Who Benefits from Biotechnology?[1]

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Good morning. I appreciate the opportunity to be with you today. My talk is going to focus on an extremely important topic. Yet, too often, it also is a topic that segregates people into competing groups that rely only on rhetoric and scare tactics rather than discussing the real issues.

We all have our biases and regardless of what anyone says, our biases influence our perspectives. As scientists we strive to eliminate our biases from our research but the very fact that we look at one issue and not another reveals our biases. What we should strive for is to control our biases and acknowledge them from the beginning.

I am the Associate Director for Iowa State University's Leopold Center for Sustainable Agriculture. I also am the Professor-in-Charge of the ISU Beginning Farmer Center. Finally, I am an ISU Extension Economist.

All this means that I view the world both from an economic perspective and from the perspective of working with agriculture and farmers. I am an educator who tries to present information in as factual a way as possible and give people the tools and means to form their own opinions. I start from the basic supposition that economics is the study of allocating scarce resources and not simply the study of money. I also feel that humans are a part of the natural system and not apart from it. The impacts of our worldly actions are governed by a set of ecological principles; some of which we understand and others that we do not fully comprehend.

As an economist, I believe in the market as an efficient mechanism for allocating resources. However, just as I believe in the efficiency of the market, I also know there are market failures. These failures take several forms. Difficulty in valuing externalities is one example. Public goods, such as air and water, are other areas where the market cannot efficiently cope with all the issues. Allocating resources between generations is another problematic area for the market. Finally, I think that concentration of market power is something that will lead to the failure of markets as an efficient mechanism for allocating resources.

In this talk I will first briefly discuss biotechnology. Next, I will share the results of a study examining the farmer impact of herbicide tolerant soybeans and Bt corn. Finally, I will draw some conclusions and discuss the implications of what I have found.

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Biotechnology

Biotechnology has been labeled "a misleading expression because it conveys a singularity or unity to what is actually a tremendously diverse set of activities and range of choices." (Buttel, 1985) A U.S. Department of Agriculture (USDA) publication notes, "… biotech processes and products are so diverse and have so little in common with one another that it is difficult to construct valid generalizations about them. Broader than genetic engineering and gene splicing, biotech includes tissue, cell, and embryo culture; protoplast fusion; bioregulation or hormonal control of physiological and metabolic processes; production of gene-controlled products; directed plant breeding; and fermentation processing." (USDA, 1987)

Throughout this paper I am simply going to use the term biotechnology, recognizing that there are inherent problems with using this single term. However, I do not want to further muddle an already confusing issue with what, for most of us, are technicalities.

Michael Fox provides a chronological presentation of the significant biotechnology events leading up to the present day. Fox begins with the breeding experiments by Mendel in 1869. (Fox, 1992) Others feel that the roots of biotechnology, especially as it relates to traditional plant breeding, can be traced back to the earliest days of agriculture and the domestication of plants and animals. Keeney, however, points out, "In contrast, the new agricultural biotechnologies provide the tools for molecular and cellular approaches to altering plants and animals." (Keeney, 1998)

This is a big distinction between more traditional plant and animal breeding and biotechnology. The traditional methods were limited to using only materials that were biologically similar. With today's biotechnology capabilities, scientists are able to construct animals and plants that would never have been possible using conventional breeding techniques.

Before considering who benefits from biotechnology, it is necessary to discuss one idea that I feel is erroneous. Many proponents of biotechnology say that this technology is necessary to feed the world. They argue that if we do not use biotechnology, many of the world's people will face starvation and other ills associated with malnutrition. This is certainly a concern; however, the evidence shows that it is not the hungry who are being fed but rather the affluent, i.e., those who can afford to buy the food. The earlier Green Revolution also was promoted as a means of eliminating world hunger. Food production has increased but we still have hungry people. The problem is not one of production but rather a problem of distribution and politics. Ho Zhiqian, a Chinese nutrition expert, was quoted as saying, "Can the Earth feed all its people? That, I'm afraid, is strictly a political question." (Reid, 1998) As we think about biotechnology, we must not confuse wanting the world to be fed with wanting to feed the world.

