. As annual farm income increases, the total acreage in agriculture in a region increases. The allocation of this acreage between crops depends upon the relative profitability of each crop. This is a somewhat unique approach to econometric models. When supply curves are typically estimated, they are estimated as a function of prices with technology embedded in the estimated function. It's very difficult then to determine how those supply curves should be shifted with new technology. In contrast, the impact that new technology will have on profit can be determined. In this case, the impact of the new herbicide-tolerant technology is determined through its per acre profitability, including both the lower cost of growing corn per acre, and the increased yield. The model will determine the profitability using input prices and commodity prices which change over time.

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Table 1

Average annual losses in corn production from weed pests under 1983 control technologies.

AGSIM Region	Average Losses
Illinois	4.7
Other corn belt	3.9
Great Lakes	12.6
Northern Plains	2.9
Southern Plains 1/	8.4
Delta	20.7
Mountain 1/	8.4
Northwest 1/	8.4
Northeast	2.1
Appalachia	12.1
Southeast	8.2

1/Average of all other regions

Source: National Agricultural Pesticide Impact Assessment Program

The regional definitions used in Table 1 include the U.S. Department of Agriculture (USDA) regions plus Illinois. In order to determine the impact of herbicide-tolerance, the current yield loss due to weeds was determined by using numbers from the National Agricultural Pesticide Impact Assessment Program, which was a study done by the USDA. There are some problems with the survey, but it provides a consistent estimate across the United States. There might be other studies that are better for specific crops or regions but in this case, consistent estimates across all the regions were needed. In some regions, there's not much loss from weeds under current technology. In the case of the corn belt, it is only about 4 percent.

Table 2

Scenario definitions lor AGSIM simulations of herbicide tolerance in U.S. corn production.

scenario	adoption profile 1/	regional availability and time period for adoption	maximum acreage adopting	cost per acre
			(percent)	(dollars)
1	A.	all regions, 1991-1996	48	26
III	B.	all regions, 1991-1996	71	13
IV	B.	Illinois, 1991-1996	71	13
	C.	other regions, 1993-1996	66	

1/SeeTable3.

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A number of scenarios were run but only three are shown in Table 2. In scenario I, the technology was made available in all regions simultaneously, beginning in 1991. The adoption rate increases annually via a logistics curve. The maximum acreage adopted is 48 percent and the cost per acre of the herbicide-tolerant technology is J26. Current chemical cost control of weeds varies by region, but it averages about $ 14-J15 per acre. The cost increase would include the cost of additional herbicide, as well as the additional cost of the seed.

The next scenario (III) again assumes all regions adopt beginning in 1991. The maximum acreage adoption is 71 percent and the cost is $13 per acre, which is slightly lower than current weed control technology costs. The 71 percent eventual adoption rate may seem rather high, but this would entail resistance to many different herbicides, as well as different seed varieties.

The last scenario (IV) deals with the impact of one region having the technology before any of the other regions. One region where the technology might be available first is the corn belt. The model looked at the availability first in Illinois starting in 1991, and then all other regions starting in 1993.

Table 3

Adoption profiles for AGSIM scenarios.

year	adoption profile		
	A	B	C
	percent of acreage adopting		
1991	6	9	
1992	13	20	
1993	25	38	20
1994	37	55	38
1995	44	66	55
1996	48	71	66

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The adoption profiles in Table 3 show the annual percentage of the corn acreage using the herbicide-tolerant technology. Adoption profile "C" only comes into play for those regions which adopt beginning in 1993, after Illinois adopted in 1991. After observing what happened in Illinois for two years, the percentage of adoption in other regions would be expected to be high their first year.

In Table 4 the yield increase in bushels per acre was determined assuming complete control of weeds. Complete weed control would probably not be economically feasible, but was assumed for the purpose of analysis. The yield increase is fairly minor in the corn belt. The most significant yield impact would be in the South. The last two columns are the net cost change at the two technology prices per acre, $26 and $13. The first net cost change is basically double current chemical weed control costs, and the other one is about current costs.