Before discussing a specific example of who benefits from biotechnology it is important to examine what agricultural examples of biotechnology have been approved.

As of May 1999, there were 15 products approved for unregulated release, 13 crop, and 2 non-crop. (USDA, 2001) There were 53 different examples within the 13 crop groups. Only three of the products contained what were described as “value-enhanced traits”. The rest contained “agronomic traits,” primarily herbicide tolerance or insect resistance.

These are the so-called first generation biotech or genetically engineered products. A second generation now being developed or tested will greatly expand the number of available crops and applications of this technology.

Herbicide-tolerant soybeans

The case of herbicide-tolerant soybeans will be used to examine the benefits of biotechnology at the farm level. The data for this analysis come from a random sample, cross-sectional survey of Iowa soybean fields. The survey was conducted by the Iowa office of the USDA’s National Agricultural Statistics Service in the fall of 2000. The data presented are for the 2000 crop year.

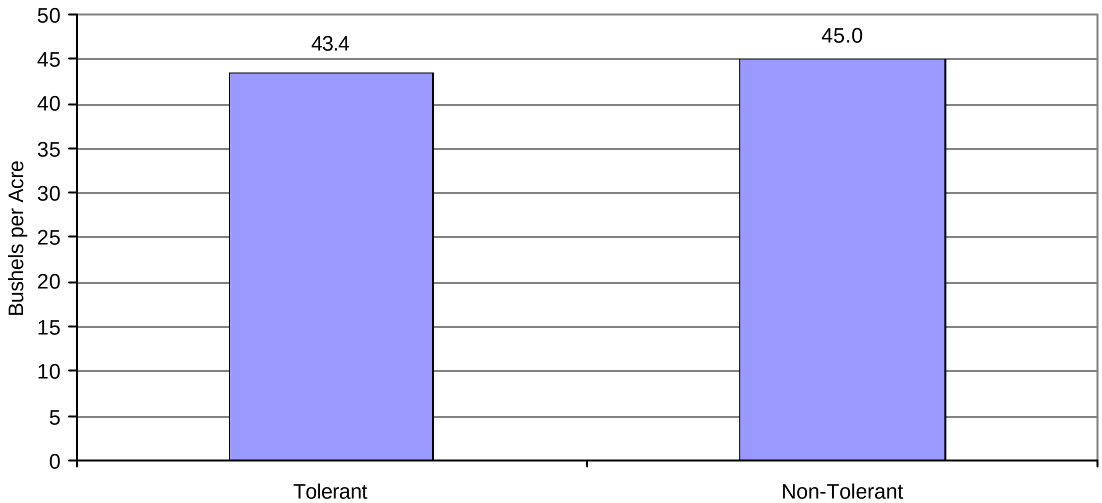
The survey covered all aspects of crop production. This included yields, pesticide and fertilizer use, seeding rates and the type and nature of machinery operations performed.

Several assumptions were necessary to compare the costs and returns for herbicide- tolerant versus non-tolerant soybeans. The price per bushel was $5.40. This price represented the average loan rate and emergency payments. The per unit cost for pesticides was obtained from various sources at Iowa State University. The per unit costs of fertilizer and seeds were the costs used in the Iowa State Extension Service cost of production estimates (Duffy and Smith, 2001). Finally, the costs for the various machinery operations represented the average custom rate charge as reported by the Iowa State University Extension Service (Edwards and Smith, 2001a).

The final data set contained observations for 172 fields. Of these fields, 63 percent (108 fields) reported using herbicide-tolerant soybeans. There were 64 fields that reported planting soybeans that were not herbicide tolerant.

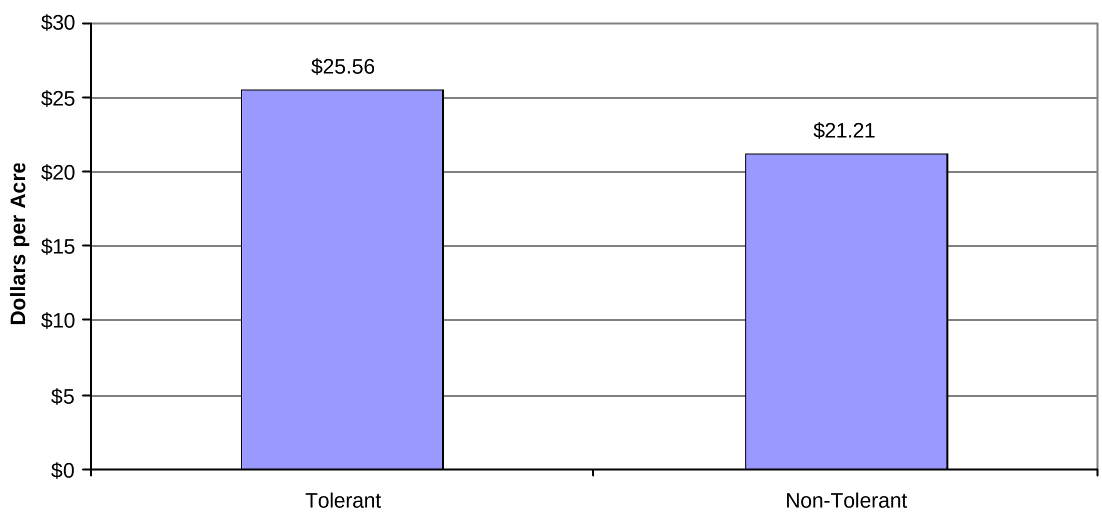
Figure 1 shows the average yields. The herbicide-tolerant soybeans averaged 43.4 bushels per acre while the non-tolerant soybeans averaged 45.0 bushels per acre. The percentage difference in yields is identical to the difference found in a similar study for the 1998 crop year (Duffy, 1999). In 1998, the yields were 49.2 and 51.2 bushels per acre for herbicide- tolerant and non-tolerant soybeans, respectively.

Figure 1: Average Yield for Herbicide Tolerant and Non-Tolerant Soybeans, 2000



The major cost differences attributed to planting herbicide-tolerant or non-tolerant soybeans are for seed and herbicide costs. Figure 2 shows the seed expenses for herbicide- tolerant and non-tolerant soybeans. The seed expenses were found by multiplying the price for seed times the seeding rate. (The seeding rate was the rate reported by the farmer.) The price for the non-tolerant seed was the price reported by Iowa State Extension (Duffy and Smith, 2001). There was a 5 percent premium added to this price to represent the price for the herbicide-tolerant seed. Five percent was a conservative estimate to reflect any price differences plus the tech fee charged.

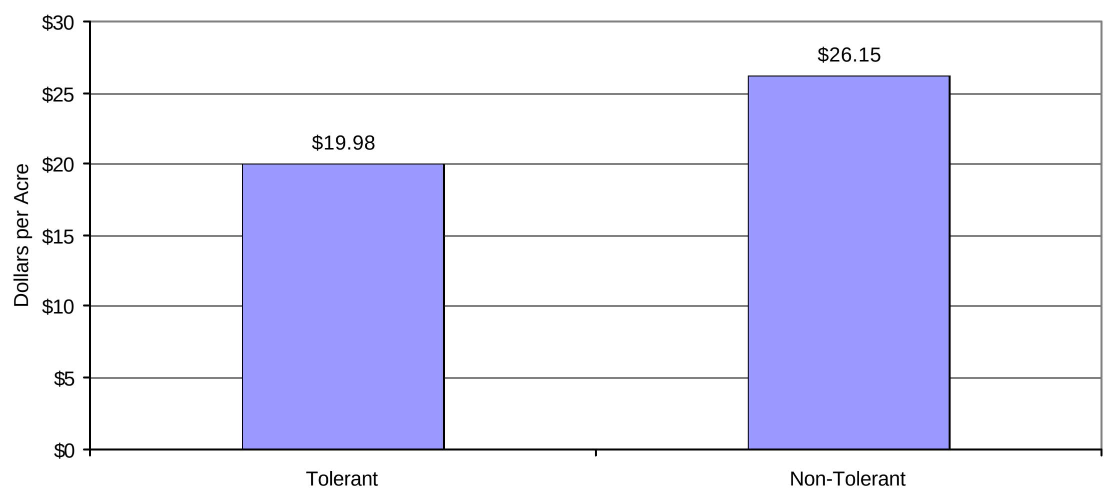
Figure 2: Average Seed Cost for Herbicide Tolerant and Non-Tolerant Soybeans, 2000