Table 5 shows the net revenue per acre from adoption the first year by region under the different scenarios. The average return per acre for the corn belt under scenario I, assuming complete weed control at $26, would only be about $4 or $7. That is not a significant net benefit to farmers. However, there are regions that have more significant weed problems who benefit much more.

Table 4

Changes in yields and in weed control costs by region for herbicide-tolerance technology. 1/.

region	yield increase	net cost change at two technology prices per acre	
		$26	$13
	bushels per acre	dollars per acre	
Illinois	5.47	10.05	-2.95
Corn belt	4.29	10.08	-2.92
Lake	12.92	8.67	-4.33
Northern plains	2.96	16.84	3.84
Southern plains	10.08	17.04	4.04
Delta	14.00	10.27	-2.73
Mountain	10.97	13.15	0.15
Northwest	11.63	9.79	-3.21
Northeast	2.05	10.54	-2.46
Appalachia	10.32	9.25	-3.75
Southeast	5.33	11.45	-1.55

1/ Applies only to the acreage using the herbicide-tolerant varieties.

Tables

Net revenue per acre from adoption of herbicide-tolerance technology in first year of availability.

	scenario		
	I	II	III
		dollars per acre	
Illinois	7.74	20.74	20.74
Corn belt	3.42	16.42	16.37
Lake	30.79	43.79	43.67
Northern plains	-7.58	5.42	5.39
Southern plains	19.09	32.09	31.99
Delta	40.08	53.08	52.94
Mountain	23.87	36.87	36.77
Northwest	36.81	49.81	49.68
Northeast	-3.17	9.83	9.81
Appalachia	26.54	39.54	39.43
Southeast	7.17	20.17	20.12

Scenario III, with a lower technology cost, is much more profitable. Since Illinois was the first state to adopt the technology in scenario IV, its net profit is the same as under the second column. The other region's net profits are lower because Illinois has already had two years of adoption and has increased corn production, lowering corn prices in the process.

There is a debate as to the sales price of this technology. Farmers currently buy most of their seed corn treated with herbicides. One strategy that herbicide and seed companies might use is to keep their prices constant and try to gain market share. This strategy might be more profitable than increasing price.

Table 6

Change in economic surplus (benefits) compared to AGSIM benchmark 1991-1996.

	scenario		
Group & year	1	II	III
		million dollars	
Consumers 1/			
1991	196	321	42
1992	614	1016	130
1993	1216	2015	891
1994	1837	3038	2051
1995	2276	3261	3261
1996	2460	4055	4055
Producers 21			
1991	-138	-158	-19
1992	-253	-243	-28
1993	-479	-462	-375
1994	-607	-506	-357
1995	-641	-451	-581
1996	-600	-325	-541

1 / Domestic and foreign. 21 Net crop and livestock income above variable costs.

The model shown in Table 6 separates the impact on consumers from producers. As is the case with most new technology, consumers gain because there is a greater quantity of corn being produced at a lower price. Consumers also include foreign consumers of American export products. Note that the producers in aggregate experience a decrease in farm income. Producers include all crop and livestock producers, not just corn producers. This decrease occurs because when

farmers adopt this profitable technology, it increases the output of corn, causing the corn price to fall, and farmers' incomes to decrease. This does not mean that the new technology is not profitable, because the old technology falls in profitability, too. When consumers' and producers' benefits are summed, the net benefit to society is positive.

Table 7

Change in corn net income above variable costs compared to AGSIM benchmark: by region, 1991-1996.