The seed cost for herbicide-tolerant soybeans averaged $5.69 per acre more than the non-tolerant fields. In 1998, the difference was $7.53 per acre. The expense for non-tolerant soybeans was lower in 1998 while the expense for the tolerant varieties was slightly higher.

The cost for herbicides is shown in Figure 3. The farmers reported the rate of each chemical they applied. The non-tolerant soybeans averaged $26.15 per acre for herbicides, which was $6.17 higher than the herbicide costs for the tolerant fields. This cost difference is similar to what was found in 1998 even though the herbicide costs, in general, are higher in 2000 when compared to 1998.

Figure 3: Average Herbicide Cost for Herbicide Tolerant and Non-Tolerant Soybeans, 2000

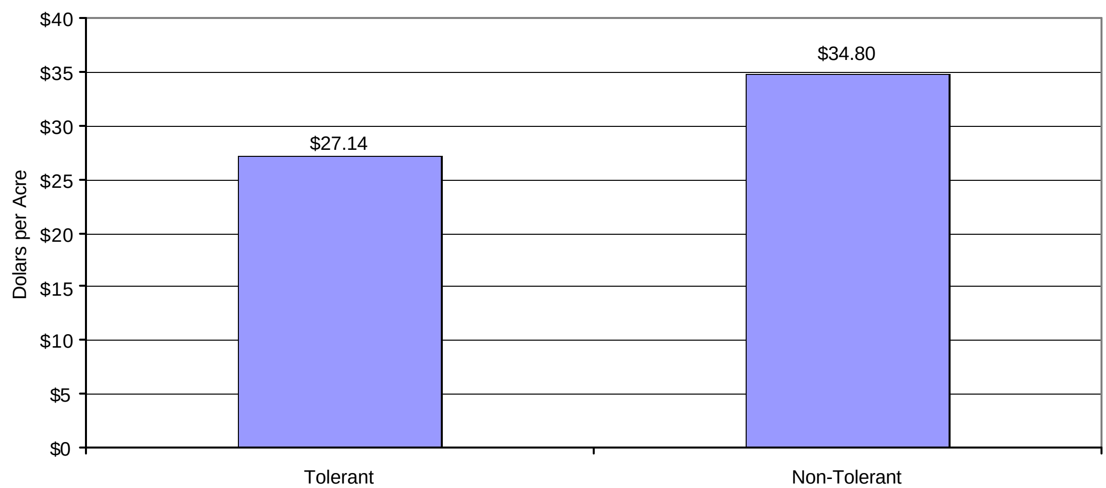


The herbicide-tolerant soybean fields had an average of 1.55 sprayer trips in 2000, compared to 2.45 trips for the non-tolerant fields. Sprayer trips ranged from 1 to 4 for the tolerant fields while 6 was the maximum number of sprayer trips reported for the non-tolerant fields.

Cultivation is another technique used to manage weeds. In 2000, 48 percent of the tolerant fields reported at least one cultivation. This compares to 63 percent of the non-tolerant fields that reported at least one cultivation. The number of cultivations ranged from 0 to 2 but the average number of cultivations reported for the tolerant fields was .59 versus an average of .85 cultivations for the non-tolerant fields.

Figure 4 presents the total weed management costs for both the tolerant and non-tolerant soybeans. This figure includes herbicide material and application costs as well as the cost for cultivations. The total weed management cost for tolerant fields was $27.14 versus $34.80 per acre for the non-tolerant fields. Again, these costs and the differences were very similar to the 1998 totals.

Figure 4: Total Weed Management Costs for Herbicide Tolerant and Non-Tolerant Soybeans, 2000

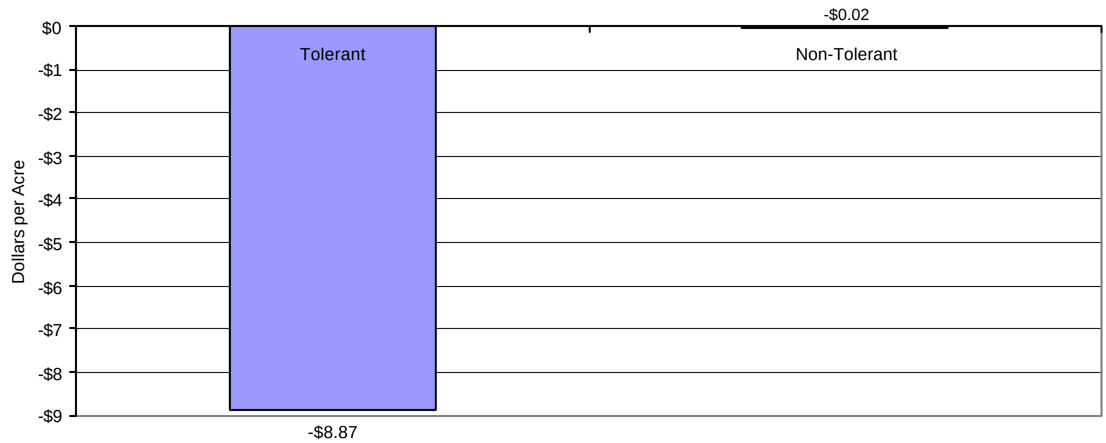


When all of the costs, including those mentioned, plus fertilizer, lime, all machinery operations, insurance, and a land charge are considered, there is essentially no difference in costs between the tolerant and non-tolerant fields.

The land charge used was calculated in three steps. First, the average statewide yield for soybeans was divided by the average rent per acre. (Edwards and Smith, 2001b) The result was $2.85 per bushel. This amount was multiplied by the average yield in the survey and the result was $125.08 per acre. This was the land charge used for all fields.

Figure 5 shows the return to labor and management for the tolerant and the non-tolerant fields. In 2000 both seed types lost money. The return to the herbicide-tolerant fields was an $8.87 per acre loss while the non-tolerant varieties essentially broke even with a calculated $.02 per acre loss.

Figure 5: Return to Labor & Management for Herbicide Tolerant and Non-Tolerant Soybeans, 2000



Two major considerations could not be included in this analysis. First, the price per bushel for either the type of soybeans was assumed to be the same. Recently there have been some considerations for price differentials based on whether or not the soybeans were herbicide tolerant. The second major consideration omitted from this analysis was the difference in time for combining. Farmers report that they are able to combine tolerant fields faster because there is less clogging of the combine. Many also report producing cleaner beans. These considerations are beyond the scope of this analysis.

These considerations notwithstanding, based on this analysis it appears that there is essentially no difference in the return to using herbicide-tolerant versus non-tolerant soybeans. This is the same conclusion that was reached in the similar 1998 study.

Use of herbicide-tolerant varieties results in lower herbicide and weed management costs. However, they also have higher seed costs and slightly lower yields.

If the returns to the herbicide tolerant and non-tolerant varieties are similar, why have the tolerant crops been adopted so readily? The acreage planted to herbicide-tolerant varieties has gone from nothing a few years ago to more than half the acres planted or higher depending on the estimate. There are several reasons for this phenomenon. First, the ease of harvest is an overriding consideration for many producers. Being able to harvest easier and faster makes farmers more willing to adopt a new technology even if it does not produce clearly superior returns.

Farmers also may be using the herbicide-tolerant varieties on fields with particularly heavy weed problems. If the average returns are comparable. then it is simpler to use the same varieties so that commingled soybeans are not an issue.

Advertising and landlord pressure could also be part of the explanation for the phenomenal rise in the use of herbicide-tolerant soybeans. Some landlords insist on clean fields and the herbicide-tolerant varieties offer that option.