Regions, year	scenario I	II	III
		million dollars	
Illinois			
1991	-28.44	-38.33	15.14
1992	-56.78	-73.31	36.68
1993	-103.63	-131.39	-53.87
1994	-145.34	-179.43	-94.69
1995	-171.34	-210.07	-160.83
1996	-184.09	-224.84	-202.42
Delta			
1991	0.51	1.26	-0.26
1992	1.54	3.49	-0.49
1993	2.96	6.65	2.23
1994	4.68	10.35	6.12
1995	6.24	13.55	9.85
1996	7.43	15.82	13.16

In scenarios I and III in Table 7, the net aggregate income of corn producers in Illinois is negative. However, in scenario IV, where Illinois had this technology for two years before any other region, Illinois corn producers have an aggregate benefit of $15 million the first year, and $36 million the second year before other regions begin to adopt. The Delta area has an increase in aggregate farm income under this technology, even if those farmers were not the first to adopt. If Illinois adopts first, the Delta region will, of course, have a negative net income during those initial years, but after the Delta region adopts, the net income becomes positive. Because there is a significant weed problem with corn in the Delta area, they benefit even if corn prices fall.

Table 8

Changes in corn acreage under scenario III by region, 1991 and 1996.

	year	
	1991	1996
	thousand acres	
Illinois	8.62	-100.71
Corn belt	18.49	-245.82
Lake	23.84	93.02
Northern plains	1.54	-103.58
Southern plains	4.53	-15.68
Delta	3.73	54.54
Mountain	0.35	-1.33
Northwest	0.46	-0.60
Northeast	1.14	-35.70
Appalachia	24.57	131.60
Southeast	22.59	-2.78
U.S.	109.85	-227.03

Table 8 shows the changes in corn acreage by region in 1991 and 1996 under scenario III. Initially there is an increase in corn production, because for the first year, farmers in this model base their decisions on the past year's corn prices. After a greater supply of corn is produced, the first year corn prices are lower. Eventually, by 1996, because of the decreased profitability of producing corn per acre, corn acreage is reduced in most regions, except for regions of the country that have the most significant weed problems, such as the Delta and Appalachian areas. The change in acreage in weed prone areas is very minor because, despite new technology, these areas do not produce very much corn to begin with.

Table 9 shows the impact on U.S. corn prices per bushel. The initial impact is very small, but by 1996 the price impact can be rather significant. Whenever complete weed control is assumed with significant adoption, quite a substantial yield increase and price decrease result.

This technology not only affects corn producers, it affects soybean producers as well because the decrease in corn profitability shifts corn acreage to soybean acreage. For the most part, many corn producers are also soybean producers. This increase in soybean acreage increases soybean production and the soybean price falls.

Table 9

Change in commodity prices compared to AGSIM benchmark: U.S. 1991 -1996.

Crop & year	scenario I	III	IV
		cents per unit	
Corn (bushel)			
1991	-2.6	-4.7	-0.6
1992	-5.3	-9.4	-1.1
1993	-9.6	-17.0	-11.2
1994	-13.5	-23.6	-17.6
1995	-15.9	-27.9	-24.5
1996	-17.0	-29.9	-28.5
Soybeans (bushel)			
1991	0.9	2.9	0.3
1992	-0.6	2.4	—
1993	-2.9	1.3	5.8
1994	-6.8	-2.3	1.6
1995	-11.6	-8.0	-3.8
1996	-15.3	-12.9	-9.9

For the first three years in scenario III, the soybean price actually went up. This was an unexpected result. In those initial years, extra corn had to be used for something, so it was used for livestock production. Livestock producers need to supply their animals with protein in the form of soybean meal. This causes a slight increase in the soybean price until significant acreage moved into soybean production, reducing its price.

In summary, assuming a complete elimination of losses from weeds and a $13 per acre substituting technology, U.S. corn production would increase about 2 to 4 percent. Corn prices might be lowered by 20 or more cents. Acreage in the corn belt will shift slightly to soybeans, while the shift outside the corn belt would be to alfalfa and other crops. Early regional adoption is beneficial to the region that uses new technology first. Consumers gain from greater output and lower prices while aggregate farm income falls.

A full report of this research can be found in Tauer and Love, "The Potential Economic Impact of Herbicide-Resistant Corn in the USA," Journal of Production Agriculture, (1989):202-207.