There are other reasons that have been mentioned such as greater flexibility, less time in the field at harvest, and so forth. Many of these become individually compelling reasons. But, given the analyses in 1998 and again in 2000, there does not appear to be any difference in the per acre profitability between the two varieties.

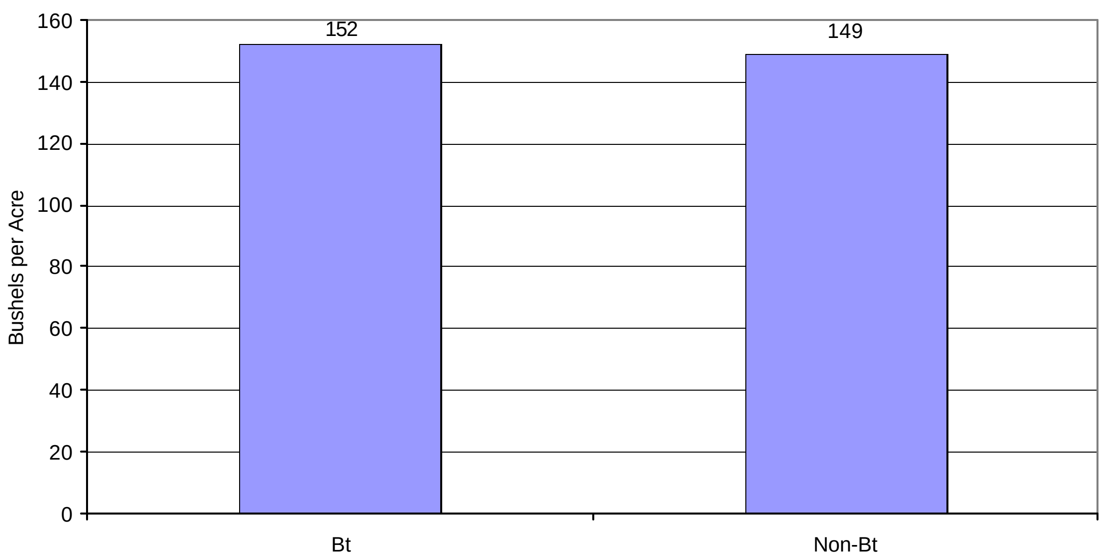
Bt Corn

The second example used to evaluate who benefits from biotechnology is Bt corn. The data used for this study come from the same data set used for the soybean example just reported. For corn, there were 128 non-Bt fields and 46 Bt fields.

The costs and returns were calculated in the same way as for the soybeans. The price used for corn was $2.06 per bushel. This price reflects the $1.76 loan rate of regular government payments plus emergency payments.

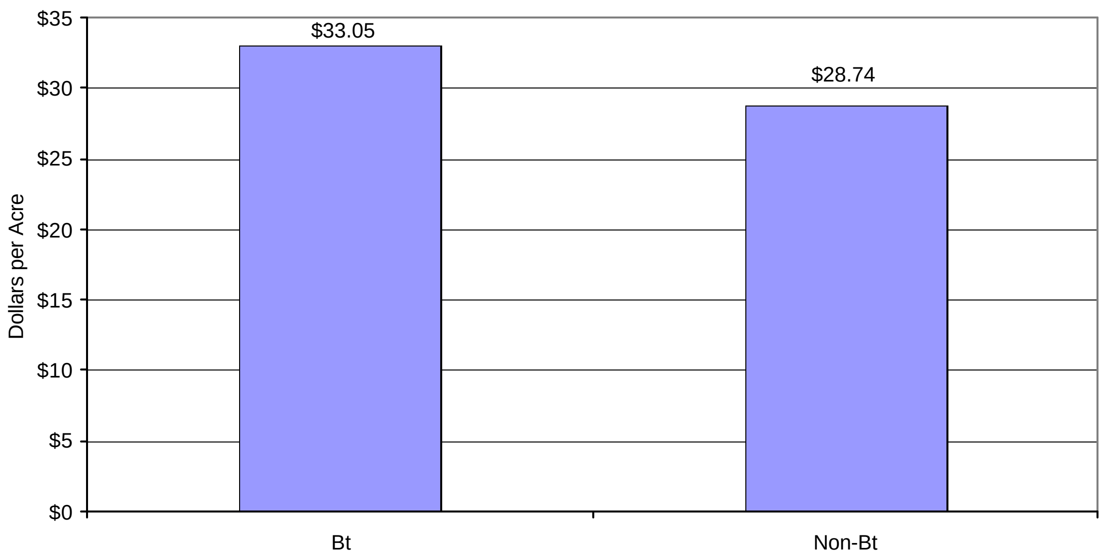
The average yield for Bt corn was 152 bushels per acre (Figure 6). The average yield for the non-BT corn was 149 bushels per acre. This yield difference is less than the difference found in the 1998 study.

Figure 6: Average Yield for Bt and Non-Bt Corn, 2000



The planting rate was reported by the farmers, while the cost for seed was reported by Iowa State Extension with a 15 percent premium added for Bt seeds. This reflects the cost differences plus the tech fee. Figure 7 shows the seed cost comparisons.

Figure 7: Average Seed Costs for Bt and Non-Bt Corn, 2000



The Bt cornfields had slightly higher total fertilizer costs per acre (Figure 8). The Bt fertilizer cost was $53.30 versus $48.67 for the non-Bt fields, much similar to the results found in 1998. Although no production reason exists for the higher fertilizer costs, it is hypothesized that the Bt fields are managed more intensively which leads to the increased fertilizer costs.

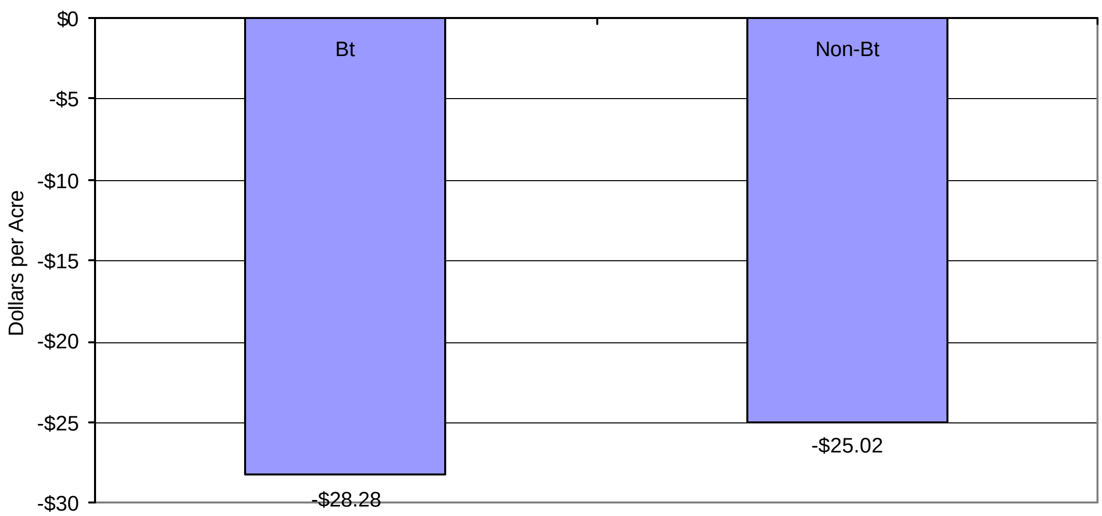
Figure 8: Total Fertilizer Costs for Bt and Non-Bt Corn, 2000

Total, non-land, costs for Bt corn averaged $207.25 per acre as opposed to the non-Bt corn that averaged $197.00 per acre. This difference is lower than the cost difference found in 1998. At that time the Bt corn was $20 per acre more costly than the non-Bt varieties.

The land charge used here was calculated similarly to the land charge for the soybeans. The average rental rate used was $130 per acre. This is higher than the Iowa average rate of $120 reported by the Iowa State Extension (Edwards and Smith, 2001b).

Both Bt and non-Bt corn showed a negative return to labor and management. The Bt corn lost an average of $28.28 per acre while the non-Bt corn posted an average loss of $25.02 (Figure 9).

Figure 9: Return to Labor and Management for Bt and Non-Bt Corn, 2000



Similar to herbicide-tolerant soybeans, Bt corn produced a return essentially equal to the non-Bt corn. Even though Bt corn has not increased in acreage as the herbicide-tolerant soybeans have, this again raises the question of why people would adopt an equal technology at all, especially given the potential marketing problems associated with Bt corn.

Many farmers plant Bt corn as a sort of insurance policy. Pest populations are unknown at the beginning of the season. There are certain fields and conditions where a pest outbreak is more likely. For these fields, the use of Bt corn could produce dramatically different results than those presented here. Remember that this is a cross-sectional study and not a side-by-side comparison.

Some farmers claim the Bt corn has more brittle stalks and that it is not as appealing to cattle as a feed. In spite of these observations, the yields for Bt corn found here are higher than the non-Bt and this was similar to the cross-sectional study in 1998.

Who Benefits from Biotechnology?

The preceding analysis shows that the primary beneficiaries of the first generation biotechnology products are most likely the seed companies that created the products. Additionally, in the case of herbicide tolerance the companies that supply the tolerant herbicides also are the benefactors from the development of the biotech crops.

It also appears that farmers have benefited from biotechnology. Their gains, however, appear to more related to greater ease of production and the ability to cover more acres as opposed to an increase in the profits per acre. The farmer benefits are evidenced by the rapid adoption of this new technology. As noted, in Iowa soybean acres planted to herbicide-tolerant varieties went from zero to more than half the total acreage in just a few years. Farmers definitely perceive a benefit even if their profits are not increasing.

It has been argued that consumers also are the beneficiaries of the first generation biotech products because the increased production leads to lower prices. Whether or not production increases depends upon the crop under consideration. For soybeans, the yields actually are slightly less, while for corn they are slightly higher.

Regardless of the crop under consideration, it is hard to determine whether consumers actually benefit from the first generation biotech products. The prices for the basic commodities covered are already low due to abundant supplies. In addition, government programs that support prices will cost the taxpayers more if the prices continue to drop.

Consumers actually spend only a fraction of their food dollar on these basic commodities. Changes in the price of the basic commodities will have little impact on the prices charged to the consumers. Additionally, a consumer backlash against biotech indicates that, for at least some consumers, the addition of biotech crops is not seen as a benefit but an added risk.

Today's biotech crops and applications are merely the first generation of products. It appears from these examples that the primary beneficiaries are the seed and chemical companies and, to a lesser extent, the farmers. What will happen with the proposed second-generation products remains to be seen.

Conclusion

The results presented here are from a cross-sectional study. Replicated, randomized plot studies by Pecinovsky also reached the same conclusions. (Iowa State University, 2001) Similar to this study, he found the Bt corn had higher yields whereas the herbicide tolerant soybeans had lower yields.

Today the primary benefactors of biotechnology are the seed companies and chemical companies. Farmers appear to be receiving some non-pecuniary benefits. And, in spite of arguments to the contrary, there is only mixed evidence with respect to consumer benefits.

The primary reason for the first generation biotech applications was to focus on input traits. Given this approach it is not surprising that the input companies are the primary beneficiaries. Biotech applications that focus on output traits, as opposed to the input traits, may produce more widely dispersed benefits.

One of the issues that I have not addressed but that is a concern to many people pertains to the externalities associated with the use of biotechnology, especially as it has been applied to date. There is a question of unknown health effects from the genetically modified products. Health officials have assured the public that this should not a concern, but this is not an entirely satisfactory reassurance to many.

Several other externality issues surround the use of biotech crops. Insect and weed resistance will develop faster with the widespread use of these products. There also is the issue of pollen drift that affects people trying to grow either organic commodities or some other type of crop requiring segregation from biotech varieties.

Biotechnology is an extremely powerful tool. It has the potential to create many useful products as well as many unforeseen problems. As with any new technology, it must be evaluated carefully. It is not prudent to expect private companies to develop products for the public good. Companies are in the business of making money and the products they pursue are designed for that end. To expect any other result from private research is not appropriate or realistic.

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